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## **Study on Heuristic Usability Evaluation for Mobile Applications**

**Master Thesis**

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Dedicated to people who changed my journey.

*It is possible to avoid failure, to always be safe. But that is also the route to a dull, uninteresting life*  
— Donald A. Norman. The Design of Everyday Things

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## **Abstract**

Usability guidelines are a useful tool for the developers to improve interaction with systems. It includes knowledge of different disciplines related to usability and provides solutions and best practices to achieve the objectives of usability. Heuristic evaluation is one of the methods most widely used to evaluate and user interfaces.

The objective of this study is to enrich the process of heuristic evaluation with the design guidelines focusing it on the evaluation of applications for mobile devices. As well as generate a homogeneous classification of guidelines content, in order to help that from design and development process, be included solutions and good practices provided by the guidelines.

In order to achieve the objectives of this work, it is provides a method for generating heuristics for mobile applications, with which four applications were evaluated, and a web tool has also been developed that allows access to the content of the guidelines using the homogeneous classification of guidelines content.

The results showed the ease and utility of performing heuristic evaluations using a set of heuristics focused on mobile applications.

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# 1 Introduction

## 1.1 Motivation

At the end of 2014 half of the world population had at least one mobile subscription, a total of 3.6 billion of unique mobile subscriptions, is expected that by 2020 three-fifths of the world population have a mobile subscription, a total of 4.6 billion unique subscriptions, these data are provided by GSMA at the Mobile World Congress 2015 (GSMA, 2015). According to the report, the growth of improvements in digital coverage reflects the acceleration in the rate of adoption in the use of smartphone, this rate reaches 60% of connections in the developed world, 51% Europe, and 70% in North America and market is expected to reach by the next four years a ceiling of 70-80%. The terminals calculated by the end of 2014 reached 2.6 billion of smartphones and market is expected that by the end of 2020 to reach 5.9 billion.

The numbers and trends show that the mobile ecosystem is huge, growing and aims to penetrate every market in the world, already in the developed world the rate of adoption is reaching its ceiling, but in the emerging markets are foreseen substantial increases. The mobile industry became an engine of the world economy in 2014 generated 3.9 of world GDP, calculated only as a direct impact of the industry without regard more extensive socio-economic effects, and market is expected that by 2020 increase to 4.2% of world GDP.

The mobile ecosystem formed by the Infrastructure, Operators, Handset Manufacturing, Distribution, Content, Apps and Services, has as a central point the mobile devices, and promotes innovation and development of new services that will be consumed by devices. Experience in the use of mobile devices nowadays not only is limited by the use of a single smartphone or device, data and services can be shared with any device that has access to the network. During the last years have grown up business models and services in unimaginable ways, with the Internet of Things and Big Data, the concept of mobile service might leave the boundaries of the smartphone even share services and data with other types of devices. The future is being built with a digital ecosystem made up various technologies, brands and services that need to interoperate transparent way for the user.

According to a report provided by comScore (comScore, 2014), in early 2014 the first milestone about the use of devices and consumption of data and services from the Internet, mobile devices surpassed desktop terminals with regard to daily data consumption. The type of content consumed by a user from a mobile device depends of several external factors, interests, context and even location, and according to the same report the content type most consumed is for Social Networks, Games, Radio, Multimedia, Shopping, Courier photography, which correspond to the categories in the app stores that have more growth and downloads, also according to a report from the State of the Nation

developers for Q3 2014, shows that business applications are overthrowing entertainment applications and are becoming the new gold mine for developers and generating sales revenues for the applications. 43% of business applications produce about \$ 10K per month compared with the consuming applications that only 19% of these applications reach the same income.

App stores are growing regarding the number of applications offered in an accelerated manner, payments through stores are growing, and smartphone sales reach record numbers. Although this is transparent to the user, within the digital ecosystem created for mobile technology, a war of platforms currently is happening. The manufacturing companies are included in this war and the OS, the universe of applications and development teams also play an important role. According to data from International Data Corporation (IDC, 2015) Worldwide Quarterly Mobile Phone Tracker, vendors shipped a total of 3334.4 million of devices worldwide during the first quarter of 2015 1Q2015. From the point of view of installed platforms on devices, Android and iOS are those with 96.3% of the world market, leaving 3.7% to platforms such as Windows Phone BlackBerry OS and others. Android leads and share 78% of the market (1Q2015), with Samsung as the biggest contributor, Apple with 18.3% (1Q2015) share market is gaining ground, according to the report Mobility Index Report Q1 2015, iOS in the first quarter of 2015 reached 72% of activations of that period, and Android 26%, only Apple's flagship iPhone 6 was responsible for 26% of activations.

Each platform installs and provides access to their respective store, according to the last report of Statista.com (Statista, 2015), the market share of the universe of Google Play (Android), there are over 1500000 published applications, and about Apple App Store (iOS) there are over 1400000 published applications. Each store has its own characteristics, different publication policies, quality control of applications, design guides and payment systems. Apple Store is known to have a universe of premium user regarding to Google Play if are considering the revenue generated by application. The market offers differences options in order to allow develop mobile applications, and the development teams know that each market has its own rules, taking care to details about to details like the programming language, knowledge of developers for each platform, design and usability guidelines suggested by each platform, type of target users, payment system of each platform, these details should be fulfilled to achieve publication process in store, especially in the case of the Apple Store.

The market increasingly calls for more and better applications, the capacity of the devices and platforms currently allows creating more visually richer applications and that they provide a better user experience. Usability and user experience are important factors related to the success of a mobile application.(Hussain & Kutar, 2009) The unique characteristics of mobile devices, which are even limitations, beside the novelty of mobile application, these are a challenge to the activity of measuring and evaluating usability. Heuristic evaluation is one of the most widely used methods for evaluating user interfaces, there are studies (Rusu, Roncagliolo, Rusu, & Collazos, 2011a) have changed the focus of this evaluation to different domains, even some authors (Inostroza, Rusu, Roncagliolo, Jimenez, & Rusu, 2012; Xu, 2013) determines that the heuristic evaluation of a touch interface can be performed by adapting of traditional heuristics and including an approach to

evaluate the physical and ergonomic interaction. By contrast, other authors consider risky mixing the approach of applications with NUI and GUI characteristics, in the case of tactile interaction.

There is a need for new methods of evaluation, especially usability evaluation that are customized for mobile devices (Inostroza et al., 2012). The platforms offered through their guidelines, information about the user interface and way of interaction between the user and each platform, as well as principles and best practices, this information can be used to enrich current evaluation methods in order to which meet the quality standards required by the stores.

This study focused on enriching the process of heuristic evaluation using the principles and good practice provided by guidelines of Android and iOS platforms, and also provide a tool for the design and development stage to allow access to the content of the guidelines using the homogeneous classification of guidelines content.

To achieve these goals was performed an analysis of the content of the guidelines in order to generate a list of heuristics for mobile applications, a study was conducted carried out heuristic evaluations to four different mobile applications and getting impressions of their evaluators. And it was also made a re-classification of the content of the guide. Finally was developed a web tool that allows access to the content of the guidelines using the new classification of the guidelines content.

## **1.2 Objectives**

Each platform regularly publishes its design guidelines within which includes recommendations and principles, these recommendations may be about the graphical interface, user experience, some other facilities available, and standard platform (SDK) (Alamri & Mustafa, 2014). The guidelines differ between platforms, and can even differ between devices. The purpose of each platform to promote the use of standards is to promote the integration of applications with the operating system, as Apple mentions in his guide, Integrating With iOS Means giving users a compelling, delightful experience That feels at home on the platform, it does not mean creating an app that looks like a copy of a built-in app. (Apple, 2015)

In the case of Apple, the violation of Apple's iOS Human Interface Guidelines is one of the most common causes why a Submitted application is rejected (Wooldridge & Schneider, 2011), Regarding Google Play the publishing process does not verify the compliance to the guidelines, which causes that within the ecosystem of Google Play there are many differences of styles and designs of applications. Despite this, with the introduction of the latest design guideline called "Material Design" about latest stable version of Android, aims to develop a single underlying system that allows for a unified experience across platforms and device sizes. (Google Inc. and the Open Handset Alliance, 2015)

In the war of platforms, the UX is one of the important things to consider, platforms put a lot of effort to publish guides in order to enhance the quantity and quality of the ecosystem of published applications in their stores, the following open question arises: Following the guidance of the platforms ensures better user experience or is necessary to add something else? Where do principles of guidelines come from? Within the philosophy of User Centred Design (UCD), may the guidelines be used only by designers and developers, or also in the evaluation stage? Are the contents of the guides homogeneously classified? The objective of this study is to explore these questions, performing the analysis of the guidelines, principles and its content, also perform the process of usability evaluating on mobile applications.

More specifically, the objective of this study is to analyse the guidelines in order to enrich the process of heuristic evaluation, focusing it to mobile applications, as well as the generation of a homogeneous content classification.

### **1.2.1 Specific Objectives**

The specific objectives for the study are:

- To study of current status of User Experience (UX) practices for mobiles applications.
- To establish heuristics for mobile applications using a methodology that extracts principles from platforms guidelines.
- To conduct heuristic evaluation of mobile applications.
- To analyse the results of heuristic evaluations and to get impressions of the evaluators about the procedure.
- To analyse and classify the content of the guidelines.
- To build a web tool for the access to the guidelines content.

### **1.3 Document Structure**

This master thesis document is divided into seven chapters:

This chapter, entitled Introduction, is chapter one. It includes introduction, motivation and objectives of this work.

Chapter 2, entitled State of the Art, presents a review of the concept of usability, User-Centered Design, guidelines, heuristic evaluations, and finally includes a bibliographic research about frameworks for designing methods and heuristics.

Chapter 3, entitled Study of Current Status of UX Practices for Mobile Applications, presents a study of the current state of UX practices for mobile applications, during which a survey was conducted. This chapter describes the methodology used, and analysis of results.

Chapter 4, entitled Redefining Usability Heuristics for Mobile Application, presents a detailed process to generate heuristics for mobile applications, this section provides an analysis of the principles of each guideline and its relationship with the heuristic evaluation, the methodology used to generate heuristics, the preparation of heuristic evaluations, the analysis of the results of evaluation, and impressions of the evaluators.

Chapter 5, entitled Content Classification of Guidelines, presents the process used to get a general classification of the guidelines content, the methodology followed, the building of a web tool, and usability analysis of this.

Chapter 6, entitled Discussion, addresses the meaning of the thesis findings, which are: Supporting usability heuristic creation, supporting mobile heuristic evaluation, guideline content classification, integration in the design process, and limitation of the study.

Finally, in chapter 7, entitled Conclusions and Future Work, the conclusions and the future lines of works are detailed.

## **1.4 What is not contained in This Thesis**

As the main purpose of this thesis is to enrich the process of heuristic evaluation with the design guidelines focusing it on the evaluation of applications for mobile devices. As well as generate a homogeneous classification of guidelines content, in order to help that from design and development process, be included solutions and good practices provided by the guides. This work will not describe in depth the development process of the web tools. It only presents its structure in order to show its functioning, and any mobile applications evaluated.

## 2 State of the Art

### 2.1 User-Centered Design and Usability

#### 2.1.1 Definition of Usability

Usability is defined by the standard "ISO / IEC 9241-11: 1998" as the effectiveness, efficiency and satisfaction With Which specified users Achieve goals specified in special environments (International Organization for Standardization, 1998). Another well-known definition is given by Nielsen: "Usability is a quality attribute that assesses how easy user interfaces are to use" (Nielsen Norman Group, 2005). The word "usability" also refers to methods for improving ease-of-use during the design process. Nielsen determines that usability is not a single property of the user interface with a dimension. Usability has multiple components and is traditionally associated with five attributes. Learnability, Efficiency, Memorability, Error, Satisfaction.

#### 2.1.2 Process of User-Centered Design

The term "User Centered Design" was proposed by Donald Norman in 1986 (Gulliksen et al., 2003) in his book Psychology of Everyday Things (now known as Design of Everyday Things) UCD was described as "a philosophy based on the needs and interest of the user, with an emphasis on making products usable and understandable."(Norman, 2013)

There are other definitions of UCD as provided by Usability Professionals Association: "UCD is an approach to design that grounds the process in information about the People Who will use the product" (Usability Professionals Association, 2015). Usability.gov defined it as "UCD is an approach for employing usability. Its product is a structured development methodology That Involves users throughout all stages of web site development, in order to create a Web site that meets users' needs" (Usability.gov, 2015). The standard ISO 9241-210 (2010) (ISO 13407: Human-Centred Design Process) generally define a process for including Human-Centered development activities through a life-cycle, but does not specify exact methods (Bertholdo, da Silva, Melo, Kon, & Silveira, 2014).

Six key principles are described in the standard:

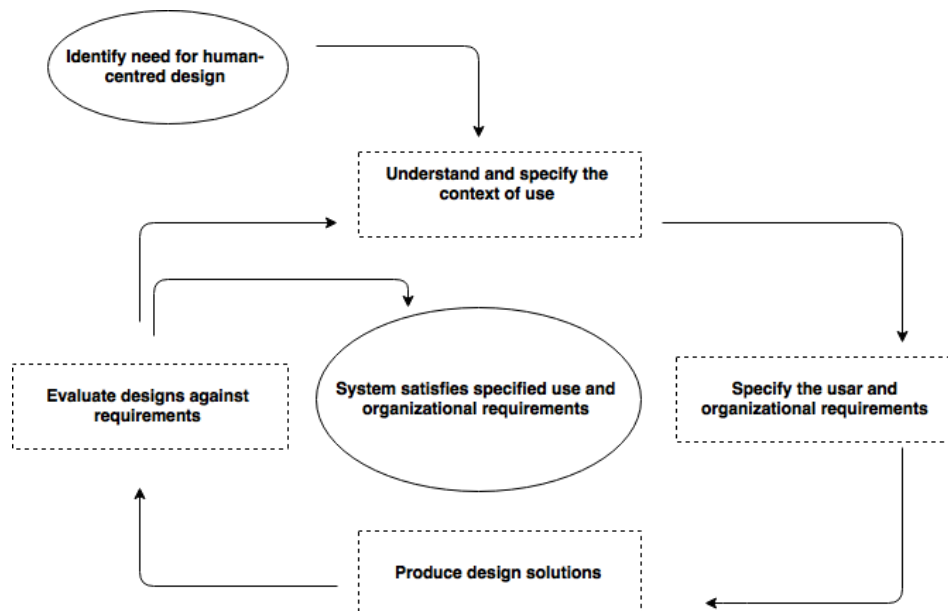
- The design is based upon an explicit understanding of users, tasks and environments.
- Users are involved throughout design and development.
- The design is driven and refined by user-centred evaluation.
- The process is iterative.



- The design addresses the whole user experience.
- The design team includes multidisciplinary skills and perspectives.

The standard also propose four general phases for the UCD process:

- Specify the context of use: Identify the people who will use the product, what they will use it for, and under what conditions they will use it.
- Specify requirements: Identify any business requirements or user goals that must be met for the product to be successful.
- Create design solutions: This part of the process may be done in stages, building from a rough concept to a complete design.
- Evaluate designs: Evaluation - ideally through usability testing with actual users - is as integral as quality testing is to good software development. (Usability.gov, 2015)



*Figure 1: Phases for the UCD process*

There are several ways to classify the methods and activities of UCD, in order to assist in the selection of methods at each stage (Ferre, Bevan, & Escobar, 2010). The four steps shown in the Table 2.1 correspond to the standard ISO 13407, from this standard ISO has developed two models called ISO TR 18529: 2000 - Ergonomics - Ergonomics of human-system interaction - Human-centered lifecycle process descriptions and ISO 18152: 2003 - Ergonomics of human-system interaction - Specification for the process assessment of human-system issues. Also the ISO TR 16982: 2002 - Ergonomics of human-system interaction - Usability methods supporting human-centered design, which is being revised as ISO 9241-230 NP - Ergonomics of human-system interaction - Part 230: Human-centered design and evaluation methods, it provides information about HCD methods that can be used to the design and evaluation (Jordi Sánchez, 2011).

Table 2.1: Methods for human-centred design

Planning	Context of use	Requirements	Design	Evaluation
<ul style="list-style-type: none"> <li>• <b>Usability planning and scoping</b></li> <li>• <b>Usability cost-benefit analysis</b></li> </ul>	<ul style="list-style-type: none"> <li>• Identify stakeholders</li> <li>• Context of use analysis</li> <li>• Survey of existing users</li> <li>• Field study/user observation</li> <li>• Diary keeping</li> <li>• Task analysis</li> </ul>	<ul style="list-style-type: none"> <li>• Stakeholder analysis</li> <li>• User cost-benefit analysis</li> <li>• User requirements interview</li> <li>• Focus groups</li> <li>• Scenarios of use</li> <li>• Persona</li> <li>• Existing system/competitor analysis</li> <li>• Task/function mapping</li> <li>• Allocation of function</li> <li>• User, usability and organizational requirements</li> </ul>	<ul style="list-style-type: none"> <li>• Brainstorming</li> <li>• Parallel design</li> <li>• <b>Design guidelines and standards</b></li> <li>• Storyboarding</li> <li>• Affinity diagram</li> <li>• Card sorting</li> <li>• Paper prototyping</li> <li>• Software prototyping</li> <li>• Wizard of Oz prototyping</li> <li>• Organizational prototyping</li> </ul>	<ul style="list-style-type: none"> <li>• Participatory evaluation</li> <li>• Assisted evaluation</li> <li>• <b>Heuristic or expert</b> evaluation</li> <li>• Controlled user testing</li> <li>• Satisfaction questionnaires</li> <li>• Assessing cognitive workload</li> <li>• Critical incidents</li> <li>• Post-experience interviews</li> </ul>

Table 2.1 shows a compilation of list of methods based on HUSAT Research Institute and the EC UsabilityNet project (Maguire, 2001). Places the Design Guidelines and Heuristic Evaluation like the methods used within the design and evaluation stage. Even the tasks of criteria to select the methods into UCD of Nigel Bevan that use the standard ISO TR 16982, includes the heuristic evaluation as part of the stage of "Understanding needs". (Bevan, 2009)

## 2.2 Usability guidelines

Usability guidelines are a useful tool for the developers to improve the interaction with systems. It includes knowledge of different disciplines related to usability and provides to developers with solutions and best practices in order to achieve the usability objectives (Påhlstorp & Gwardak, 2007). The guidelines include information from the high-level approach applied to a variety of topics until the smallest granularity, or low level, applied to specific cases (Mariage, Vanderdonckt, & Pribeanu, 2005). The usability guidelines contained in a style guide can be principles, Recommendations rules or Figure 2 shows the order and types of guidelines. (Akoumianakis & Stephanidis, 1999)

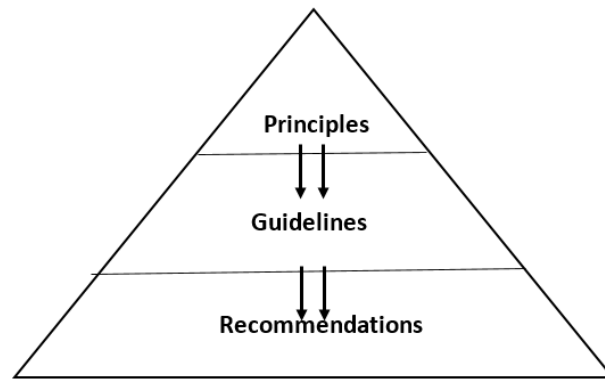


Figure 2: Types of guidelines.

Guidelines for user interfaces can be divided according to their purpose, the following division is taken from the Book User-Centred Engineering (Richter & Flückiger, 2014), and shows the different types of guidelines according to the purpose of use:

*Legal stipulations:* Regulations, principally aimed at ensuring the safety of workers when dealing with technical devices (especially devices with monitors)

*Standards:* National and international standards which aim to standardise the use of technology and make using technology simpler for users by setting out design rules.

*Collections of rules:* Collections of rules for optimising development of user interfaces. They are usually freely available. These include general usability principles.

*User interface patterns:* An attempt to describe recurring or similar design problems and to offer proven approaches to their resolution by using patterns.

*Vendor or platform style guides:* These describe the prescribed look and feel of an application for a specific operating system.

*Corporate style guides:* Rules pertaining to look and feel and corporate design with which a company's various applications are expected to comply.

*Project style guides:* Guidelines for ensuring the consistency of the user interface during development of an application (e.g. when using several UI designers) or consumer product.

This document is focused on the analysis of the Guidelines provided by Google and Apple, Android User Guidelines (Google Inc. and the Open Handset Alliance, 2015), iOS Human Interface Guidelines (Apple, 2015), and the principles contained therein. Each guideline will be analysed in the sections 4.3.2 and 4.3.3. They will also be discussed the general principles of usability provided by Nielsen for heuristic evaluations in section 4.3.4.

## 2.3 Heuristic Evaluation

Heuristic evaluation is considered as a method of inspection of analytical evaluation, another approach involves theoretically based models (Preece, Sharp, & Rogers, 2015). It is the best-known usability inspection techniques and was developed by Jakob Nielsen of Bell Labs and after SunSoft (Constantine & Lockwood, 1999). Nielsen determined heuristic evaluation as a systematic inspection of the user interface by the observation of an interface and in finding good and bad things, usually performed by evaluators who can use certain documented rules (guidelines). (Nielsen, 1994)

According to subsequent investigations of Nielsen, it established that the recommended number of evaluators to perform a heuristic evaluation is between three and five, any additional evaluator could be used in alternative methods of ensuring the effectiveness of the inspection. They found that there was a rapid increase in discovering problems on in the range of 1 to 5 evaluators, and for the interval between 5 and 10, it decreased drastically. (Molich & Nielsen, 1990)

The 80% of significant usability issues were found by four or five evaluators in an experiment conducted in 1990 by Virzi but, in 1994, Lewis using a data collected from a different study, he determined that there is no relationship between the frequency and severity of problems and he recommended handle the severity and frequency like an independent way.

From the point of view of business and marketing it is a good strategy to invest in evaluations during the development process, from the point of view of quality it is more expensive to fix bugs after the product development stage. Conducting a heuristic evaluation, the designers to have an early feedback about their designs, this is an advantage because they would have the ability to apply any change or improvement over the product early. (Virzi, Resnick, & Ottens, 1992)

### 2.3.1 Usability heuristics for User Interface Design

Nielsen proposed a set of 10 general principles for interaction design, the original set of heuristics was introduced together with his colleagues and was described empirically from an analysis of 149 usability issues, they called it "heuristics" because they are broad rules of thumb and not specific usability guidelines. (Nielsen Norman Group, 2015)

#### **Visibility of system status**

The system should always keep users informed about what is going on, through appropriate feedback within reasonable time.

#### **Match between system and the real world**

The system should speak the users' language, with words, phrases and concepts familiar to the user, rather than system-oriented terms. Follow real-world conventions, making information appear in a natural and logical order.

### **User control and freedom**

Users often choose system functions by mistake and will need a clearly marked "emergency exit" to leave the unwanted state without having to go through an extended dialogue. Support undo and redo.

### **Consistency and standards**

Users should not have to wonder whether different words, situations, or actions mean the same thing. Follow platform conventions.

### **Error prevention**

Even better than good error messages is a careful design which prevents a problem from occurring in the first place. Either eliminate error-prone conditions or check for them and present users with a confirmation option before they commit to the action.

### **Recognition rather than recall**

Minimize the user's memory load by making objects, actions, and options visible. The user should not have to remember information from one part of the dialogue to another. Instructions for use of the system should be visible or easily retrievable whenever appropriate.

### **Flexibility and efficiency of use**

Accelerators -- unseen by the novice user -- may often speed up the interaction for the expert user such that the system can cater to both inexperienced and experienced users. Allow users to tailor frequent actions.

### **Aesthetic and minimalist design**

Dialogues should not contain information which is irrelevant or rarely needed. Every extra unit of information in a dialogue competes with the relevant units of information and diminishes their relative visibility.

### **Help users recognize, diagnose, and recover from errors**

Error messages should be expressed in plain language (no codes), precisely indicate the problem, and constructively suggest a solution.

### **Help and documentation**

Even though it is better if the system can be used without documentation, it may be necessary to provide help and documentation. Any such information should be easy to search, focused on the user's task, list concrete steps to be carried out, and not be too large.

## **2.4 Bibliographic research on Conceptual Frameworks for Designing Methods and Heuristics**

This section provides a review of the Frameworks selected from literature through a research and selection process based on our discretion. The set of publications bet on the heuristic evaluation as a method of inspection of easy use and low cost, but looking to improve their effectiveness on specific domains in which traditional heuristics may not be enough.

### **2.4.1 How Applicable is Your Evaluation Methods - Really?**

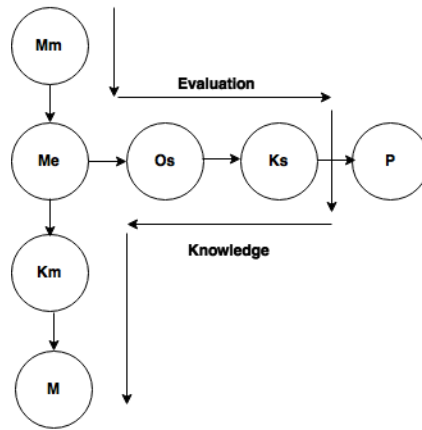
#### **2.4.1.1 Summary**

The domain explored in this paper is the evaluation of methods for evaluating fun and entertainment, though the approach can be generalized for different domains. (Wiberg, Jegers, & Desurvire, 2009) The authors conducted this research about heuristic evaluations applied to emerging domains motivated by the lack of literature about the subject and knowing that in publication since 1990 published methods only includes description and usage of heuristic with a little guidance about how it were developed. For this reason, the authors propose a process or method to develop "methods".

There were intentions to bring Nielsen's heuristics to the field of entertainment such as heuristics applied for videogame development, however some problems arose eventually each new set of heuristics had to be validated and modified for each individual videogame, even due to physical differences in the hardware, was necessary to create sub-versions of heuristics for the same videogame. This paper proposes a conceptual framework for developing heuristics as a tool for experts evaluation of product that generate a set of heuristic focused on specific domains. The study cases presented in the paper covers products within the domain of entertainment it: video games and entertainment pervasive web sites.

Early research were conducted about methodology development for the HCI, despite the knowledge to analyse, evaluate and design methods developed earlier years, the research were only focused to the methods results, few efforts were made about the procedure itself. The process of methods evaluation is briefly mentioned in publications, this has motivated the authors to present a standard procedure for the analysis and design of usability evaluation methods.

The conceptual model for developing or designing evaluation methods and heuristic lists, is presented as a diagram with two types of outputs, P and M.



*Figure 3 Two types of evaluation processes showing the evaluation*

- [P] The final product to which the assessment was applied and already contains the improvements obtained as results of evaluations.
- [M] The method that was used to evaluate [P], but containing improvements as a result of Meta-evaluation.

In order to achieve these two outputs it is necessary to evaluate an object [Os] using evaluation method [Me], a knowledge is obtained like a result of this evaluation [Ks], while a method of evaluation [Mm] will be applied to a target evaluation method [Me] and provide knowledge [Km] which is used as input for the designing of a new and more appropriate method [M], finally [Ks] is used as input for the final product [P].

The first study in which the methodology was applied to define and evaluate "Methods of Evaluation" was conducted in the project called SupaFly, which is a special kind of game that makes use of multiple technologies (such as both mobile and stationary computing technology, cell phones, RFID technology, Embedded and Augmented reality systems, the Web, etc.). The overall aim was: to conduct methodological research considering evaluation methods for user experiences in pervasive gaming settings, to improve the quality of the SupaFly game prototype and to improve the general understanding of user experience in pervasive gaming usage settings/situations.

Laboratory studies had a technical challenge to handle a large number of user interactions including the daily life interactions of the player, so a possible solution would be the use of ethnographic methods, capturing user interaction from the context of everyday life, nevertheless due to the logistics, lack of resources and another management problems it was impossible to perform, finally the solution consisted of the joining of three methods to capture the gameplay and user experience: Qualitative questionnaires, System logs of user activities and focus group interviews.

Due to commercial reasons, the delivery date of the prototype was brought forward, the processes to improve the interaction were reduced and this generated a significant negative impact on the expected results, but this change of

approach proposed a modification in the methodology, in which, the constraints such as budget, resources and time were included.

In the second study the methodology was applied to the domain of entertainment services, specifically the EWSs sites (Entertainment web sites), that provide some kind of entertainment. Within the study a heterogeneous group of seven EWSs were included, the overall impact was the change of process approach, which moved from a linear structure to another in which at each stage considered the usability. As a result were defined a list of 10 heuristics, with a rating system used into the experts evaluation stage in order to exclude less-ranked heuristic in each iteration of the list. Finally the authors conclude that the implementation of the methodology in the cases presented had two purposes: 1) to give particular designers feedback on design solutions 2) become input in the process of redefining or redesigning methods.

#### 2.4.1.2 Valuable Information

This paper presents a conceptual framework to design methods and heuristic, the framework has two important elements: the model to be applied and the object to be evaluated, both are evaluated and refined in order to obtain two finished products, this idea expressed by the authors can lay the foundations to design and test methods, especially if you want to establish methodologies for evaluation, re designing or creating of an entirely new evaluation framework for new technologies or unexplored domain.

In this study, the methodology is applied to obtain a list of heuristics that will be used to the evaluation of websites, although the websites belonged to the same domain, evaluators added a ranking system and they argued that for special cases, some heuristics might not be used because it is not compatible or is not covered within the domain. The important value of this work is the ranking system provided by the evaluators.

### 2.4.2 A Methodology to Establish Usability Heuristics

#### 2.4.2.1 Summary

This paper propose a new methodology to define usability heuristics focused to specific domains, and it present a case study about the emerging information technology: Grid Computing, Interactive Television, Virtual Worlds (Rusu, Roncagliolo, Rusu, & Collazos, 2011b). Within the benefits to be gained by having customized the heuristics, the authors argue that, the Nielsen's heuristics do not cover broadly the current universe of technologies especially the growing field of mobile application.



The motivation of the authors was similar to that presented in the analysis of the paper of the previous section (How Applicable is Your Evaluation Methods – Really?) but it was focused directly on the method of usability inspections. The lack of information in the literature regarding the development of new methods of inspection as well as about usability heuristics and the growing interest about usability of applications belonging to emerging technologies were the motivations to propose a methodology.

The methodology for establishing new usability heuristics for specific applications has six steps:

Step 1: Exploration Stage, to conduct research on the device characteristics and related work.

Step 2: A descriptive stage, to highlight the most important characteristics of the previously collected information, in order to formalize the main concepts associated with the research.

Step 3: Pre-heuristic approach based on traditional heuristics.

Step 4: Formal definition for heuristics for touchscreen-based Mobile

Step 5: Validation Stage.

Paso 6: A refinement stage, based on the feedback from the validation stage.

In order to validate the methodology, were conducted a set of experiments in order to apply the new heuristics to each one of the three above-mentioned domains; the authors finally concluded that the methodology allow the development of usability heuristics and an associated usability checklist.

In later publications, the authors achieved to perform the implementation and validation of the heuristics proposed. Finally they reached a conclusion: If the heuristics are very specific, probably becoming hard work to understand and apply, must be found the right balance between generality and specificity; General heuristics may be supplemented by specific checklist.

#### 2.4.2.2 Valuable Information

This paper provides a well-defined framework and it is a starting point for future research which are focused on identifying a specific sets of heuristics. The framework proposed a set of six steps ranging starting from the research or exploratory stage and ending with the validation and refinement of the final product.

The objective of this study is to define a list of heuristics using the framework and use this heuristic in order to conduct an expert evaluation, furthermore to present the result for applying the methodology on two real-life examples: the usability heuristics for Grid Computing Applications and Interactive Television. The stage of validation of the method is widely detailed in the paper presented by the same

authors and some are analysed in this work. The ease and simplicity to apply the methodology have been key to be used for various research work that are seeking to define heuristics for particular domains, and even different authors have proposed new methodologies based on this research.

### 2.4.3 Evaluating a Methodology to Establish Usability Heuristics

#### 2.4.3.1 Summary

This work belongs to the stage of validation of previously revised methodology (A Methodology to Establish Usability Heuristics) (Rusu et al., 2011b). The authors after of applying the methodology to to different projects in order to obtain and validate a list of heuristics, they decided to validate the methodology using a meta-evaluation, which aimed to determine the ease of apply the technique and go identify aspects which could be improved. (Jiménez, Rusu, Roncagliolo, Inostroza, & Rusu, 2012)

This paper includes the results of four experiments and involved five researchers to perform it, who through the methodology generated some heuristics for the following areas: Grid Computing, Interactive Television, Virtual Worlds and Touchscreen Mobile Device. Each validation has an individual publication that shows the process in detail in order to analyse the usability and usefulness of the methodology, the five evaluators once completed evaluation task, their participated in the method evaluation sharing their impressions through a survey. This survey was focused on capturing the individual experiences of each participant while they applied the methodology, and some information about the experience of evaluation of each individual area into the process.

Finally the authors concluded that it was possible to validate the pertinence for formalizing and applying a methodology. In order to perform the experiment of validation, a group of 5 researchers who had previously used the methodology participated in a survey and shared their impressions, the results showed that the methodology is neutrally easy to apply, and maybe there was lack of specificity in some stages of the methodology, which could be noticeable if you want to reach a low granularity.

#### 2.4.3.2 Valuable Information

This paper presents the validation through a meta-evaluation of a methodology used to generate heuristics. The framework of evaluation allow to the future research to verify the process of generation of heuristics. For purposes of our research we have focused on validation of Touchscreen Mobile Devices. Researchers agreed that the phase of experimental validation was the most once of the most difficult to perform “The coordination of the evaluators and the interpretation of new heuristics is a complicated task”. In this process was

generated a set of 11 heuristics that can be used as a starting point for defining the heuristics of mobile applications. And using this heuristics, the evaluation have identified more usability problems that using the traditional heuristics. Furthermore, the researcher highlighted that the problems identified through the new set of heuristics were related with this particular domain.

Although the results of the methodology showed that new heuristics were more efficient than Nielsen's, finally the evaluators' comments and results of individual stages provided valuable information to improve the methodology.

## **2.4.4 Usability Heuristics for Touchscreen-based Mobile Devices**

### **2.4.4.1 Summary**

This paper presents in detail the implementation of the previously revised methodology on a project of touchscreen-based mobile devices. The purpose is to define a set of usability heuristics for evaluating devices with touch screens. The method is based on the methodology that the authors themselves raised, finally the results will be the evaluations and their validations. (Inostroza et al., 2012)

As part of the literature review proposal according to the methodology, the authors conducted a review of the main features of mobile devices based on touch screens, also about of the features of the mobiles such as the taxonomy, the physical interface and its main challenges for usability. The stage of validation presented in this document corresponds to the validation of the results regarding the effectiveness of the heuristics applied, the validation regarding the effectiveness of the methodology itself was reviewed in the previous section.

The steps followed according to the methodology are: An exploration Stage, a descriptive stage, pre-heuristic approach based on traditional heuristics, formal definition of heuristics, validation, a refinement stage. The object to be analysed is the mobile device itself. The researchers performed a description of its concept and features based on the literature, and they defines the mobile device like a small gadget with basic processing capabilities, permanent or itinerant network connection and a limited memory capacity.

Despite the fact that the context of mobile device usage it initially consisted of fewer features, with time were increasing, this features can be summarized over three key aspect that affect the design of user interface:

- These are devices generally used with the hands
- They use wireless connection
- They support adding new applications, and connection to internet

If we look for not so general features of the devices:

- They have a small screen which should present a lot of information

- They can contain buttons that generally have more than one function
- They are limited in processing power and storage

Within the literature reviewed, there is the classification for mobile devices carried out by Schiefer and Decker, it is regarding to the size, weight, modes of input and output data, implementation, kind of use, the ability to communicate, operating system type. This classification can be summarized in the following groups: (1) mobile standard PC, (2) mobile internet devices, (3) handhelds or PDAs, (4) smartphones, (5) feature phones, (6) simple phones and (7) special terminals.

Terminals based on touch screens according to the previous classification, it fall into the categories (1) (2) (3) (4), and have been identified the key features for analysing usability of these devices: Mobile context of use, Small screen size, Screen resolution, Limited processing, memory and energy capabilities, Data entry methods.

Three iterations were carried out the experiment, each provides information to the next, in this way is refining process. During the first iteration steps 1, 2, 3 consisted of a literature review and classification of the device, in step 3 was used as the basis of the heuristics defined by Nielsen in order to define their own new heuristics, making a match with the characteristics device and general heuristics Nielsen. Finally a set of "11 heuristics" was obtained. During the second iteration heuristics previously obtained were refined and the steps 5, 6, 4 in this order were executed. The third iteration were followed by the steps 5 and 6 with the difference that two of the most experienced evaluators used the heuristics of Nielsen and the two less experienced newly defined heuristics, the data obtained in step 5 were analysed in step six for create a list of observations and possible improvements, so a mapping of both heuristics.

Among the results of the research, was presented a comparative table of the heuristics obtained by applying the method compared with heuristics Nielsen, Table 2.2 shows a mapping between Touchscreen-based mobile device heuristics and Nielsen.

Table 2.2 Touchscreen-based mobile device heuristics

Touchscreen-based mobile device heuristics		Nielsen's heuristics	
Id	Name	Id	Name
<b>TMD1</b>	Visibility of system status	<b>H1</b>	Visibility of system status
<b>TMD2</b>	Match between system and the real world	<b>H2</b>	Match between system and the real world
<b>TMD3</b>	User control and freedom	<b>H3</b>	User control and freedom
<b>TMD4</b>	Consistency and standards	<b>H4</b>	Consistency and standards
<b>TMD5</b>	Error prevention	<b>H5</b>	Error prevention
<b>TMD6</b>	Minimize the user's memory load	<b>H6</b>	Minimize the user's memory load
<b>TMD7</b>	Customization and shortcuts	<b>H7</b>	Flexibility and efficiency of use
<b>TMD8</b>	Aesthetic and minimalist design	<b>H8</b>	Aesthetic and minimalist design
<b>TMD9</b>	Help users recognize, diagnose, and recover from error	<b>H9</b>	Help users recognize, diagnose, and recover from error
<b>TMD10</b>	Help and documentation	<b>H10</b>	Help and documentation
<b>TMD11</b>	Physical interaction and ergonomics		

Although both lists look similar by their names, the definitions and the way to apply are substantially different, an example is the case of TMD5 y H5 "error prevention"

#### TMD5 - Error prevention

*"The device should have a careful graphic user interface and physical user interface design, in order to prevent errors. The non-available functionalities should be hidden or disabled and the user should be able to get additional information about all available functionality. Users should be warned when errors are likely to occur."*

#### H5 - Error prevention

*"Even better than good error messages is a careful design which prevents a problem from occurring in the first place. Either eliminate error-prone conditions or check for them and present users with a confirmation option before they commit to the action."*

Finally the validation stage presents evidence on the effectiveness on applying heuristics focalized to the context of use. The inspections were conducted by two separate groups of evaluators, some using heuristics for touch mobile devices and other those of Nielsen, a total of 53 usability problems were found by the evaluators, but more problems captured by the group using heuristics for touch devices, including an analysis of severity, problems with a slight rise in severity were detected by the group of heuristics based on touch devices.

Among the conclusions presented by the authors emphasize that there should be a proper balance between specificity and generality, if you have very specific heuristics probably will be very hard and difficult to implement and understand.

#### *2.4.4.1.1 Valuable Information*

The valuable information is the detailed application of the methodology on a similar context of the mobile applications. Within of the steps some key points were obtained such as the classification of devices and the extraction of the main characteristics thereof, the templates used to collect information could be used as basis for future applications of the methodology. The iterations show us the evolutionary cycle that list heuristics suffered during the entire process and especially the results of the validation shows the importance of specific heuristics.

Not only have the details of the implementation of the methodology is also important to know that the authors themselves in the conclusions argue about the granularity of the wanted heuristics, and its balance between ease / specificity, is something that would be taken as an next research topic.

### **2.4.5 Heuristic Evaluation on Mobile Interfaces: A New Checklist**

#### *2.4.5.1.1 Summary*

This paper presents a compilation of heuristic evaluation checklists adopted from literature and adapted to the context of mobile device interfaces. The methodology used is a variation of the methodologies for developing heuristics taken from the literature, the aim of the authors is to provide a tool that not only works for expert assessments, also as a checklist of best practices. (Yáñez Gómez, Cascado Caballero, & Sevillano, 2014)

The methodology used to obtain the guidance of heuristics for mobile environment, is based on the methodology presented by Rusu in his work "A Methodology to Establish Usability Heuristics" (Rusu et al., 2011a) although it differ in a small details, the process to establish the new set of usability heuristics is the same.

The six steps outlined in the methodology are:

- A clear definition of the problem scope.
- Rearrange existing and well-known heuristics into a new compilation.
- Develop a compilation of different proposed subheuristics. ("Heuristic" in this paper refers to a global usability issue that must be evaluated or taken into account when designing. In contrast, the term "subheuristic" refers to specific guidelines items.)
- Enriching the list with mobile-specific subheuristic.

- To homogenize the redaction and format of subheuristics in order to make it useful for non-experts.
- Evaluation.

Step1) Problem Scope Definition: From literature is extracted a division of mobile devices which it grouped into three broad categories:: feature phones, Smartphones, touch phone/touch tablets, a division that reminds us the generations of mobile, the current generation is for touch devices. Each generation has strong differences in their interaction and interface due to physical constraints. Such restrictions also were reviewed and analysed by the authors, and they proposed a classification that used as axis the improvement of usability, according to the literature, the main constraints when designing for mobile devices are:

- Limited input/output facilities
- Mobility and varying context
- Type of Task
- Multi Devices access
- Limited processing capability and power
- Adoption

Step 2) Rearrangement of Traditional Heuristic: The first step was to collect heuristics known from literature, an important source for this collection was the research work of Torrente (Torrente, Prieto, Gutiérrez, & de Sagastegui, M Elena Alva, 2013), in which the author selected the most influential heuristic guides, a compilation of 9 guides heuristics that make up 83 globally heuristics and 361 individual sub heuristics, in this research the authors only took the heuristics, the sub-heuristics to be more specific should be related to mobile devices. Finally a set of 13 main heuristics regrouped.

Step 3) Compilation of Sub heuristics from Traditional General Heuristic Checklists: Of the 361 sub-heuristics posed by Torrent, were excluded those that did not fit the context of usability on mobile devices, such heuristics applied for desktop applications, etc. During this step were obtained 158 sub-heuristics, some were regrouped and reclassified into a hierarchy of sub-heuristics, the first proposal can be seen in the original document.

Step 4) Compilation of Mobile-Specific Sub heuristics: Because the extraction of sub-heuristics literature not correspond to a specific context of mobile device during this step was enriched the list with mobile-specific sub-heuristics taken from mobile usability studies and best practices that actually do not provide HE. As a final result 72 new sub-heuristics were added and the final compilation like the graph below.

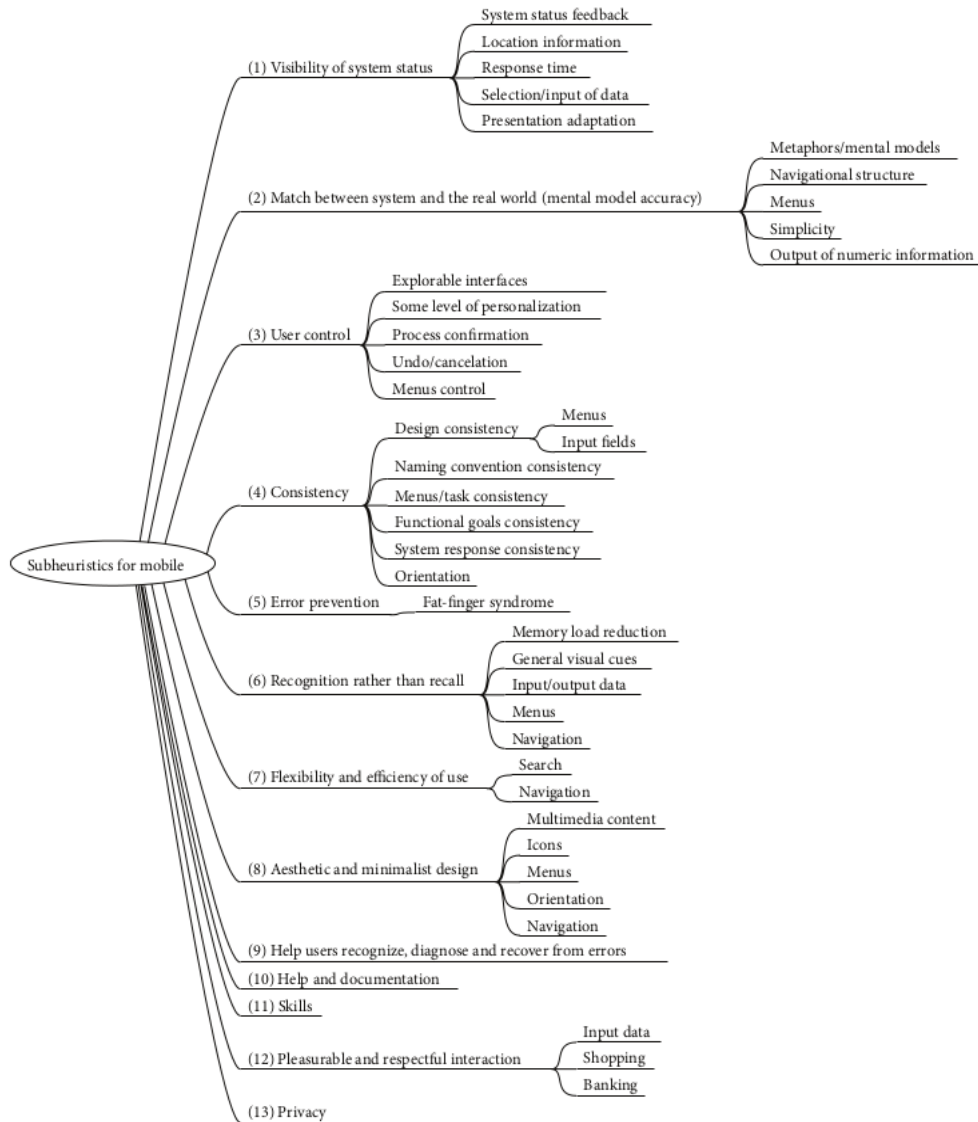


Figure 4: Final framework for classification of detected sub-heuristics.

Step 5) A total of 13 heuristics and 230 sub-heuristics was obtained as a result of the heuristics homogenize, in the final compilation the intermediate classifications were omitted, also semantically related item were together reaching a common presentation of heuristic guides in the literature.

The final set, the sub heuristic list is formed by 69% of items extracted from literature and the 13 main heuristics have a remarkable influence of the proposals by Nielsen with an order and different approach, emphasize concepts such as skills adaptation and pleasurable and respectful interaction with the user and privacy, elevating them to the category of heuristic item.

The validation of the heuristics obtained was not performed thoroughly during the experiment, but preliminary tests were performed and the results show that the Proposed HE guideline is a helpful tool for engineers, designers and technicians with little specific knowledge of usability, such conclusion is based on a hypothesis



presented by the authors in which the "sub heuristics" actually are more a specific and detailed heuristics, proved to be easy to use for non-experts evaluators.

#### 2.4.5.2 Valuable Information

The valuable information provided by the study is a depth research and review of the literature in order to develop the first four steps of the methodology, although the methodology presented is valuable, does not vary much from that presented by other authors analysed above, is important to emphasize the amount of re-used heuristics correspond to 69% of the sub proposals heuristics, and the rest are taken from best practices and recommendations for mobile interfaces. Although the authors did not validate this in the research, provided the idea that the more granular heuristics are obtained, will help inexperienced evaluators but also would provide a guide or tool for designing more usable interfaces in pre-evaluating stage, in this case they would be referring to the design guidelines as a proactive tool.

Best practices, principles and design guidelines are currently presented by companies such Apple and Google that they have a high market share as platforms for mobile devices. In the case of iOS guides are conceivable as minimum requirements to fulfil by an application for that it can be accepted in the markets, the review of these requirements may be considered in the design and evaluation stages. The question remains open, Are Nielsen heuristics aligned with current guidelines for mobile? Or are only the starting point?

#### 2.4.6 Conclusions of the bibliographic research

- Heuristic evaluation is one of the inspection methods most used as it has several advantages over other techniques, such as: its implementation is easy, fast and cheap, it is suitable for every software life-cycle. (Yáñez Gómez et al., 2014) 10 Nielsen heuristics are widely known and widely used within heuristic evaluations. (Rusu et al., 2011a)
- There is the need to upgrade the usability evaluation methods for emerging technologies, such as mobile applications (Rusu et al., 2011a) , the traditional methods do not regard particularities on emerging technologies, such as unique features in smart phones or mobile applications. Therefore it is important to create a more accurate assessment methods and adapt them to the new context. (Inostroza et al., 2012)
- There are approaches or conceptual frameworks that aim to propose the necessary steps to develop new methods of evaluation or heuristics. (Wiberg et al., 2009). The methodologies were applied to different types of projects and were validated against Nielsen heuristics.

- The experiments conducted showed that for new specific heuristics are more effective than the heuristics of Nielsen finding problems. (Jiménez et al., 2012) The potential offered by the methodologies to develop methods is valuable in the case of future research on evaluation methods for specific domains. (Wiberg et al., 2009)
- One of the features of heuristic customization is the ability to determine the granularity, if heuristics are more specific with high granularity (greater number and analysis depth) it is beneficial for novice evaluators, but directly affecting the execution time, becoming the evaluation like a tedious and impractical method.
- To define new heuristics, the work analysed took as the basis Nielsen heuristics and proceeded to enrich them with different sources of heuristics, research, principles, best practices and all information related to the domain. Upon completion and to validate heuristics the researcher conducted an experiment in which it is measured the effectiveness of new heuristics versus Nielsen at the time of collecting usability problems.
- In some experiments it was necessary to include a ranking method in order to establish weight to the issues in terms of the criticality, this helps to the validation stage of methodology identifying heuristics which help to find critical problems, and also it helps for prioritizing problem resolution.
- It is remarkable to mention that none of the research papers trying to define heuristics totally based on the principles of the platform guidelines, nor attempt to analyse how these principles are related to traditional Nielsen's.

### 3 Study of Current Status of UX Practices for Mobile Applications

In order to understand the practices in UX and usability normally used by industry; An online survey was conducted and distributed through mailing lists of groups linked to HCI and UX mobile applications. The results of this survey can be checked with the amplitude in the annex 9.1. This section contains the methodology and the analysis of results.

#### 3.1 Methodology

We conduct an online survey in order to get an overview of the current state of the UX and Usability within processes of development of mobile applications in the industry. We follow the next steps in the process of creating the survey to data analysis:

1. Definition of the survey questions.
2. Creation of the online form using as survey management system the LimeSurvey platform.
3. Select a group of evaluators to pilot test the survey.
4. Modification of survey questions according to the recommendations obtained.
5. Search research groups on HCI and UX to promote the link to the survey, and invite them to participate in the study.
6. Publication the link to the survey in a public link.
7. Publication of the survey link on Mail groups, forums and contacted companies.
8. Collection and analysis of data.

During the evaluation stage of the survey, comments of four evaluators were received, a total of 13 suggestions were collected and applied in the final survey. The final survey received 53 unique responses. The answers will be discussed in the next section.

## 3.2 Data Analysis

The following section presents the analysis of data obtained through the survey. The Annex 9.1 contains all survey questions and results.

### 3.2.1 About the companies

Responses were received from 53 different companies spread across 25 countries, among which are classified as private, universities and other Freelance, the largest number of participants were private companies (36). To determine the types of mobile applications that are developed a list was included in the questionnaire with different categories, using the same classification found in stores application, the most selected categories are:

- Business (29)
- Entertainment (15)
- Finance (15)
- Education (13 )
- Productivity (13)
- Utilities (10)

This is consistent with the latest market report on the application that puts the Business category as the new gold mine for apps.

### 3.2.2 About the processes and activities of usability

About development methodologies that apply the great majority (38), we find agile methodologies as the preferred, a few respondents mentioned Waterfall, and finally we found some respondents mentioned mixed methodologies. Figure 5

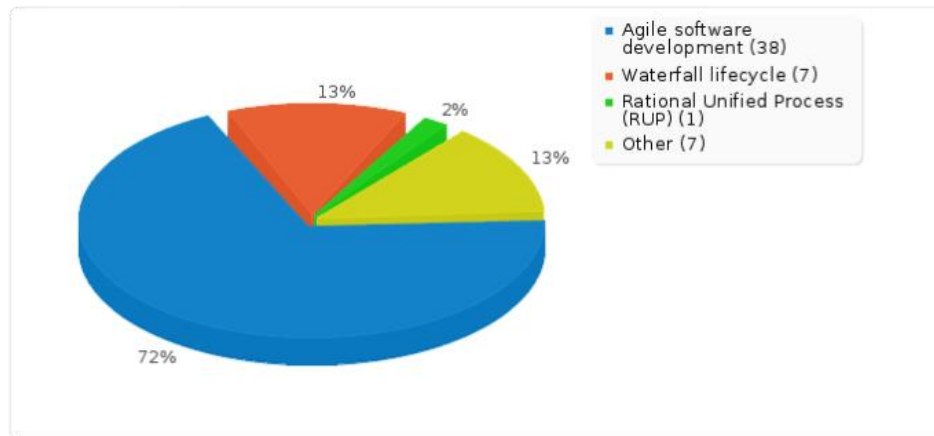


Figure 5 Please state the software development methodology or approach you follow in your organization

In the questions asking about how often they applied usability activities within the stages of requirements, design, testing and deployment most respondents reported that Sometimes and Very Often are applied usability activities. Table 3.1

Also we been asked about usability methods carried within the company at every stage of development, such as: Product Concept Design, User and Task Analysis, Usability Requirements Specification, Prototype Usability Testing, Usability Testing with User, and finally Usability inspection by experts. Being the latter relevant to our study.

Table 3.1 How often the following usability activities are carried out in your organization? - [Usability inspection (by experts)]

Answer	Count	Percentage
Never	18	33.96%
Sometimes	16	30.19%
Very Often	10	18.87%
Always	9	16.98%
No answer	0	0.00%

The result indicates that although mostly expert inspections are performed, they are not always applied to all projects. The next step is to know the type of methods used by activity:

Table 3.2 Please mark the methods used at least once in your organization in design-related activities

Answer	Count	Percentage
User Interface Guidelines or Standards	38	71.70%
Product style guide	25	47.17%
Card Sorting	22	41.51%
Navigation Map	22	41.51%
GUI State Transition Diagram	12	22.64%
Other (Content Strategy and HFP mockups None)	3	5.66%

Table 3.3 Please mark the User Interface Guidelines used at least once in your organization

Answer	Count	Percentage
Android UI Guidelines	30	78.95%
Web Standards	27	71.05%
iOS UI Guidelines	25	65.79%
Windows Mobile UI Guidelines	12	31.58%
Other ( Google Material Design Libr Blanco Siesta, sello SIMPLIT Internal standards)	3	7.89%

In the design stage we noticed a tendency to use style guides for each platform, these style guides can also help to develop sub-heuristics that will be used in the evaluation stage of the product. In the case of inspections, asked about the most popular methods of assessment, obtaining the following results:

Table 3.4 Please mark the usability methods used at least once in your organization in evaluation-related activities

Answer	Count	Percentage
Analysis of user feedback	29	58.00%
Interviews to users	26	52.00%
Heuristic Evaluation	24	48.00%
UX (User eXperience) Questionnaire	24	48.00%
Satisfaction Questionnaire	22	44.00%
Thinking Aloud	19	38.00%
Analysis of use logs (Google Analytics or similar)	18	36.00%
Performance Measurement (measuring user efficiency)	16	32.00%
Laboratory Usability Testing	13	26.00%
Remote Evaluation	12	24.00%
Conformance Inspections	7	14.00%
Wizard of Oz	2	4.00%
Other (none,usability survey)	2	4.00%

Table 3.5 Who was in charge of applying usability methods?

Answer	Count	Percentage
Development team staff self-taught in usability	19	39.58%
Usability experts	14	29.17%
Other (UX Designers,developer,no one - ad hoc,UX designer,Only sometimes,someone with empiric knowledge)	8	16.67%
Development team staff with a usability training	7	14.58%

### 3.3 Conclusions

From information gathered from the survey, the following conclusions were obtained:

- Private companies were in greater numbers participating in the survey
- The three most popular categories of mobile applications within the groups surveyed were: Business, Entertainment and Finance.
- Agile methodology, or any adaptation of agile during the development process is the most used by majority of the groups surveyed, the second position is the traditional waterfall.
- The level of usability managed at different stages as requirements, design, evaluation, development, was rated Very Often and Sometimes by most those surveyed.
- The frequency of use of usability activities as Product Concept Design, User and Task Analysis, Usability Requirements Specification, Prototype Usability Testing, Usability Testing with User, Usability inspection by experts were qualified as Sometimes and Very Often and on rare cases Never.
- Storyboards, Scenarios and Persona are the methods that have been used to stage requirements.
- Guidelines or Standards, Product style guide and card sorting are the most commonly methods used for design phase.

- Android UI Guidelines, Web Standards and iOS UI Guidelines are used by organizations.
- The most widely used methods of evaluation are: Analysis of user feedback, Interviews to users, Heuristic Evaluation, UX questionnaires.
- Within the lists of heuristics used to conduct evaluations, Nielsen heuristics are the majority.
- The research groups indicated they used between 1-5 evaluators, having 1 - 4 years of experience.
- 19 groups responded to their development teams are responsible for applying usability methods, 14 responses indicated that they used usability experts.
- As benefits of heuristic evaluation, some responses suggested that the evaluation is low cost, easy to apply and improve product quality.
- Some believe that the heuristic should modified to be applied to mobile applications for differences in the paradigm of use.
- Among the changes and improvements of the heuristics are: clarify the tasks, approach and include context of use.



## 4 Redefining Usability Heuristics for Mobile Application

### 4.1 Introduction

In this study we propose a set of heuristics focused on mobile applications, which are based on a review of the principles and philosophies promoted by official design guidelines of Android and iOS. This heuristic for mobile application is not only an evaluation tool, is also a compilation of good practices and may be useful as a guide to designing applications. The section 4.2 provide the method used to define heuristics for mobile applications, section 4.3 provides the results of applying the methodology for determining heuristics, heuristic evaluations conducted, their results and post evaluations are found in the section of the study design.

### 4.2 Method

In order to get a set of heuristics for mobile applications we have established five steps, the process that we have used was inspired by the methodology proposed by Rusu (Rusu et al., 2011a) that were reviewed in the section on literature review.

*Scoping the problem:* Define clearly the scope of the problem, determine the object of study and characteristics in order to identify the sources of research in the next step.

*Identification of sources of information and data collection:* Collecting of the relevant and related to the investigation.

*Description of the most important of the collected information:* Condense the most important collected information, especially related to the heuristics as: Principles, Guidelines and Recommendations.

*Correlation of the information collected with traditional heuristics:* Heuristics, principles, guidelines and recommendations identified in the previous step will be associated with the traditional usability heuristics. (Nielsen)

*Homogenization and formal definition of the heuristic:* Formal definition of the set of heuristics according to the list obtained in the previous step, homogenize their writing and use a format in order to make them more useful for non-experts.

*Evaluation of heuristics:* Conduct a heuristic evaluation using the set of heuristics and verify their results, then conduct a post-evaluation survey to the participants. Finally submit for review the list of heuristics to experts and conduct a survey in order to get their overview.

## 4.3 Results

### 4.3.1 Scoping the problem

Heuristic evaluation as a method of inspection is known and widely used to be easy to perform, low resource costs and helps to find a lot usability issues. Despite its advantages, the original definition of the heuristics of Nielsen it was focused on desktop paradigm and not detected correctly usability issues for specific domains.

Later investigations such as those conducted by Rusu (Rusu et al., 2011a), showed the need to create a methodology for establishing heuristics for specific domains, they conducted a systematic review of traditional heuristics and bibliography related to the domain and they proposed methodologies and new heuristics. However, in the field of mobile applications developers have comprehensive information on the principles and recommendations which are offered by each mobile platforms, like a solution or a way to improve the quality of the applications in their stores. Conducting a study of the guidelines is possible to obtain an updated and focused on mobile applications list of principles and recommendations that allow refresh the traditional Nielsen heuristics.

### 4.3.2 Identification of sources of information and data collection

Part of the objectives of this research is to define a set of heuristics based on information provided by official design guidelines of the Android and iOS platforms respectively, we have selected Nielsen heuristics as basis and sources of information will be Android and iOS official guidelines.

#### 4.3.2.1 Android guidelines

*Android Design Guidelines:* They are shaped by goals for users that apply to apps as well as the system at large. As you work with Android, keep these goals in mind. (Google Inc. and the Open Handset Alliance, 2015)

*Material Design Guidelines:* They provides the goals and principles focused on Google's new philosophy called Material Design, this is a comprehensive guide for visual, motion, and interaction design across platforms and devices. (Google Inc. and the Open Handset Alliance, 2015)

#### 4.3.2.2 iOS guidelines

*iOS Human Interface Guidelines :* They describe the guidelines and principles that help your design to improve the user interface and UX for iOS app, do not describe how to implement your code. The access to the guidelines is free and it is available on their official website. This research was performed using the updated review of the Guideline to 04/08/2015.(Apple, 2015)

### 4.3.3 Description of the most important of the collected information (3)

#### 4.3.3.1 Android guidelines

Android guides are formed by three overarching goals that include general principles. These design principles were developed by and for the Android user experience team to keep users' best interests in mind. Full details of the principles can be found in Android Design Principles. The Table 4.1 shows a summary of the heuristics of Nielsen, Android Design Principle of User Experience and Design Principles for Android Developers and Designers.

*Table 4.1: Comparison between Nielsen Heuristics, Android Design Principle of User Experience and Design Principles for Android Developers and Designers.*

	<b>Nielsen</b>	<b>Android Design Principles UX</b>	<b>Android Design Principles</b>
1	Visibility of system status	Enchant Me	Delight me in surprising ways
2	Match between system and the real world	Simplify My Life	Real objects are more fun than buttons and menus
3	User control and freedom	Make Me Amazing	Let me make it mine
4	Consistency and standards		Get to know me
5	Error prevention		Keep it brief
6	Recognition rather than recall		Pictures are faster than words
7	Flexibility and efficiency of use		Decide for me but let me have the final say
8	Aesthetic and minimalist design		Only show what I need when I need it
9	Help users recognize, diagnose, and recover from errors		I should always know where I am
10	Help and documentation		Never lose my stuff
11			If it looks the same, it should act the same
12			Only interrupt me if it's important
13			Make Me Amazing
14			Give me tricks that work everywhere
15			It's not my fault

16			Sprinkle encouragement
17			Do the heavy lifting for me
18			Make important things fast

**Enchant me:** It promotes combining the beauty, simplicity and purpose to create a magical experience in an application who should be elegant and aesthetically pleasing at multiple levels. The transitions are fast and clear; the design and typography are sharp and significant. Application icons are art. The principles under this goal are:

- **Delight me in surprising ways:** It promotes the use of animations, timely and subtle sound effects to enhance the experience. This is closely related to Nielsen 8 (see Table 4.1), talks about the subtlety of using effects to enhance the experience and that affect the design.
- **Real objects are more fun than buttons and menus:** The goal is to reduce cognitive effort from the user, allowing manipulate objects directly. This is closely related to Nielsen 2 (see Table 4.1), talks about the relation between system objects and the real world.
- **Let me make it mine:** It promotes customization and user control over the application without the primary tasks are hidden. This is closely related to Nielsen 7 (see Table 4.1), because it talks about the flexibility of customizing the application and control over customization without hiding their primary tasks.
- **Get to know me:** Do not ask the same information repeatedly if you can learn and offer it again when required. This is closely related to Nielsen 7 (see Table 4.1), speaking on efficiency by allowing users to tailor frequent actions.

**Simplify my life:** Create easy to understand applications from the first use. Simple tasks never require complex procedures, and complex tasks are tailored to the human hand and mind. Regardless of age or cultures, people should feel firmly control without feeling overwhelmed by the amount of options.

- **Keep it brief:** Keep the dialogue short with simple words. This is closely related to Nielsen 8 (see Table 4.1), because it talks about the content in the dialogues, and any extra information could reduce the visibility relative and difficult to get the user's attention more efficiently.
- **Pictures are faster than words:** The use of an image can be a lot more efficient than the words when you express ideas. This is closely related to Nielsen in August (see Table 4.1), it proposes the use of images over words to improve relative visibility.
- **Decide for me but let me have the final say:** If the complex decisions can be estimated it is possible act before applying in order to reduce the load on

options for the user, but always allow "undo". This is closely related to Nielsen 3 and 7 (see Table 4.1), because it talks about improving efficiency at the time to make certain decisions by the user, but with the capability of allowing "undo".

- ***Only show what I need when I need it:*** Avoid showing a complex task in a full way, people are overwhelmed when they view too much at once, break tasks into small steps and shows the steps as they progress. This is closely related to Nielsen in August (see Table 4.1), that aims to reduce the amount of information displayed on the screen, split large tasks into small, digestible pieces of information, and hide options that are not essential at the time.
- ***I should always know where I am:*** People should always know where they are, and what the status of their tasks in progress is. This is closely related to Nielsen 1 (see Table 4.1), speaking about visibility at any moment of the system status to the user.
- ***Never lose my stuff:*** If possible saves the information that people will need later, recalls settings and customizations even between devices in this way the user's tasks will be much easier. This is closely related to Nielsen 6 (see Table 4.1) talks about the information created by the user may be used throughout the application without having to ask again.
- ***If it looks the same, it should act the same:*** Consistency between the visual and actions. This is closely related to Nielsen 4 (see Table 4.1), because it talks about the consistency in the application.
- ***Only interrupt me if it's important:*** Reduce interruptions to a minimum at least that is critical or time-sensitive. People want to stay focused on their tasks. This is closely related to Nielsen 1 (see Table 4.1) talks about the appropriate feedback on system status visibility.

**Make Me Amazing:** Beyond usability, Android applications become a powerful tool to innovate the work of individuals, improving the flow of their work with multitasking, notifications and communication between applications.

- ***Give me tricks that work everywhere:*** Easy to learn and easy to remember application, taking advantage of visual patterns and muscle memory of other Android applications. This is closely related to Nielsen 7 (see Table 4.1), because it speaks to provide facilities to make the application easier to learn through accelerators.
- ***It's not my fault:*** In the event of a failure or error, the way communicate it must be clear, friendly, avoiding technicalities and providing necessary information to the user in order to allow recover from the error. This is closely related to Nielsen 9 (see Table 4.1) because talks on how to address the user when an error has occurred, and provide the mechanisms to resolve it.
- ***Sprinkle encouragement:*** Designing easy-to-complete tasks, using object manipulation, splitting tasks into smaller steps, providing feedback even with a slight change in colour. This is closely related to Nielsen 1 and 7 (see Table 4.1), because it speaks of providing efficiency and feedback during task performance.

- ***Do the heavy lifting for me:*** Provide shortcuts to complete tasks more easily, make the users feel like expert. This is closely related to Nielsen 7 (see Table 4.1), that aims to provide shortcut to make novice users feel as experts in using the application.
- ***Make important things fast:*** Prioritize the core functionality, making it easy to find and quick to use. This is closely related to Nielsen 6 and 7 (see Table 4.1), because it talks about making easy to find features to enhance the efficiency by creating priority in the core functionality.

#### 4.3.3.2 iOS guidelines

iOS guidelines define three core philosophies for designing applications over iOS:

- ***Deference.*** The UI helps people understand and interact with the content, but never competes with it.
- ***Clarity.*** Text is legible at every size, icons are precise and lucid, adornments are subtle and appropriate, and a sharpened focus on functionality motivates the design.
- ***Depth.*** Visual layers and realistic motion impart vitality and heighten people's delight and understanding.

These three points encompass the philosophy for the development over the platform and provide a set of specific guidelines for iOS within a category that is called UI Design Basics. The guidelines provided are very specific to the platform, and these are a useful tool for the developer over iOS but not as general design principles for general heuristics regardless of platform. However, there are six design principles well established in the Guide iOS that are based on general principles. The Table 4.2 shows a summary of the Nielsen heuristics, iOS Design Principle and iOS Design Basis.

Table 4.2: Comparison between Nielsen heuristics, iOS Design Principle and iOS Design Basics

	Nielsen	iOS Design Principles	iOS UI Design Basics
1	Visibility of system status	Aesthetic Integrity	Defer to Content
2	Match between system and the real world	Consistency	Provide Clarity
3	User control and freedom	Direct Manipulation	Use Depth to Communicate
4	Consistency and standards	Feedback	Build in Adaptivity
5	Error prevention	Metaphors	Provide a Great Experience in Each Environment
6	Recognition rather than recall	User Control	Use Layout to Communicate

7	Flexibility and efficiency of use		Start Instantly
8	Aesthetic and minimalist design		Always Be Prepared to Stop
9	Help users recognize, diagnose, and recover from errors		Navigation
10	Help and documentation		Modal Context
11			Users Know the Standard Gesture
12			Interactive Elements Invite Touch
13			Feedback Aids Understanding
14			Inputting Information Should Be Easy
15			Animation
16			Branding
17			Color Enhances Communication
18			Text Should Always Be Legible
19			Graphics
20			Terminology and Wording
21			Use Standard UI Elements Correctly
22			Downplay File and Document Handling
23			Be Configurable If Necessary
24			Take Advantage of iOS Technologies

- Aesthetic Integrity:*** It is not the measure of beauty and style of an application, is the best way in which the appearance and behaviour of an application is integrated with the function of sending a consistent message. This is closely related to Nielsen 8 (see Table 4.2), Nielsen heuristics not present a criterion for assessing the aesthetic design, promotes reduce irrelevant information which could difficult the visibility of the core functionality, this heuristic advocates a minimum and functional design.

- **Consistency:** Consistency helps people extrapolating their knowledge and skills from one part of the UI to another, even between applications. It is based on standards or paradigms and provides an experience of internal consistency. It defines three types of consistency: industry standard and platforms consistency, himself or internal consistency, consistency between versions. This is closely related to Nielsen 4 (see Table 4.2), the heuristics of Nielsen talks about consistency.
- **Direct Manipulation:** It is the paradigm shift of interaction with objects that are manipulated directly on the screen without the use of controls. It produces more engaged with the tasks and ease of understanding the results. This is closely related to Nielsen 6, 8 (see Table 4.2), because it minimizes the memory load by making visible the options on objects, and to allow its use through Multi-Touch interface eliminating any intermediary for manipulation and improving visibility. This principle is directly related to domain-specific applications such as, games, 3D manipulation, etc.
- **Feedback:** Show results and updates on the progress of their tasks. This is closely related to Nielsen 1 (see Table 4.2), Nielsen heuristics does not establish how to provide Feedback, only indicates that should be appropriate and within a reasonable time to keep the user informed. In iOS guide action is promoted the use of perceptible feedback in response to each user.
- **Metaphors:** Use family experiences and knowledge of the real world into virtual objects and actions in the application. The correct use of metaphors helps quickly understand about the use. It is best when an app uses a metaphor to suggest a usage or experience without letting the metaphor enforce the limitations of the object or action on which it's based. This is closely related to Nielsen 2 (see Table 4.2). Nielsen Heuristics also talks about follow the real-world conventions, making information appear in natural and logical order.
- **User Control:** Do not allow that the applications initiate and control actions, which is user's authority. An app may suggest initiate action but cannot make decisions that correspond to the user. This is closely related to Nielsen 2 (see Table 4.2), the heuristics of Nielsen talks about always give control to the user, even if you make a mistake allow one "emergency exit".

#### 4.3.4 Correlation of the information collected with traditional heuristics

This section contains an analysis and the correlation between principles and heuristics of the guidelines and Nielsen heuristic. Finally it is propose a final homogenizing and formally defined list of a new heuristic for mobile applications.

##### 4.3.4.1 Android guidelines

After analysis of the Android design principles, a relationship has been proposed with the mapping of the principles and heuristics of Nielsen.



Table 4.3: Nielsen vs Android Heuristics

	Nielsen	Android
1	Visibility of system status	I should always know where I am Only interrupt me if it's important
2	Match between system and the real world	Real objects are more fun than buttons and menus
3	User control and freedom	
4	Consistency and standards	If it looks the same, it should act the same
5	Error prevention	
6	Recognition rather than recall	Never lose my stuff
7	Flexibility and efficiency of use	Get to know me Give me tricks that work everywhere Sprinkle encouragement Do the heavy lifting for me Let me make it mine Decide for me but let me have the final say Make important things fast
8	Aesthetic and minimalist design	Delight me in surprising ways Keep it brief Pictures are faster than words Only show what I need when I need it
9	Help users recognize, diagnose, and recover from errors	It's not my fault
10	Help and documentation	

The Table 4.3 shows that seven of the ten heuristics of Nielsen have correspondence with the Android design principles and these can be enriched and focused towards mobile applications. Although some principles were related to more than a heuristic Nielsen in Table were placed within the heuristics that corresponded to their primary objective. The eighteen principles of Android were associated with heuristics Nielsen, even several belong to the same heuristics; this is the case of Nielsen heuristics 1 with two Android principles, Nielsen heuristics 7 with seven Android principles, Nielsen heuristics 8 with four Android principles. Nielsen heuristics that did not have a direct correspondence were 3, 5 and 10.

#### 4.3.4.2 iOS guidelines

After the analysis to the design principles of IOS, a relationship has been proposed with the mapping of the revised principles and Nielsen heuristics.

*Table 4.4: Nielsen Heuristics vs. iOS Design Principles*

	<b>Nielsen</b>	<b>iOS Design Principles</b>
1	Visibility of system status	Feedback
2	Match between system and the real world	Metaphors
3	User control and freedom	User Control
4	Consistency and standards	Consistency
5	Error prevention	
6	Recognition rather than recall	Direct Manipulation
7	Flexibility and efficiency of use	
8	Aesthetic and minimalist design	Aesthetic Integrity, Direct Manipulation
9	Help users recognize, diagnose, and recover from errors	
10	Help and documentation	
11		

The Table 4.4 shows that six of the ten heuristics of Nielsen have correspondence with the principles of Design for iOS and can be enriched and focused towards mobile applications according to the guideline. In order to carry out this correspondence were only considered the iOS Design Principles, the list of iOS UI Design Basic was not included because it provides guidelines for specific use onto the platform, the focus of our study is to find a list of heuristics that can be used to evaluate applications over both platforms, however the information provided by iOS UI Design Basis is an important source of information for developers.

#### 4.3.5 Homogenization and formal definition of the heuristic (5)

This section provides a short list of heuristics based on partial lists obtained in the previous section. The Table 4.5 below shows the correlation of the design guidelines of both platforms with Nielsen heuristics

Table 4.5: Nielsen, Android and iOS Heuristics Correlation

	Nielsen	Android	iOS
1	Visibility of system status	I should always know where I am Only interrupt me if it's important	Feedback
2	Match between system and the real world	Real objects are more fun than buttons and menus	Metaphors
3	User control and freedom		User Control
4	Consistency and standards	If it looks the same, it should act the same	Consistency
5	Error prevention		
6	Recognition rather than recall	Never lose my stuff	Direct Manipulation
7	Flexibility and efficiency of use	Get to know me	
		Give me tricks that work everywhere	
		Sprinkle encouragement	
		Do the heavy lifting for me	
		Let me make it mine	
		Decide for me but let me have the final say	
8	Aesthetic and minimalist design	Make important things fast	Aesthetic Integrity, Direct Manipulation
		Delight me in surprising ways	
		Keep it brief	
		Pictures are faster than words	
		Only show what I need when I need it	
9	Help users recognize, diagnose, and recover from errors	It's not my fault	
10	Help and documentation		

For homogenization guidelines related to each Nielsen heuristic are grouped and the characteristics of each one are extracted, similar or repeated features have been also merged. Finally, a code and a new name have been established for the heuristic which reflects its new purpose. The principle of "Direct Manipulation" found in the guidelines for iOS was not considered in the analysis because it is

focused on specific application domains. Nielsen's heuristic #10 about "Help and documentation" was not considered neither because mobile applications do not typically provide integrated documentation or help.

For the formal definition of heuristics the following format was established:

- *ID*: MA00, heuristic ID, MA = Mobile Application and Number
- *Name*: Heuristic name
- *Nielsen Name*: Nielsen heuristic name related
- *Features*: Heuristic features

#### 4.3.5.1 A set of Heuristics for Mobiles Applications

As a result of the heuristics definition step, is presented a list of heuristics enriched with the principles of the Android and iOS guidelines Table 4.6. Using the format established then we formally defined nine heuristics.

*Table 4.6: Heuristics for Evaluating Mobile Applications*

<b>ID:</b>	MA01
<b>Name:</b>	Make system status visible
<b>Nielsen Name:</b>	Visibility of system status
<b>Features:</b>	<ul style="list-style-type: none"><li>• Always keep users informed about what is going on.</li><li>• Provide appropriate feedback within reasonable time.</li><li>• Give people confidence that they know their way around.</li><li>• Make places in your app look distinct and use transitions to show relationships among screens.</li><li>• Provide feedback on tasks in progress.</li><li>• Feedback acknowledges people's actions, shows them the results, and updates them on the progress of their task.</li></ul>

<b>ID:</b>	MA02
<b>Name:</b>	Offer real world objects whenever possible, that can be directly manipulated
<b>Nielsen Name:</b>	Visibility of system status
<b>Features:</b>	<ul style="list-style-type: none"> <li>• Always keep users informed about what is going on.</li> <li>• Provide appropriate feedback within reasonable time.</li> <li>• Give people confidence that they know their way around.</li> <li>• Make places in your app look distinct and use transitions to show relationships among screens.</li> <li>• Provide feedback on tasks in progress.</li> <li>• Feedback acknowledges people's actions, shows them the results, and updates them on the progress of their task.</li> </ul>
<b>Examples:</b>	
<b>ID:</b>	MA03
<b>Name:</b>	Let the user have the control
<b>Nielsen Name:</b>	User control and freedom
<b>Features:</b>	<ul style="list-style-type: none"> <li>• Users often choose system functions by mistake.</li> <li>• Support undo and redo.</li> <li>• People—not apps—should initiate and control actions.</li> <li>• People expect to have ample opportunity to cancel an operation before it begins</li> <li>• People expect to get a chance to confirm their intention to perform a potentially destructive action.</li> <li>• People expect to be able to gracefully stop an operation that's underway.</li> </ul>

<b>ID:</b>	MA04
<b>Name:</b>	Achieve consistency (internal within the app and external with other apps in the platform)
<b>Nielsen Name:</b>	Consistency and standards
<b>Features:</b>	<ul style="list-style-type: none"> <li>• Users should not have to wonder whether different words, situations, or actions mean the same thing.</li> <li>• Is the app consistent with platform standards and conventions? Does it use system-provided controls, views, and icons correctly? Does it incorporate device features in ways that users expect?</li> <li>• Is the app consistent within itself? Does text use uniform terminology and style? Do the same icons always mean the same thing? Can people predict what will happen when they perform the same action in different places? Do custom UI elements look and behave the same throughout the app?</li> <li>• Within reason, is the app consistent with its earlier versions? Have the terms and meanings remained the same? Are the fundamental concepts and primary functionality essentially unchanged?</li> <li>• Discerns the functional differences, making them visually distinct rather than subtle.</li> <li>• Avoid modes, which are places that look similar but act differently on the same input.</li> </ul>
<b>ID:</b>	MA05
<b>Name:</b>	Consider error-prone conditions
<b>Nielsen Name:</b>	Error prevention
<b>Features:</b>	<ul style="list-style-type: none"> <li>• Even better than good error messages is a careful design which prevents a problem from occurring in the first place.</li> <li>• Eliminate error-prone conditions or check for them and present users with a confirmation option before they commit to the action.</li> <li>• Break complex tasks into smaller steps that can</li> </ul>

	be easily accomplished. Give feedback on actions.
<b>ID:</b>	MA06
<b>Name:</b>	Have the app remember important stuff and not the user
<b>Nielsen Name:</b>	Recognition rather than recall
<b>Features:</b>	<ul style="list-style-type: none"> <li>• Make objects, actions, and options visible.</li> <li>• User should not have to remember information from one part of the dialogue to another.</li> <li>• Instructions for use of the system should be visible or easily retrievable whenever appropriate.</li> <li>• Save what people took time to create and let them access it from anywhere.</li> <li>• Remember settings, personal touches, and creations across phones, tablets, and computers.</li> </ul>
<b>ID:</b>	MA07
<b>Name:</b>	Strive for high efficiency of use in default settings, but allow customization
<b>Nielsen Name:</b>	Flexibility and efficiency of use
<b>Features:</b>	<ul style="list-style-type: none"> <li>• Accelerators -- unseen by the novice user -- may often speed up the interaction for the expert user so that the system can cater to both inexperienced and experienced users.</li> <li>• Allow users to tailor frequent actions.</li> <li>• Learn peoples' preferences over time.</li> <li>• Make your app easier to learn by leveraging visual patterns and muscle memory from other apps.</li> <li>• Take your best guess and act rather than asking first.</li> <li>• Provide sensible, beautiful defaults, but also consider fun, optional customizations that don't hinder primary tasks.</li> </ul>

	<ul style="list-style-type: none"> <li>• Make novices feel like experts by enabling them to do things they never thought they could.</li> <li>• Decide what most important action in your app is and make it easy to find and fast to use.</li> </ul>
<b>ID:</b>	MA08
<b>Name:</b>	Design for simplicity and aesthetics
<b>Nielsen Name:</b>	Aesthetic and minimalist design
<b>Features:</b>	<ul style="list-style-type: none"> <li>• Dialogues should not contain information which is irrelevant or rarely needed.</li> <li>• Every extra unit of information in a dialogue competes with the relevant units of information and diminishes their relative visibility.</li> <li>• Use short phrases with simple words.</li> <li>• Consider using pictures to explain ideas.</li> <li>• Break tasks and information into small, digestible chunks.</li> <li>• Hide options that aren't essential at the moment, and teach people as they go.</li> <li>• People care about whether an app delivers the functionality it promises, but they're also affected by the app's appearance and behaviour in strong sometimes subliminal ways.</li> </ul>
<b>ID:</b>	MA09
<b>Name:</b>	When a user error happens, take the user's feelings and needs into account
<b>Nielsen Name:</b>	Help users recognize, diagnose, and recover from errors
<b>Features:</b>	<ul style="list-style-type: none"> <li>• Expressed in plain language (no codes)</li> <li>• Precisely indicate the problem</li> <li>• Constructively suggest a solution.</li> <li>• Be gentle in how you prompt people to make</li> </ul>



	corrections.  • Give clear recovery instructions but spare them the technical details.
--	--

#### 4.3.5.2 Severity rating

In order to establish a weight for each usability issues, a scale of severity for every violation heuristics was established Table 4.7. From the point of view of the evaluator will set a weight from 1 to 5 depending on the difficulty that a user might overcome some issues using the application. The severity scale is very similar to the scale proposed by Nielsen with the difference that added "Medium" between "Major" and "Minor", this scale was proposed by Denise Pierotti. (Pierotti, 1996)

*Table 4.7: Five-point rating scale for severity of usability*

<b>Cosmetic:</b> Will not affect usability. Fix if possible.	1
<b>Minor:</b> Users can easily work around the problem. Fixing this should be given low priority.	2
<b>Medium:</b> Users stumble, but quickly adapt.	3
<b>Major:</b> Users have difficulty, but are able to find workarounds. Fixing this should be mandatory.	5
<b>Catastrophic:</b> Users are unable to work. Fixing mandatory.	5
<b>Not Applicable</b>	NA

#### 4.3.6 Evaluation of heuristics

To evaluate the list of heuristics, they were used in the evaluations of four mobile applications, then evaluators participated in a survey to collect their feedback about heuristics and process. The design of evaluations, conduction and results will be analysed in the next section.

## 4.4 Study Design

The study was designed to evaluate the impressions of evaluators after performing heuristic evaluations of mobile applications. To accomplish the objectives of this work were designed and conducted heuristic evaluations for four mobile applications. The preparation of the heuristic evaluation is detailed in section 4.4.1, the execution of the evaluation in section 4.4.2, the results obtained by heuristic evaluations are detailed in the section 4.4.4.

The study phases from its preparation to the evaluation of the results are:

1. Preparation of the necessary documentation for the heuristic evaluation
2. Selection of participants
3. Conduct of heuristic evaluations
4. Post Evaluation Questionnaire to the evaluators
5. Expert evaluation questionnaire
6. Analysis of results

### 4.4.1 Preparing Heuristic Evaluation

#### 4.4.1.1 Preparation of the necessary documentation for the heuristic evaluation

In order to conduct a heuristic evaluation is necessary to generate the material and documentation that will be used by the evaluators to perform their tasks. In a heuristic evaluation shall be selected heuristics that will be applied during the evaluation, in this case study will be used heuristic defined in the section 4.3.5.1. It is also necessary to provide a format for collecting usability issues found. Five documents will be provided to assessors:

1. **Heuristic Evaluation – Instructions:** Document with a brief explanation about the purpose of the heuristic evaluation, also the detail of the documentation provided to the evaluator and the procedure to follow.
2. **Heuristic Evaluation – Checklist:** It contains a detailed list of heuristics to be used to conduct the evaluation.
3. **Heuristic Evaluation – Record Sheet:** Sheet to register issues found.
4. **Heuristic Evaluation Post-evaluation Questionnaire:** Questionnaire to be filled after completing heuristic evaluation.
5. **Expert Evaluator Questionnaire:** Questionnaire to be filled after completing heuristic evaluation. (only expert evaluator)

##### 4.4.1.1.1 Heuristic Evaluation - Instructions

The instruction document provides to the evaluator an overview about heuristic evaluation process, the aim is to help in recognizing of the documentary material received and show how to fill it. Finally defines the steps to be carried out for

evaluation. In the Table 4.8 are shown the instructions provided to the evaluator. Instructions document is in Annex 9.2.

*Table 4.8: Heuristic Evaluation Procedure*

1.	Recognize the materials provided, 4 different documents including instructions.
2.	Please have your mobile device with the application will be evaluated.
3.	Please read the document "Heuristic Evaluation - Checklist".
4.	Check the start time.
5.	If the application does not have a navigation map, identify a starting point and browse through each part of the mobile application.
6.	During each navigation, assess the compliance of each part of the design, find any violation of the heuristics.
7.	If an issue is found:
7.1.	Records the problem on "Heuristic Evaluation – Record Sheet", include it in the row related to the heuristic.
7.2.	Write a brief description of issue and identifies the context of how it was discovered (e.g., what screen was it on);
7.3.	Rate the issue using one of the six values of the rating scale for severity table. (Heuristic Evaluation Checklist)
7.4.	Number your issue in order to match the information between columns.
8.	After the evaluation, check the end time and uses the document "Heuristic Evaluation Post-evaluation Questionnaire" to register your opinions about the process.

#### 4.4.1.1.2 Heuristic Evaluation - Checklist

This document is for informational purposes for the assessor. It contains the table of severity scales and the list of heuristics. The full document is in Annex 9.3.

#### 4.4.1.1.3 Heuristic Evaluation - Record Sheet

This document allows evaluators to record usability issues using a table of four columns, the first column has the nine heuristics with their codes, the second column is a space to enter short description of the issue, the third column is to indicate how the heuristic is violated, and the fourth is to indicate the degree of severity. The way to fill it in is to enter all issues line by line in the row corresponding to the Heuristic. The Figure 6 shows an extract of the form which must be filled in by the evaluator. The full document is in Annex 9.4.

Please complete the next sheet with the issues information found during the evaluation.

Heuristics	Brief Description of Issues	How was the Heuristic violated?	Severity
<b>MA01.</b> Make system status visible - Visibility of system status			
<b>MA02.</b> Offer real world objects whenever possible, that can be directly manipulated			
<b>MA03.</b> Let the user have the control - User control and freedom			
<b>MA04.</b> Achieve consistency			

Figure 6: Extract of the Record Sheet Document

#### 4.4.1.1.4 Heuristic Evaluation Post-evaluation Questionnaire

The document contains a questionnaire to be filled by the evaluators after completion of the heuristic evaluation. The aim is to gather impressions about the heuristic evaluation and process. The design of the questionnaire includes eight open and closed questions in which the conformity of the evaluator is collected. The questions asked about the knowledge of the evaluator heuristic evaluation, and about the usefulness of the heuristics provided, open questions collect comments and suggestions about the process. The Figure 7 shows an extract from the questionnaire, the full document be found in the Annex 9.5.

1. Which is your level of knowledge about Heuristic Evaluation?

None	Limited	Moderate	Broad	Expert

2. Which is your level of knowledge about Jakob Nielsen's 10 usability heuristics?

(<http://www.nngroup.com/articles/ten-usability-heuristics/>)

None	Limited	Moderate	Broad	Expert

Figure 7: Extract of the Post-evaluation Questionnaire

#### 4.4.1.1.5 Expert Evaluator Questionnaire

This document contains a questionnaire to be filled in only by expert evaluators. The aim of the document is to collect feedback from experts about heuristics and the evaluation process. The design of the questionnaire includes nine open and closed questions. The Figure 8 shows an extract of the questionnaire, the full document can be found in the Annex 9.6.

7. This set of heuristic is applicable to a wide range of categories of mobile applications

Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree

8. This set of heuristics can help mobile application designers to get a better understanding of the design decisions that provide high usability, and compliance with Android and iOS user interface guidelines.

Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree

Figure 8: Extract of Expert Evaluator Questionnaire

#### 4.4.1.2 Selection of Participants

Four mobile applications were selected to be evaluated by their respective development teams. The Table 4.9 shows information of the applications and the number of evaluators in each team.

Table 4.9 : Information of mobile applications for heuristic evaluation

Name	Category	Country	Version	OS	Evaluators
Sports Ecuador	Sports	Ecuador	3.0	Android / iOS	4
UPM Titulaciones	Educational	Spain	1.04.04	iOS	1
ETSIINF UPM	Educational	Spain	0.0.1 (beta)	Android / iOS	1
LAN PRAM	Tools	Ecuador	1.0	Android	1

The selected applications are within the following categories: Sports, Educational and Tools. In some cases they have versions for both platforms. Configuration evaluation teams for each application is shown in the section corresponding to the evaluations.

#### 4.4.2 Conducting a Heuristic Evaluation

For the conduction of the heuristic evaluation were agreed meetings with each development teams, in the case of teams that were in Ecuador, the evaluation was preformed through video conference using Skype, during the evaluation they were carried out the following activities:

1. Generate the necessary documents for each of the Evaluators
2. Reading and explanation of the introduction document
3. Perform the evaluation with everyone evaluators
4. Collect the document "Record Sheet" with usability issues found
5. Ask the evaluator to answer the questionnaire document " Heuristic Evaluation Post-evaluation Questionnaire"

##### 4.4.2.1 Heuristic Evaluation of ETSIINF UPM Application

This is an application for students, teachers and staff of Service that allows access to the information available to the university community from their mobile devices. Provides services such as: news, announcements, events calendar and information about department, faculty services, subjects, bus schedules and links. The application is developed for Android and iOS platforms, it is currently in beta in version 0.0.1 and is classified within stores as Educational. The evaluation was performed by the current application developer, who was given the full documentation and were explained the objectives and procedures. Approximately the evaluation of each platform took around 30 minutes

*Table 4.10: Configuration of the heuristic evaluation of ETSIINF UPM*

Order	App Name	Platform	Evaluator ID	Evaluator Profile
1	ETSIINF UPM	iOS	Evaluator 1	Interaction designer, UI, UX, Evaluator
2	ETSIINF UPM	Android	Evaluator 2	Interaction designer, UI, UX, Evaluator

The Table 4.10 shows the configuration and the order in which the heuristic evaluations was carried out, the process was conducted with the evaluator in person, the evaluator executed an exploratory navigation over all application options registering usability issues during navigation. After the evaluation, the evaluation filled the post evaluation questionnaire. The evaluation results are located in section 4.4.3 and the questionnaire in the section 4.4.4.

#### 4.4.2.2 Heuristic Evaluation of iOS Titulaciones de Grado Application UPM Application

This is an application for students, teachers and staff of service that provides access to information from their mobile devices concerning about undergraduate degrees offered by the UPM. The application is developed only for the iOS platform is currently in version 1.4 and is located within the Educational category. The evaluation of this platform was made by its maintainer, who was provided with the necessary documentation and was explained the objectives and procedures. Approximately evaluation took around 20 minutes.

*Table 4.11: Configuration of the heuristic evaluation of UPM Titulaciones*

Order	App Name	Platform	Evaluator ID	Evaluator Profile
1	UPM TITULACIONES	iOS	Evaluator 1	Mobile Developer

The Table 4.11 shows the configuration and the order in which the heuristic evaluations of the application is carried out, the process was conducted by the evaluator in person, the evaluator executed an exploratory navigation over all application options registering usability issues during navigation. After the evaluation, the evaluation filled the post evaluation questionnaire. The evaluation results are located in section X and the questionnaire in the section x.

#### 4.4.2.3 Boarding Application of an Airline

This is an application used by an airline for sending boarding state messages of the flights using a mobile device, it is a private tool and is not published in stores. The application is developed only for Android. The evaluation of this platform was conducted by the developer and take around 60 minutes, the evaluator was in Ecuador and was supported throughout the whole process via videoconference the documentation was sent to and received by digital media.

*Table 4.12: Configuration of the heuristic evaluation of LAN PRAM*

Order	App Name	Platform	Evaluator ID	Evaluator Profile
1	LAN PRAM	Android	Evaluator 1	Mobile Developer

The Table 4.12 shows the configuration and the order in which the heuristic evaluations of the application is carried out, the process was conducted by the evaluator in person, the evaluator executed an exploratory navigation over all application options registering usability issues during navigation. After the evaluation, the evaluation filled the post evaluation questionnaire. The evaluation results are located in section 4.4.3 and the questionnaire in the section 4.4.4.

#### 4.4.2.4 Sport Application

This is an application of information regarding soccer in Ecuador, has services such as news, schedules, league tables, alerts, customization on information and information about teams. The application was developed for Android and iOS platforms, it is currently in version 3.0 and is classified within the stores as Sport.

The evaluation of this platform was conducted by the development team. Approximately the evaluation of each platform took about 60 minutes, the evaluators were in Ecuador and received instructions and were supervised during the whole process via videoconference and documentation was sent and received by digital media.

*Table 4.13: Configuration of the heuristic evaluation of Sport Ecuador*

Order	App Name	Platform	Evaluator ID	Evaluator Profile
1	Sport Ecuador	Android	Evaluator 1	Director de Tecnología
2	Sport Ecuador	Android	Evaluator 2	Interaction designer, UI, UX, Evaluator
2	Sport Ecuador	iOS	Evaluator 3	Developer
2	Sport Ecuador	iOS	Evaluator 4	Developer

The Table 4.13 shows the configuration and the order in which the heuristic evaluations were conducted, were selected 4 participants as evaluators and distributed into two groups of equal numbers for each platform Android and iOS respectively. Each evaluator conducted an exploratory navigation over all the application options registering usability issues. Upon completion the filled the post evaluation questionnaire.

#### 4.4.3 Results of Heuristics Evaluations

##### 4.4.3.1 Results of ETSIINF UPM Evaluations

A total of 16 usability issues were found during the inspections of Android and iOS application version respectively. Table 4.14 shows the number of issues encountered by each evaluator corresponding to each heuristic.



Table 4.14: ETSIINF UPM - Usability issues by evaluator

Heuristics	Evaluator 1	Evaluator 2	Total
MA01	1	0	1
MA02	0	0	0
MA03	2	1	3
MA04	1	3	4
MA05	3	2	5
MA06	1	0	1
MA07	0	1	1
MA08	0	0	0
MA09	1	0	1
			0
<b>TOTAL</b>	9	7	16

Figure 9 shows the number of issues found by each evaluator, in this case each evaluation was performed for Android and iOS version respectively. The Android version was evaluated first had two additional incidents over the iOS version.

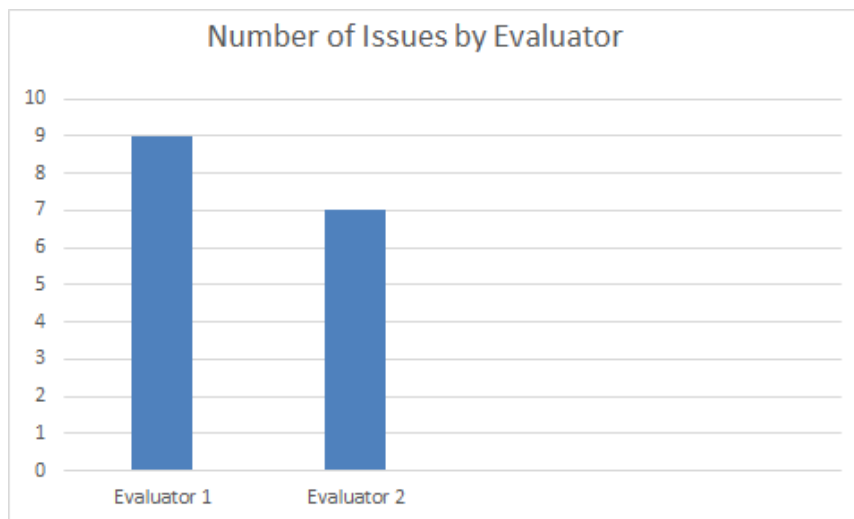


Figure 9: ETSIINF UPM - Usability issues by evaluator

Figure 10 showing the relationship of errors found by each heuristic. The heuristics that most issues helped to found was the **MA05** "Consider error-prone conditions - Error prevention" followed by **MA04** "Achieve consistency (internal and external within the app with other apps in the platform)" and **MA03** "Let the user Have the Control - User Control and freedom".

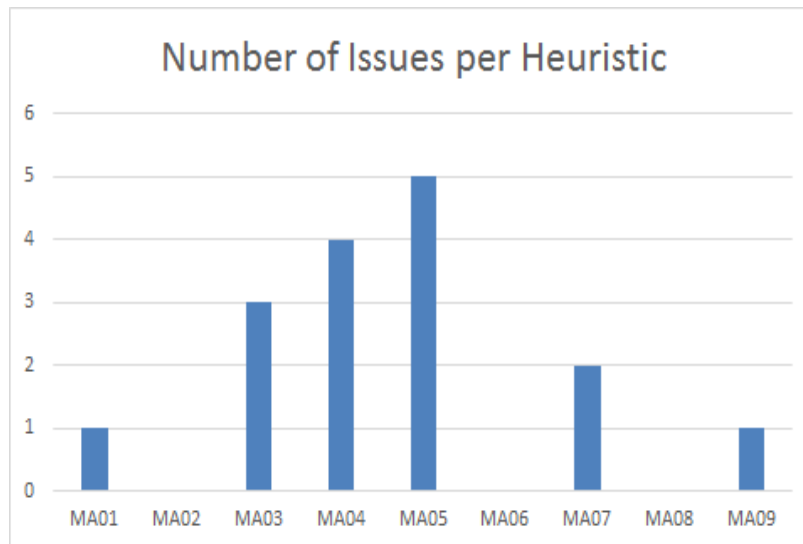


Figure 10: ETSINF UPM - Usability issues by Heuristic

Table 4.15 shows the number of usability issues reported by the evaluators and ranked by severity. In the "Average Severity" column is calculated the average of severity of all occurrences for each heuristic. According to these values the heuristics **MA01** and **MA05** have a higher average degree of severity for this evaluation.

Table 4.15: ETSINF UPM - Ranking of usability issues by heuristic

	Cosmetic	Minor	Medium	Major	Catastrophic	Total per Heuristic	Average Severity
<b>MA01</b>	0	0	1	0	0	1	3,00
<b>MA02</b>	0	0	0	0	0	0	0
<b>MA03</b>	0	1	2	0	0	3	2,67
<b>MA04</b>	4	0	0	0	0	4	1,00
<b>MA05</b>	0	2	2	1	0	5	2,80
<b>MA06</b>	0	0	0	0	0	0	0
<b>MA07</b>	0	2	0	0	0	2	2,00
<b>MA08</b>	0	0	0	0	0	0	0
<b>MA09</b>	0	1	0	0	0	1	2,00
<b>Total</b>	4	6	5	1	0	16	2,19

The data of the Table 4.15 data are shown in Figure 11 for each heuristic is shown the number of issues ranked by severity, in this case MA04 has the highest number of cosmetic issues, the "medium issues" appear in MA05, MA03 MA01 and "Minor" in MA09, MA07, MA05, MA03.

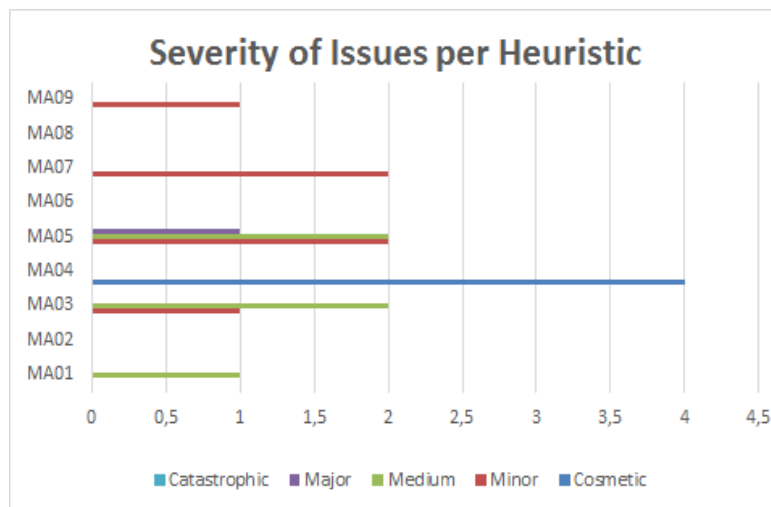


Figure 11: ETSIINF UPM - Severity of usability issues by heuristic

Figure 11 shows the total number of issues grouped by severity, in this case most issues have been classified as Minor, Medium and Cosmetic.

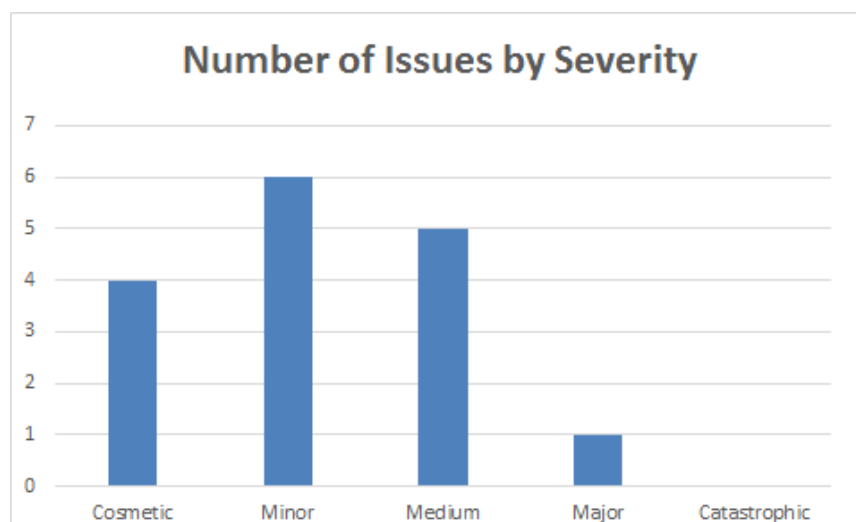


Figure 12: ETSIINF UPM - Usability issues by severity

#### 4.4.3.2 Results of iOS Titulaciones de Grado UPM Evaluations

A total of 2 usability issues were found during the inspection conducted to the application. Figure 13 shows the number of issues encountered by each of the heuristics. Only two heuristics detected usability issues, **MA08** "Design for simplicity and aesthetics - Aesthetic and minimalist design" and **MA09** "When a user mistake happens, take the user's feelings and needs into account - Help users Recognize, diagnose, and recover from errors".

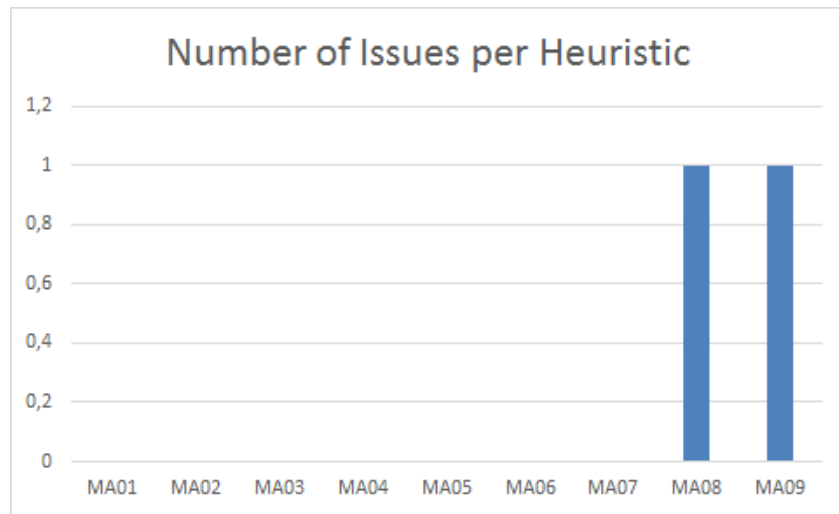


Figure 13: UPM Titulaciones - Usability issues by Heuristic

Table 4.16 shows the number of usability issues reported by the evaluator and ranked by severity. In the "Average Severity" column is calculated the average of severity of all occurrences for each heuristic. According to these values the heuristics, for the two reported cases, the severity was rated as Cosmetics.

Table 4.16: UPM Titulaciones - Ranking of usability issues by heuristic

	Cosmetic	Minor	Medium	Major	Catastrophic	Total per Heuristic	Average Severity
MA01	0	0	0	0	0	0	0
MA02	0	0	0	0	0	0	0
MA03	0	0	0	0	0	0	0
MA04	0	0	0	0	0	0	0
MA05	0	0	0	0	0	0	0
MA06	0	0	0	0	0	0	0
MA07	0	0	0	0	0	0	0
MA08	1	0	0	0	0	1	1,00
MA09	1	0	0	0	0	1	1,00
Total	2	0	0	0	0	2	1,00

The data of the Table 4.16 data are shown in Figure 14 for each heuristic is shown the number of issues ranked by severity, in this case MA09 and MA08 have two cosmetic issues.

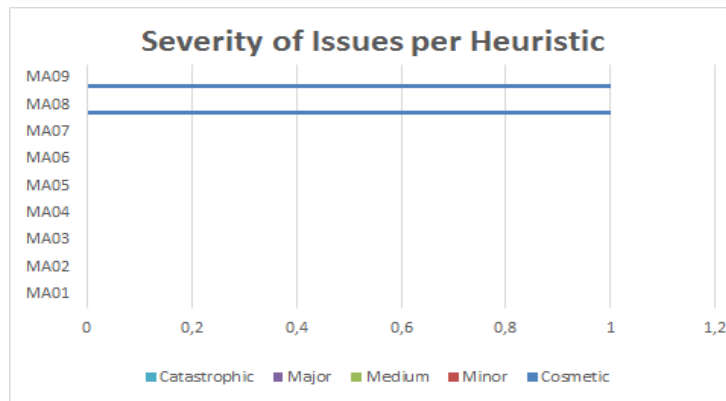


Figure 14: UPM Titulaciones - Severity of usability issues by heuristic

#### 4.4.3.3 Result of Boarding Application of an Airline

A total of 13 usability issues were found during the inspection conducted to the application. Figure 15 shows the number of issues encountered by each of the heuristics, the heuristic that more issues helped to find was the **MA04** "Achieve consistency (internal and external Within the app with Other apps in the platform)" followed by **MA01**, **MA05**, **MA08**.

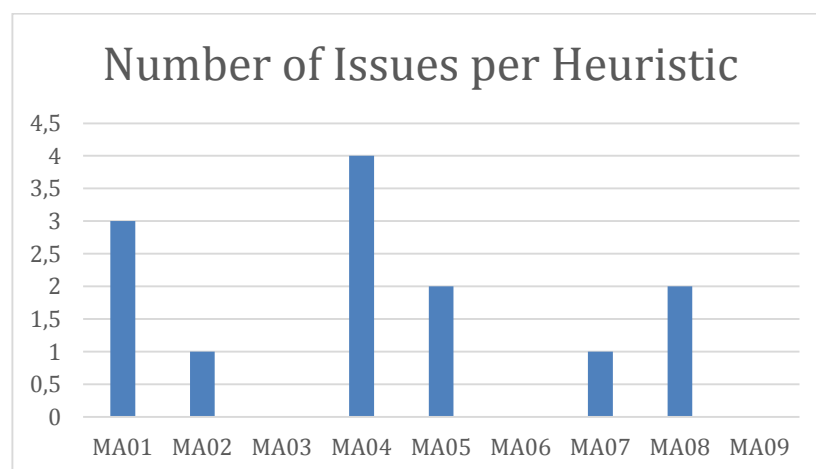


Figure 15: LAN PRAM - Usability issues by Heuristic

Figure 15 shows the number of usability issues reported by the evaluator and ranked by severity. In the "Average Severity" column is calculated the average of severity of all occurrences for each heuristic. According to these values the heuristics MA07 have a higher average degree of severity for this evaluation.

Table 4.17: LAN PRAM - Ranking of usability issues by heuristic

	Cosmetic	Minor	Medium	Major	Catastrophic	Total per Heuristic	Average Severity
MA01	2	1	0	0	0	3	1,33
MA02	0	1	0	0	0	1	2,00
MA03	0	0	0	0	0	0	0
MA04	1	2	1	0	0	4	2,00
MA05	0	2	0	0	0	2	2,00
MA06	0	0	0	0	0	0	0
MA07	0	0	0	0	1	1	5,00
MA08	2	0	0	0	0	2	1,00
MA09	0	0	0	0	0	0	0
Total	5	6	1	0	1	13	1,92

The data of the Table 4.17 data are shown in Figure 16 for each heuristic is shown the number of issues ranked by severity, in this case MA01 MA08 has the highest number of cosmetic issues, the “minor issues” appear in MA05, MA04 and “Medium” in MA04, but MA07 has a “Catastrophic” issue.

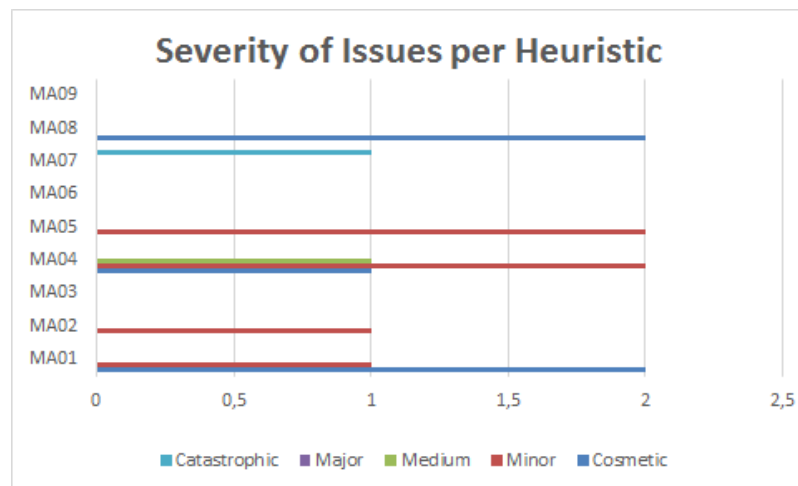


Figure 16: LAN PRAM - Severity of usability issues by heuristic

Figure 16 shows the total number of issues grouped by severity, in this case most issues have been classified as minor and cosmetic.

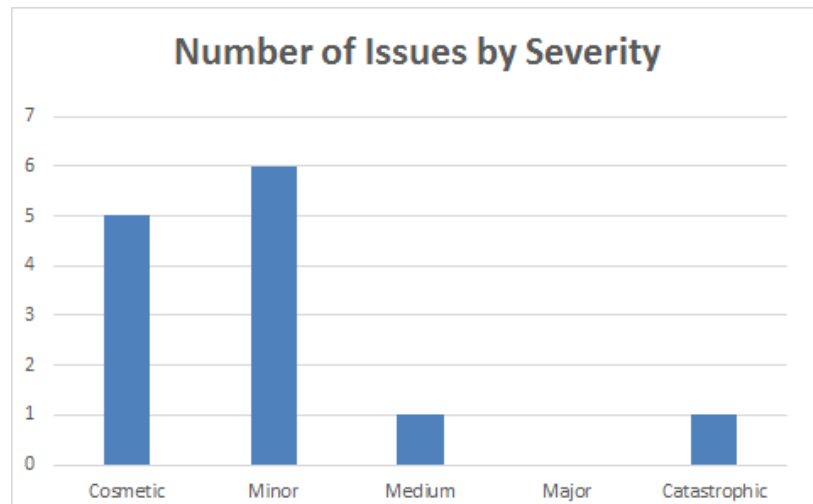


Figure 17: LAN PRAM - Usability issues by severity

#### 4.4.3.4 Results of Sport Application

A total of 44 usability issues were found during the four inspections of Android and iOS application version respectively. Table 4.18 shows the number of problems encountered by each evaluator corresponding to each heuristic.

Table 4.18: Sport Ecuador - Usability issues by evaluator

Heuristics	Evaluator 1	Evaluator 2	Evaluator 3	Evaluator 4	Total
MA01	3	1	3	4	11
MA02	4	0	0	1	5
MA03	0	0	1	0	1
MA04	7	1	5	4	17
MA05	1	2	0	0	3
MA06	0	0	0	0	0
MA07	0	1	0	0	1
MA08	0	0	0	0	0
MA09	3	0	2	1	6
<b>TOTAL</b>	<b>18</b>	<b>5</b>	<b>11</b>	<b>10</b>	<b>44</b>

Figure 18 shows the number of issues found by each evaluator, in this case each two evaluation was performed an inspection for Android and iOS version respectively. Is remarkable a big difference between the evaluator 1 and evaluator 2 who conducted the inspection on the same platform.

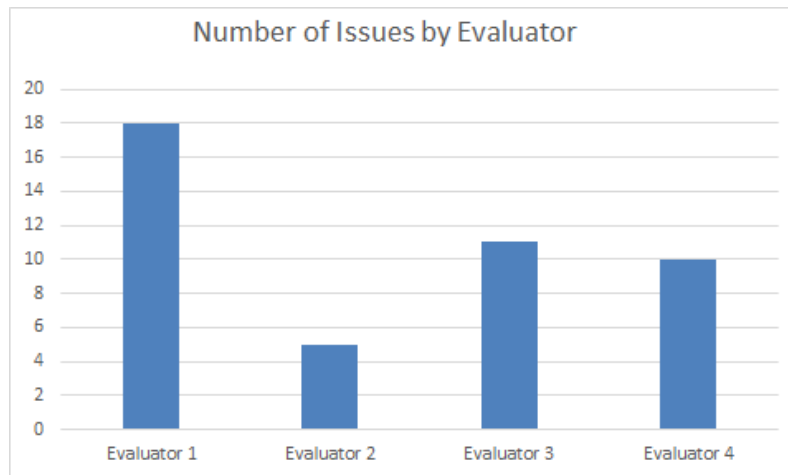


Figure 18: Sport Ecuador - Usability issues by evaluator

Figure 19 shows the relationship of errors found by each heuristic. The heuristics that most issues helped to found **MA04** “Achieve consistency (internal within the app and external with other apps in the platform)” followed by **MA01** Make system status visible “, **MA02** and **MA09**.

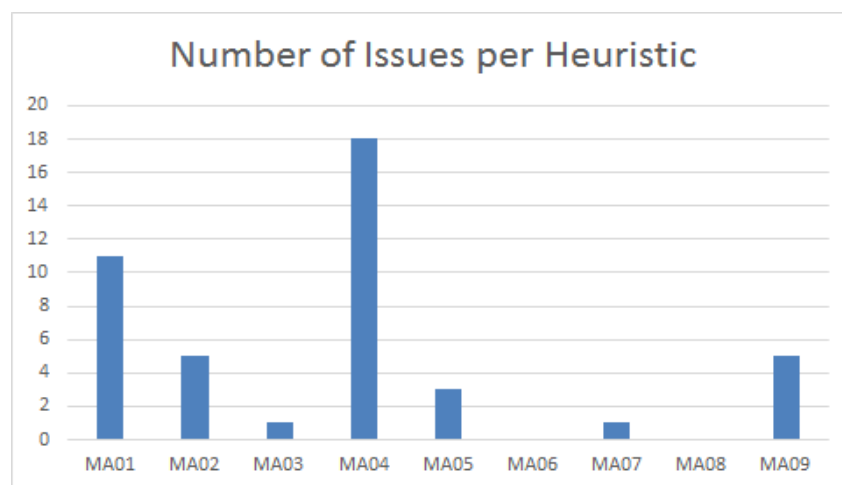


Figure 19: Sport Ecuador - Usability issues by Heuristic

Figure 19 shows the number of usability issues reported by the evaluators and ranked by severity. In the "Average Severity" column is calculated the average of severity of all occurrences for each heuristic. According to these values the heuristics **MA09** and **MA07** have a higher average degree of severity for this evaluation.



Table 4.19: Sport Ecuador - Ranking of usability issues by heuristic

	Cosmetic	Minor	Medium	Major	Catastrophic	Total per Heuristic	Average Severity
MA01	6	2	2	1	0	11	1,82
MA02	1	4	0	0	0	5	1,80
MA03	1	0	0	0	0	1	1,00
MA04	8	3	6	1	0	18	2,00
MA05	2	0	1	0	0	3	1,67
MA06	0	0	0	0	0	0	0
MA07	0	1	0	0	0	1	2,00
MA08	0	0	0	0	0	0	0
MA09	2	1	1	0	1	5	2,40
<b>Total</b>	<b>20</b>	<b>11</b>	<b>10</b>	<b>2</b>	<b>1</b>	<b>44</b>	<b>1,93</b>

The data of the Figure 19 data are shown in Figure 20 for each heuristic is shown the number of issues ranked by severity, in this case MA04, MA06 has the highest number of cosmetic issues, the “medium issues” appear in MA04, MA01 and “Minor” in MA04, MA02.

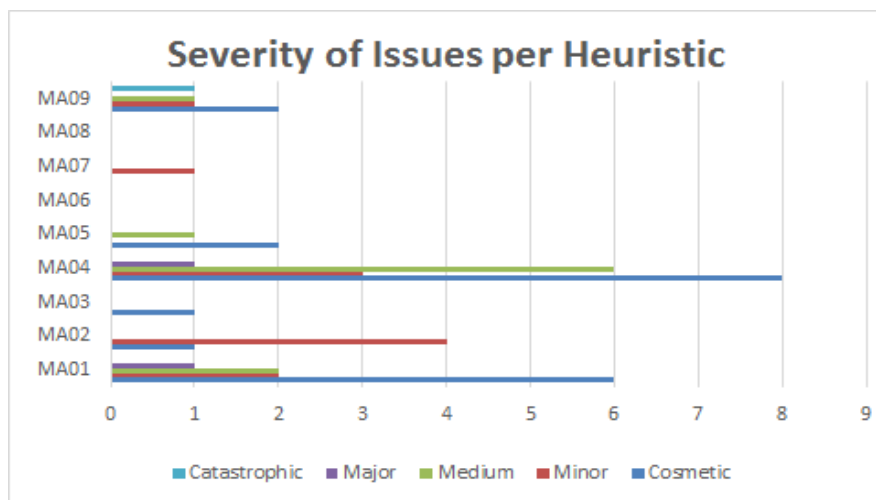
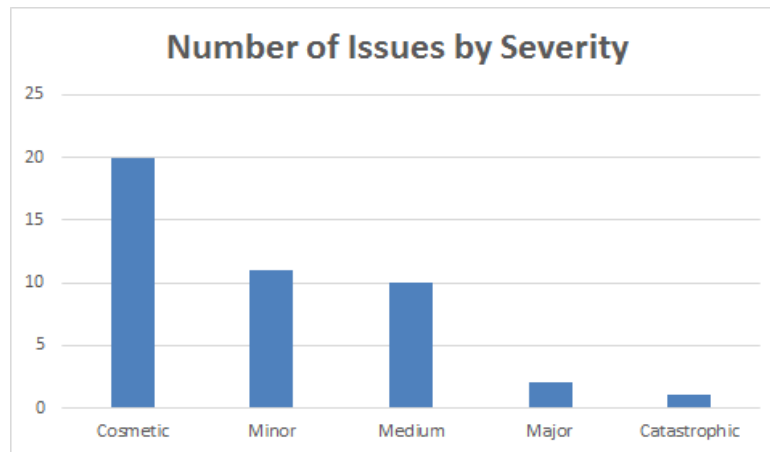


Figure 20: Sport Ecuador - Severity of usability issues by heuristic

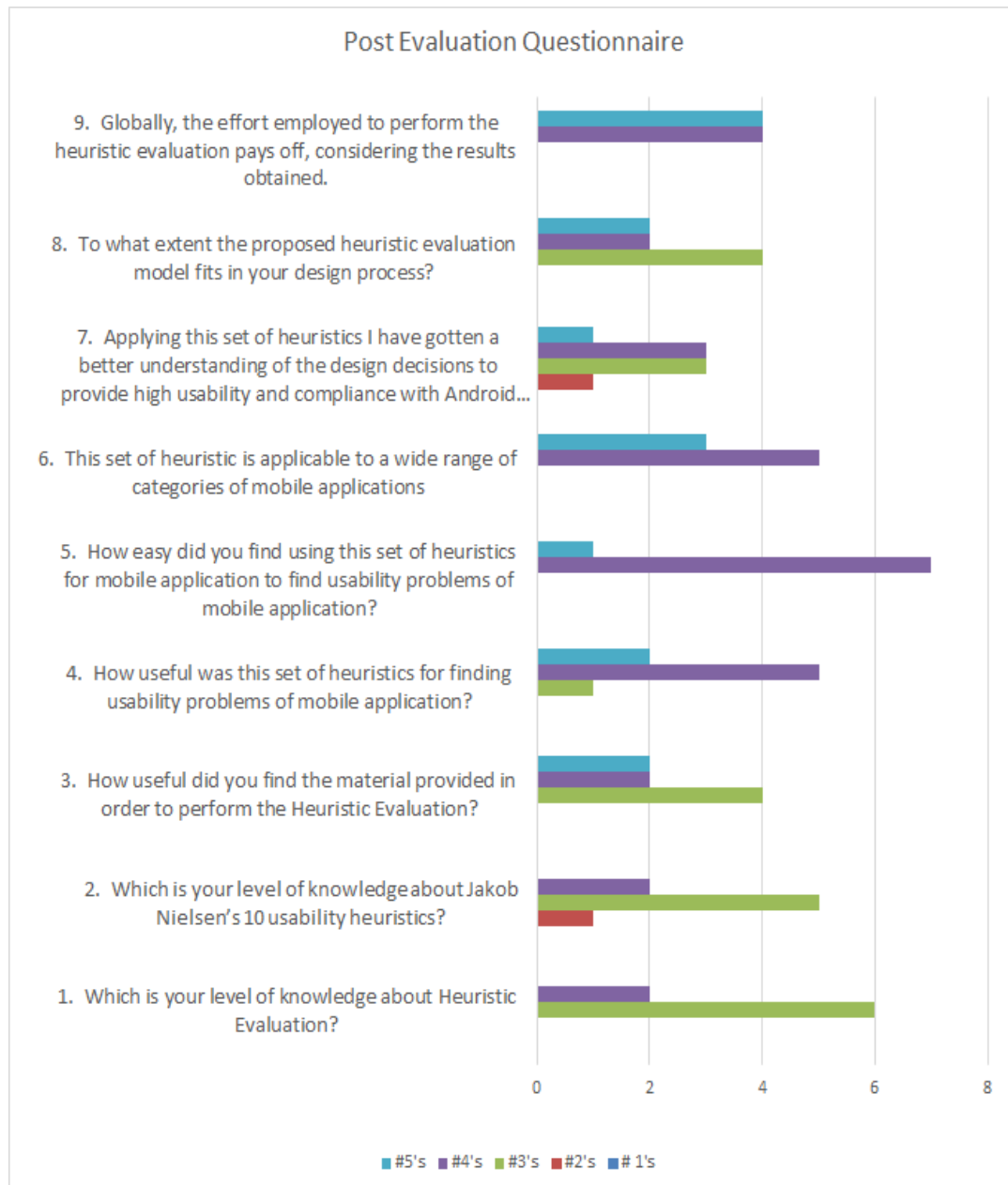
Figure 21 shows the total number of issues grouped by severity, in this case most issues have been classified as cosmetic, minor and medium.



*Figure 21: Sport Ecuador - Usability issues by severity*

#### 4.4.4 Results of Post-evaluation Questionnaire

The Post-evaluation questionnaire aims to collect the feedback of the evaluators about the heuristics for mobile and the whole evaluation process. For the eight evaluations performed (four for each platform respectively) a questionnaire was supplied to each evaluator. The questionnaire has 9 closed questions using the Likert scale which they sought to measure the acceptance of the evaluators about topics such as: knowledge of the heuristic evaluation, how useful and easier to implement was the process, the range of applicability of the heuristics for all categories of applications, the impact by using heuristics for mobile in their understanding of the design guidelines, and the benefit of conducting a heuristic evaluation. Figure 22 shows the results of the questions using the scale of 1 to 5, going from low to high acceptance according to the kind of question.



*Figure 22: Heuristic Evaluation, Post-evaluation questionnaire results*

For the level of knowledge about heuristic evaluations (question 1) the scale of low to high were: (None, Limited, Moderate, Broad, and Expert). Most evaluators consider having a moderate level of knowledge and two evaluators have a broad knowledge on the subject. The same scale was used in Question 2, about the level of knowledge of the heuristics of Nielsen, most evaluators stated to have a moderate knowledge, two evaluators with broad knowledge and one with limited knowledge.

About the usefulness and ease of applying heuristics for mobile, the following scales were used (Not useful, Not particularly useful, useful, useful Somewhat, Very useful) and (Very difficult, difficult, Neutral, Easy, Very Easy). In the case of the usefulness of the materials provided (question 3) most of the evaluators rated it as

"Useful" and four evaluators rated between "somewhat useful" and "very useful". About the usefulness in finding usability issues using heuristics (question 4), most evaluators considered them "somewhat useful" and some even "Very useful". About the ease of using heuristics for mobile applications (Question 5) most of the evaluators considered "Easy" to use and one evaluator "very easy". About the range of applicability of the heuristics for the different categories of mobile devices (Question 6) the perception of the evaluators is that the heuristics can be used in a wide range of application categories. The perception of the evaluators about getting a better understanding of the design decisions applying the heuristic is neutral (Question 7). In the case of knowing the extent to which heuristic evaluation fit in the design process (Question 8) the evaluators responded that somewhat would fit within your current design process. Finally, the perception of the evaluators about the benefits obtained by performing a heuristic evaluation (Question 9), most are strongly agree, so they do consider benefit to implement it within their design process.

Five open questions were performed which were designed to collect more broadly the opinions and comments of the evaluator about the usefulness of the procedure and the heuristics. Within their answers provided they emphasized that some heuristics as the MA01, MA04, and MA07 give additional value to heuristic evaluations for mobile applications. About the design process, some evaluators agreed that the heuristic evaluation would be useful in prototyping. Some comments about the general process mentioned that for evaluators with little knowledge of the design guidelines, could find too general the heuristics, this could decrease the effectiveness of the evaluation.

#### 4.4.5 Discussion

Eight heuristic evaluations in four different mobile applications showed results different kinds of incidences of usability, including some ranked as catastrophic. During the evaluations, on-site and via videoconference, evaluators could find usability issues that even violated the design guidelines of the platforms. The results of the evaluations were given to development groups and it will be repaired considering their severity.

In total 75 usability issues were found by all evaluators, of which the MA04, MA1 and MA05 heuristics registered 26, 15 and 10 incidents respectively, these heuristics talk about consistency, visibility of system status and error prevention, these could be considered as common issues in applications, but also, these are easiest to detect even for a evaluator with little knowledge about guidelines. For the two evaluators who registered a lower number of incidents, it would be interesting to conduct further research and try to find if is due to little knowledge about the guidelines or about the heuristic evaluation process.

About the ease to apply and usefulness of the evaluation process and the list of heuristics for mobile applications, in both cases the evaluators provided with positive comments, although it is possible that future research could be measured the granularity of the heuristics, in other words, create two types of heuristics that

differ in range and granularity of its content, in this way the task for evaluators with little knowledge or heuristic evaluation guidelines would make it easier. The heuristics presented in this study can be considered low granularity and may be more effective for experienced evaluators.

It is remarkable to emphasize that a large number of evaluators agreed that the heuristic evaluation process fits or may fit into their design process, also they consider that the effort to make this type of evaluation is rewarded regarding to the feedback that this generates. Future research could measure the impact of implementing heuristic evaluations in the design process. Most evaluators consider that if the set of heuristics can be applied to a wide range of categories of mobile applications, it would be interesting for future research to conduct a study by applying the heuristic on a variety of applications in different categories in order to determine their effectiveness in each category.

According to the comments collected from the evaluators, the ease and efficiency of using the heuristics could depend on the level of knowledge about design guidelines for each platform. This would also be linked to the granularity of the heuristics with lower granularity the result of the evaluation depends on the knowledge and experience of the evaluator, increased granularity provides all the necessary details to the evaluator, but makes the assessment a slower process, in order to validate this assertion in future research could work with a configuration of novice and expert evaluators using heuristics with different granularity.

## 5 Content Classification of Guidelines

### 5.1 Introduction

Part of the objectives of this research is the study and analysis of the design guidelines of the Android and iOS platforms. One of the questions posed during the research was:

How to fit design platform guidelines within the design cycle of a mobile application?

The current problem is the broad difference between the classifications of information in both guidelines. This may hinder the work of design and implementation especially at the time of seeking common elements similar between each platform. In previous chapters an analysis was conducted about the use of the information provided by the guidelines within the evaluation stage. In this chapter we propose a content reclassification of the guidelines in order that it can be used by developers at the stage of design and implementation. In order to facilitate the use of the new classification a web application was created and tested that will work as a tool for the designer or developer.

### 5.2 Method

In order to propose a general classification that covers all content provided by the guidelines of the platforms, the following activities were carried out:

- Analysis and classification of the existing categories of the guides.
- Definition of general categories.
- Unified classification.

#### 5.2.1 Analysis and classification of categories of the guides

##### 5.2.1.1 Android Guideline

The Android guidelines (Google Inc. and the Open Handset Alliance, 2015) contain 10 main sections and 65 sub sections. Table 5.1 shows the structure of the information and classification of contents.

*Material design:* This section provides an overview of material design philosophy, objectives and principles.

*Create Vision:* This section is outside of the Material Design guidelines and it is considered like "Pure Android", provides three global principles for Android UX which comprise all detailed principles for designers and developers.

*What is material?* : This section provides an overview of the main components that make up the philosophy "Material" which are: environment, 3D world, light and shadow

*Animation:* This section provides information and best practices related to animations.

*Style:* This section provides guidelines for using colours, icons, images, typography and writing style.

*Layout:* Material design is guided by print-based design elements such as typography, grids, space, scale, colour, and imagery, to create hierarchy, meaning, and focus that immerse the user in the experience. This section prove the principles, units, metric, structure and the adaptation of the UI, specifically under the philosophy of design materials.

*Components:* This section includes information on all UI elements. Some sections correspond to a subset of UI elements, including an internal list of items. Example: Selection controls groups: Checkbox, Radio button, Switch. In the Table 5.1 they are shown only the main categories, sub-sections are considered in the general reclassification.

*Patterns:* This section provides information on: the structure of the applications, data format, use of empty spaces, error handling, gestures, launch screens, loading images, navigation drawer, navigation, scrolling techniques, searching, selections, settings, swipe to refresh.

*Usability:* This section provides guidelines and best practices on accessibility and bidirectionality.

*Resources:* This section is a repository of useful downloadable items for the developer or designer.

Table 5.1 Android guideline, structure of the information

	<b>Material design</b>		<b>Layout</b>		<b>Patterns</b>
1	Introduction	17	Principles	44	App structure
	<b>Create Vision</b>	18	Units and measurements	45	Data formats
2	Android Design Principles	19	Metrics & key lines	46	Empty states
	<b>What is material?</b>	20	Structure	47	Errors
3	Environment	21	Adaptive UI	48	Gestures
4	3D world		<b>Components</b>	49	Launch screens
5	Light and shadow	22	Bottom sheets	50	Loading images
6	Material properties	23	Buttons	51	Navigation drawer
7	Elevation and shadows	24	Buttons: Floating Action Button	52	Navigation
	<b>Animation</b>	25	Cards	53	Navigational transitions
8	Authentic motion	26	Chips	54	Scrolling techniques
9	Responsive interaction	27	Data tables	55	Search
10	Meaningful transitions	28	Dialogs	56	Selection
11	Delightful details	29	Dividers	57	Settings
	<b>Style</b>	30	Grid lists	58	Swipe to refresh
12	Color	31	Lists		<b>Usability</b>
13	Icons	32	Lists: Controls	59	Accessibility
14	Imagery	33	Menus	60	Bi-directionality
15	Typography	34	Pickers		<b>Resources</b>
16	Writing	35	Progress & activity	61	Color palettes
		36	Selection controls	62	Devices
		37	Sliders	63	Layout templates
		38	Snackbars & toasts	64	Roboto & Noto fonts
		39	Subheaders	65	Sticker sheets & icons
		40	Tabs		
		41	Text fields		
		42	Toolbars		
		43	Tooltips		



### 5.2.1.2 iOS Guidelines

The iOS guidelines (Apple, 2015) contain 5 main sections and 46 sub sections. Table 5.2 shows the structure of the information and classification of contents.

*UI Design Basic:* This section describes the guidelines and principles that help users to design a better user interface and user experience of mobile application, from the point of view of the current version of iOS, it provides information about the anatomy of an app, layout, navigation, modal context, feedback, animations, branding, colour and typography, icons and graphics, etc.

*Design Strategies:* This section proved strategies for application design, general design principles, methodology and case study.

*iOS Technologies Guidelines:* This section provides guidelines for iOS technology such as: HealthKit, Passbook, etc.

*UI Elements Guidelines:* This section provides guidelines for the use of UI Elements, these are divided into four groups: Bars, Content Views, Controls, and Temporary Views. All elements are distributed within these four groups. In the Table 5.2Table 5.1 shown only the main categories, sub-sections are considered in the general reclassification.

*Icon and Image Design Guidelines:* This section provides design guidelines and best practices for use of icons, images, and buttons.

Table 5.2 iOS guidelines, structure of the information

	UI Design Basis		iOS Technologies Guidelines		UI Elements Guidelines
1	Designing for iOS	16	App Extensions	36	Bars
2	iOS App Anatomy	17	Notifications	37	Content Views
3	Adaptivity and Layout	18	Multitasking	38	Controls
4	Starting and Stopping	19	Social Media	39	Temporary Views
5	Navigation	20	iCloud		<b>Icon and Image Design Guidelines</b>
6	Modal Contexts	21	HealthKit	40	Icon and Image Sizes
7	Interactivity and Feedback	22	Passbook	41	App Icon
8	Animation	23	Apple Pay	42	Launch Images
9	Branding	24	In-App Purchase	43	Bar Button Icons
10	Color and Typography	25	Game Center	44	Newsstand Icons
11	Icons and Graphics	26	iAd Rich Media Ads	45	Web Clip Icons
12	Terminology and Wording	27	AirPrint	46	Creating Resizable Images
13	Integrating with iOS	28	Accessing User Data		
	<b>Design Strategies</b>	29	Quick Look		
14	Design Principles	30	Sound		
15	From Concept to	31	VoiceOver		

	Product				
		32	Routing		
		33	Edit Menu		
		34	Undo and Redo		
		35	Keyboards and Input Views		

### 5.2.2 Definition of general categories

In order to create a list of general categories which cover categories of both guidelines the following activities were carried out:

- Each category was described according to their function or content:
- The descriptions were grouped according to their affinity
- The descriptions were homogenized, merging similar.

After carry out these activities, we proceed to prepare a list which will then be used to classify all elements of the guidelines under a common approach. The list contains 15 elements:

- Principles
- Adapting Layout
- UI Component Elements
- Design
- Specific Technology
- General Interface
- Structure and Layout
- Data Format
- Accessibility
- Navigation
- Integration
- Actions
- Animation
- Interaction
- Resources
- 

The internal classification of "UI Component Elements" is a special case because on Android does not provide a clear definition of the elements and iOS offers a classification based on four groups. In order to define a global categorization, we have adopted the classification given in the research project "Framework for interaction design for mobile applications" (Abimael Barea Puyana, 2015) which presents a comparative study between elements of both platforms and proposes a general categorization, based on the proposal for iOS and adding two groups:

- Bars
- Content Views
- Controls
- Temporary Views
- Navigation
- Progress & Activity

For grouping of elements stage, the authors decided to include only those who work for structuring information on the top level navigation, those who are used in the middle level and those that provide feedback or basic actions. Further elements with specific characteristics were excluded. For purposes of our research, we've updated the list including all elements of both guidelines.

### 5.2.3 Unified Classification

The Table 5.3 shows the classification of the elements of the guidelines of Android and iOS using predefined general categories. Have been separated the elements within the category "UI Component Elements" and are shown in the Table 5.4

*Table 5.3 Unified classification of the guidelines elements*

Categories	iOS		Categories	Material Design
Principles	Designing for iOS		Principles	Introduction
Structure and Layout	iOS App Anatomy			<b>Create Vision</b>
Structure and Layout	Adaptivity and Layout		Principles	Android Design Principles
Actions	Starting and Stopping			<b>What is material?</b>
Navigation	Navigation		General Interface	Environment
Navigation	Modal Contexts		General Interface	3D world
Interaction	Interactivity and Feedback		General Interface	Light and shadow
Animation	Animation		General Interface	Material properties
Design	Branding		General Interface	Elevation and shadows
Design	Color and Typography			<b>Animation</b>
Design	Icons and Graphics		Animation	Authentic motion

Design	Terminology and Wording		Animation	Responsive interaction
Integration	Integrating with iOS		Animation	Meaningful transitions
	<b>Design Strategies</b>		Animation	Delightful details
Principles	Design Principles			<b>Style</b>
	From Concept to Product		Design	Color
	<b>iOS Technologies Guidelines</b>		Design	Icons
Specific Technology	App Extensions		Design	Imagery
Specific Technology	Notifications		Design	Typography
Specific Technology	Multitasking		Design	Writing
Specific Technology	Social Media			<b>Layout</b>
Specific Technology	iCloud		Principles / Structure and Layout	Principles
Specific Technology	HealthKit		Structure and Layout	Units and measurements
Specific Technology	Passbook		Structure and Layout	Metrics & keylines
Specific Technology	Apple Pay		Structure and Layout	Structure
Specific Technology	In-App Purchase		Structure and Layout / Adapting Layout	Adaptive UI
Specific Technology	Game Center			<b>Patterns</b>
Specific Technology	iAd Rich Media Ads		Structure and Layout	App structure
Specific Technology	AirPrint		Data Format	Data formats
Specific Technology	Accessing User Data		Structure and Layout	Empty states
Specific Technology	Quick Look		Data Format	Errors
Specific Technology	Sound		Integration	Gestures
Specific Technology	VoiceOver		General Interface	Launch screens
Specific Technology	Routing		Design	Loading images
Specific Technology	Edit Menu		UI Component Elements	Navigation drawer
Specific Technology	Undo and Redo		Navigation	Navigation
Specific	Keyboards and Input		Navigation	Navigational

Technology	Views			transitions
	<b>Icon and Image Design Guidelines</b>		Actions	Scrolling techniques
Design	Icon and Image Sizes		Actions	Search
Design	App Icon		Actions	Selection
Design	Launch Images		Actions	Settings
Design	Bar Button Icons		Actions	Swipe to refresh
Design	Newsstand Icons			<b>Usability</b>
Design	Web Clip Icons		Usability	Accessibility
Design	Creating Resizable Images		Usability	Bidirectionality
				<b>Resources</b>
			Resources	Color palettes
			Resources	Devices
			Resources	Layout templates
			Resources	Roboto & Noto fonts
			Resources	Sticker sheets & icons

Table 5.4 Unified classification of the UI elements

Categories	iOS		Categories	Material Design
	<b>Bars</b>		Temporary Views / Controls	<b>Bottom sheets</b>
Bars	The Status Bar		Controls	<b>Buttons</b>
Bars	Navigation Bar		Controls	Flat & raised buttons
Bars	Toolbar		Controls	Icon toggles
Bars	Toolbar and Navigation Bar Buttons		Controls	Mobile dropdown buttons
Navigation / Bars	Tab Bar		Controls	<b>Buttons: Floating Action Button</b>
Bars	Tab Bar Icons		Content Views	<b>Cards</b>
Bars	Search Bar		Content Views / Control	<b>Chips</b>
Navigation / Bars	Scope Bar		Content Views	<b>Data tables</b>
	<b>Content Views</b>			<b>Dialogs</b>
Temporary Views/ Content Views	Activity		Temporary Views	Alerts

Content Views	Activity View Controller		Temporary Views	Simple menus
Content Views	Collection View		Temporary Views	Simple dialogs
Content Views (No tiene imagen)	Container View Controller		Temporary Views	Confirmation dialogs
Content Views	Image View		Temporary Views	Full-screen dialogs
Content Views	Map View			<b>Dividers</b>
Content Views	Page View Controller		Controls	Full-bleed dividers
Content Views	Popover		Controls	Inset dividers
Content Views	Scroll View		Controls	Subheaders and dividers
Navigation / Content Views	Split View Controller		Content Views	<b>Grid lists</b>
Content Views	Table View		Content Views	Lists
Content Views	Text View			<b>Lists: Controls</b>
Content Views	Web View		Controls	List Controls - Checkbox
	<b>Controls</b>		Controls	List Controls - Switch
Progress & Activity / Controls	Activity Indicator		Controls	List Controls - Reorder
Controls	Contact Add Button		Controls	List Controls - Expand/collapse
Controls	Date Picker		Controls	List Controls - Leave-behinds
Controls	Detail Disclosure Button		Controls	Menu controls - Check
Controls	Info Button		Controls	Menu controls - Inline information
Controls	Label		Controls	Menu controls - Nested menu indicator
Progress & Activity / Controls	Network Activity Indicator		Navigation	<b>Menus</b>
Controls	Page Control			<b>Pickers</b>
Controls	Picker		Controls	Date pickers
Progress & Activity / Controls	Progress View		Controls	Time pickers

Progress & Activity/ Controls	Refresh Control			<b>Progress &amp; activity</b>
Controls	Rounded Rectangle Button		Progress & Activity	Linear
Controls	Segmented Control		Progress & Activity	Circular
Controls	Slider			<b>Selection controls</b>
Controls	Stepper		Controls	Checkbox
Controls	Switch		Controls	Radio button
Controls	System Button		Controls	Switch
Controls	Text Field			<b>Sliders</b>
	<b>Temporary Views</b>		Controls	Continuous slider
Temporary Views	Alert		Controls	Discrete slider
Temporary Views	Action Sheet		Temporary Views	<b>Snackbars &amp; toasts</b>
Temporary Views	Modal View			<b>Subheaders</b>
			Content Views	List subheaders
			Content Views	Grid subheaders
			Content Views	Menu subheaders
				<b>Tabs</b>
			Navigation	Fixed tabs
			Navigation	Scrollable tabs
				<b>Text fields</b>
			Controls	Single-line text field
			Controls	Floating labels
			Controls	Multi-line text field
			Controls	Full-width text field
			Controls	Character counter
			Controls	Auto-complete text field
			Controls	Search filter
			Bar	<b>Toolbars</b>
				<b>Tooltips</b>
				<b>Structure</b>
			Bar	App bar
			Bar	System bars
				Side nav
				Whiteframes

## 5.3 Web Tool

In order to facilitate the use of this classification categories, was made a web application operating as a tool for the developer and designer. The objective of the application is to serve as a centralized portal for all content of the design guidelines, with a general classification and shortcuts to each element of the guidelines.

### 5.3.1 Technology

To develop the site were used following technologies:

- Wordpress 4.2.2: Content Management System CMS
- PHP 5.4: Programming language on the server
- MySQL 5.5 : Database
- Apache 2.4.9: Web server
- A modified version of the theme GK Portfolio, with support of "Responsive Design" to allow the website to adapt to any device from which is accessed.

The website is a proof of concept that seeks to bring the categorization of contents of design guidelines through a web platform that is also compatible with all mobile devices. The tool is hosted on a private server under the following link: <http://jorgeisaac.com/guidelines>

### 5.3.2 Structure

The web tool is composed of four main sections which can be recognized in the figure, the elements that are displayed are designed as an information card with a link to its respective content. The sections are numerically identified in Figure 23:

*Categories menu [1]:* Top menu with all categories and sub categories.

*Content Area [2]:* Area where the items will be displayed

*Guidelines item [3]:* Information card of element Figure 24 it contains the name of the section [1], the link to the content [2] and an identifier of guideline (Android, iOS) [3]

*Search [4]:* Search bar, allows search by name of the elements.



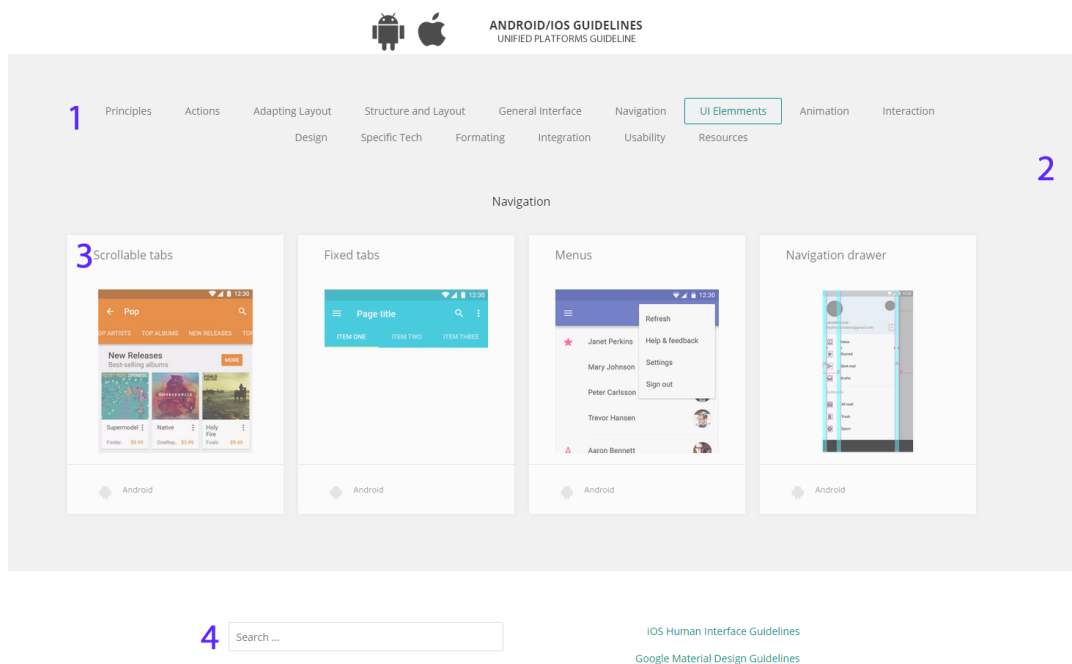


Figure 23 Unified Platform Guidelines, Sections

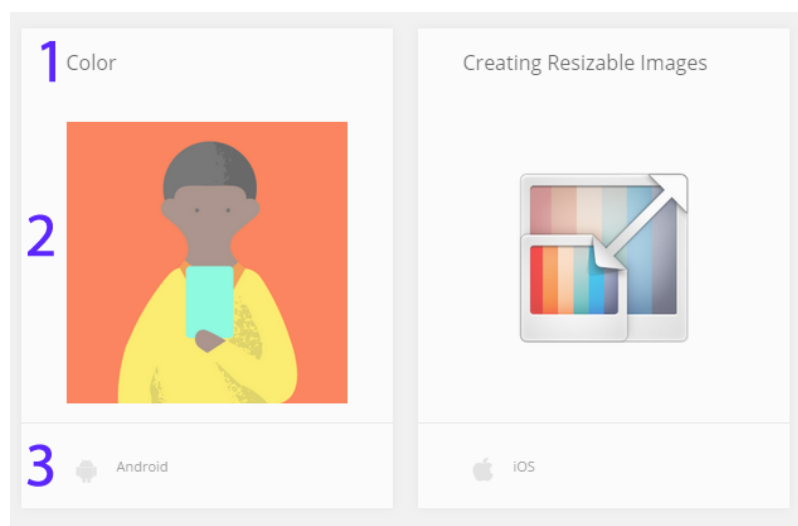


Figure 24 Item Sections

## 5.4 Study Design

The study was designed to assess impression participants after using the web tool in their normal daily activities. In order to complete the objectives of this study a longitudinal study with five participants was carried out. The participants for a period of three days used the tool as part of their daily activities, at the end of this trial period, users were asked to evaluate their satisfaction with regard to the tool. The participants were selected from a group of mobile developers in Ecuador. Each participant was given access to the tool and its operation was explained.

We have selected the attributes of usability that will be evaluated are Satisfaction, the absence of discomfort and positive attitude in the use of the product. It is therefore

a subjective factor. This variable is measured by gathering the impressions of users using satisfaction questionnaires.

#### 5.4.1 Usability Evaluation Methods

For the study we have selected as a method of evaluation of usability to satisfactions questionnaires, helping us to gathering impressions from users.

The purpose of this study is to apply two different questionnaires, even though they were performed during the same session, the questionnaire is divided into: The first part is a System Usability Scale (SUS) and the second part User Experience Questionnaire (UEQ).

SUS (System Usability Scale) is a 10-item Likert scale questionnaire that gives an overview of satisfaction with software (usabilitynet.org, 2015).The questionnaire provided the participants is in the Annex 9.7.

UEQ (User Experience Questionnaire) allows a quick assessment of the user experience of interactive products (UEQ-online, ). The format of the questionnaire allows to users express feelings, impressions, and attitudes that arise when they use a product. UEQ the satisfaction is divided in 6 scales: Attractiveness, Perspicuity, Efficiency, Dependability, Stimulation, and Novelty. The questionnaire provided the participants is in the Annex 9.7.

#### 5.4.2 Longitudinal Study

The longitudinal study was an uncontrolled environment without predefined tasks and users would use it freely for a time period.

*Users:* The participants of this study were five mobile applications developers working in the same office and who constantly consume the contents of the design guidelines platforms.

*Context of use:* The location for the study were the workplace of the participants during their daily activities. The participants entered the web using their computers and used the tool for a period of 3 days freely. The version of the web tool they used was the final version. The satisfaction questionnaires were submitted online to be completed by users after its testing period.

*Test Procedure:* The test location was in the user's workplace. Indications and presentation of the web tool were conducted by videoconference. Users were informed that they had 3 days to use the tool in order to access the content of the guidelines of Android and iOS. At the end of the testing period would complete a questionnaire. There were no scenarios or defined tasks, users were free to use the tool.

*Metric:* The variables of usability measures are Satisfaction. Satisfaction is a measure that reflects the user's impressions after using the system and answer the questionnaire. The questionnaires used SUS, UEQ. See Appendix.

## 5.5 Results

In this chapter the results obtained in the longitudinal study about the web tool are presented. The study was conducted with a group of five members of the development team for mobile applications was formed by developers and designers, this is the same team that participated in the heuristic evaluations, their daily work is to develop and maintain some mobile applications.

All participants are professional developers in the industry, they are currently working on applications that are published in the shops of the platforms. As it was mentioned in the study design the participants used the web tool for your daily working time (longitudinal study) and after that trial period filled two questionnaires of satisfaction.

The following section contains the results obtained by this study.

### 5.5.1 UX Measurement via Questionnaires

The participants completed the longitudinal study survey after having used the web tool for 3 days. From all participants, 100% indicated know about iOS Human Interface Guidelines, 75% know about Android Design Guidelines and 50% specifically about Material Design. Figure 25

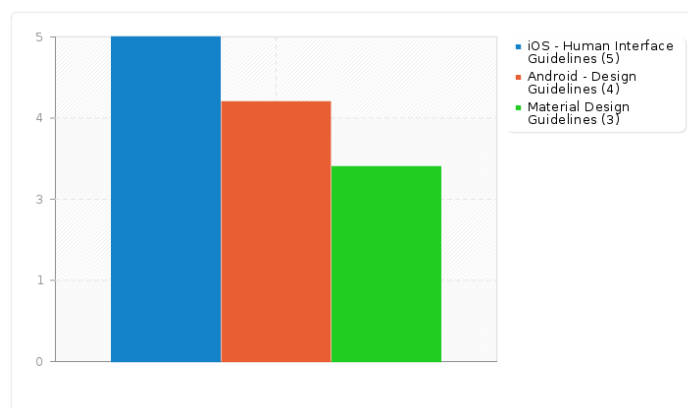
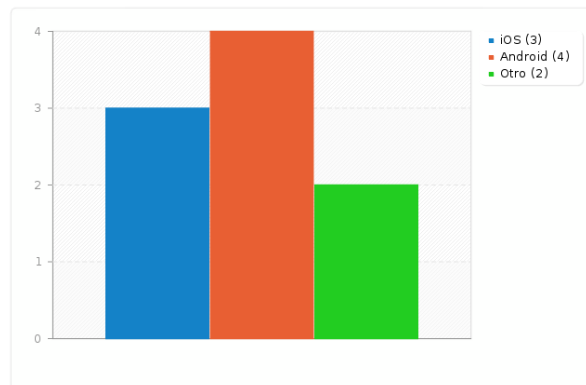


Figure 25 Do you know anything about the Android or iOS UI guidelines?

From all participants 75% had experience developing mobile applications, 25% had no experience in development but they knew about the prototype design. From they had experience in developing 100% had developed experience on iOS and Android, 66.7% had also developed experience on Blackberry. Figure 26. The

experience of participating in development of mobile applications was between 1 and 4 years.



*Figure 26 What platform have you developed for?*

The assessment of user satisfaction performed with System Usability Scale (SUS) overall gave a score of 64.5 it would be slightly below average, but if we analyse the individual data we have a score of 80 high above the average and two of 70, 75 that are above the average. There are two cases in which the score is low and very low, 64 and 32, the first is slightly below the average and 32 if it is below the average. Table 5.5

*Table 5.5 SUS Results for Web Tool*

<b>Users</b>	<b>SUS Score</b>
<b>P1</b>	80,0
<b>P2</b>	32,5
<b>P3</b>	65,0
<b>P4</b>	70,0
<b>P5</b>	75,0

The Table 5.6 shows the information obtained by the UEQ about usage analysis of the tool during the test period. After completing the test period the participants considered that attractiveness, efficiency, stimulation and novelty are Above Average and they were considered as excellent the perspicuity and dependability.

Table 5.6 UEQ Results for Web Tool

Scale	Mean	Comparisson to benchmark	Interpretation
Attractiveness	1,35	Above average	25% of results better, 50% of results worse
Perspiciuity	1,85	Excellent	In the range of the 10% best results
Efficiency	1,25	Above Average	25% of results better, 50% of results worse
Dependability	1,7	Excellent	In the range of the 10% best results
Stimulation	1,45	Above Average	10% of results better, 75% of results worse
Novelty	0,95	Above Average	25% of results better, 50% of results worse

### 5.5.2 Analysis

Regarding the usability of the tool measured with the SUS questionnaire, the overall score of all participants is slightly below average for the tool, but there is a single value considerably lower than could affect the overall average. Excluding this value the rest of the evaluations are positive for the tool, although it is probably not possible to ensure that a participant with little knowledge about the platforms design guidelines found difficulty using the tool, because it would have a classification a little bit unknown from their experience. Otherwise the participant to know in depth the content of the guidelines could you quickly familiarize yourself with the tool. To determine these statements it would be necessary to conduct an experiment and to compare this tool with each of the guidelines.

Regarding satisfaction measured users with the UEQ then questionnaire test period, for 6 variables measured, the participants rated the tool above average, and the perspicuity and stimulation variables obtained a rating of excellent, which indicates the ease with which the user is familiarized himself with the product and felt the motivation to use it.

## 6 Discussion

To appreciate the impact of our work and subsequent applications of the results, we need to discuss areas in which our efforts have important significance. After discussing the important stages that this research has covered and which are described in previous chapters, such as: establishing heuristics for mobile applications using a methodology that extracts principles from platforms guidelines, evaluating mobile applications and analysing the results of the evaluations and the impressions of the evaluators, and finally carrying out a content classification for platform guidelines.

### 6.1 Supporting Usability Heuristic Creation

The method described in this research allows the creation of usability heuristic for mobile applications evaluation. This work aimed to enrich the traditional heuristics with the principles provided by the guidelines platforms, it is also possible that the source of the principles, guidelines and best practices could vary depending on the needs of the application. The method described in the present work (see Chapter 4) provides the steps for creating usability heuristics, this could be extended to other guidelines or particular domains, and the method would not change. Currently it is common that heuristics used in the heuristic evaluation of mobile applications are the same as have been used in traditional systems, although many of the principles that today are described in the guidelines have their origin on the traditional heuristics, the approach has currently changed significantly, not only by the kind of technology that covers but also due to the paradigm shift between the user and the system, and it is extremely necessary to have heuristics that cover this paradigm shift.

This work provides a tool for evaluators in order to allow them to generate heuristics related to the principles or best practices of mobile applications, even if this approach could be applied in different types of applications for mobile devices, not only smartphones .

### 6.2 Supporting Mobile Heuristic Evaluation

The method described in this work (see Chapter 4) provides the steps necessary to perform a heuristic evaluation to mobile applications. Annex 9.2, 9.3, 9.4, 9.5, 9.6 provides the forms and all the material needed by the evaluators to conduct an evaluation. Our work provides valuable information for testing, presents a study that demonstrates the use of heuristics for mobile applications as well as the procedure of the evaluation and all necessary materials for evaluation. As evaluation results usability incidents were obtained, the impressions of the evaluators about the evaluation process and the scope of the heuristics for mobile applications were also collected and analysed. The purpose of our work is to

minimize the context gap between traditional heuristics and the mobile applications heuristics, linking them with to the official sources which is used by developers and designers. The information provided by the evaluators regarding the process serves as a source for further research and improvements on the process, this first scope got good impressions from the evaluators.

### **6.3 Guideline Content Classification**

For developers who are interested in fulfilling the principles, best practices that are provided by the guidelines of the platforms, our work provides a tool that classifies the content of the guidelines of Android and iOS and displays it in a web application, helping in the search of information. The classification of content that has this tool was clearly detailed in Chapter 5, and the tool was evaluated by a group of developers who provided their impressions and improvements for the tool.

An important aspect in the use of this tool is to facilitate developer or designer of mobile applications to access the content of both guidelines. In our research this access is classified according to general criteria. Our work addresses the problem faced by designers or developers when they work on a mobile application supported by both platforms, and it is necessary to have the tools and clear information in order to avoid losing any details or mixing the concepts of each platform. The approach is to complete the circle in the design starting from the concept and design, based on the principles and best practices up to the evaluation.

### **6.4 Integration in the design process**

Our study has described methods and tools which can be used as techniques within the stages of design and evaluation of mobile applications. Within a design process with a UCD approach, how our research would fit? In chapter 2 was discussed the way in which heuristic evaluation forms part of the activities within a UCD process.

Our work provides: A method for generating mobile applications heuristics, necessary information to conduct a heuristic evaluation, a tool to access to the content of the guidelines under a common classification. The Figure 1 shows the stages of UCD: Planning, context of use, requirements, design, and evaluation. In the stage of design the use of the web tool would fit, in the evaluation stage the definition of new heuristics and heuristic evaluation would fit. But it is likely that the definition of new heuristics can be an activity previously performed during requirements activities, because the needs and requirements of the application are explored there. The list of heuristics could provide useful information for design activities.

## **6.5 Limitations of the study**

During the stages of this study it was necessary to validate the results of each stage by participants. Collecting their impressions about our work, provided the necessary information to improve at every stage, but there were limitations that need to be considered for future research. Although the participants knew about usability evaluation, we cannot qualify them as experts in heuristics, reason for which we were limited to perform an expert's evaluation about the process. The number of participants was also a limiting factor when performing evaluations, especially for the study of usability for the web tool. About the heuristic evaluation, with a greater number of evaluators we could carry out an informal evaluation on the granularity and effectiveness of the proposed set of heuristic mobile applications.



## 7 Conclusions and Future Work

### 7.1 Introduction

Having defined and evaluated a set of heuristics, and an accompanying web tool, this section presents the conclusions of the work carried out and identifies the lines for further work.

### 7.2 Conclusions

We conducted a survey in order to determine the current status of usability activities in the industry, in which we find:

- The guidelines or standards, product style guide and card sorting are the most commonly methods used into the design phase, the industry uses the Android and iOS guidelines.
- The heuristic evaluation can be found within the most common methods of evaluation along with: analysis of user feedback, interviews to users and UX questionnaires.
- For perform a heuristic evaluation of mobile applications, the Nielsen heuristics are widely used, although its limitations are known in the field of mobile applications.

A method for defining mobile applications heuristics was presented, enriching the Nielsen heuristics with the principles and good practices extracted from Android and iOS guidelines.

A case study was performed in order to evaluate four mobile applications using a set of heuristics and to gather the evaluators' impressions about the process and the set of heuristics.

Several type of usability issues were recorded during the heuristic evaluation of mobile applications, which were ranked using a scale of criticality. The evaluators found the evaluation process quite easy to apply, and the set of heuristics for mobile applications were labelled as very useful.

A classification of the content of the guidelines was presented and used in order to create a web tool, which supports the developer or designer for access to the contents of the guidelines.

The web tool was evaluated by a team of developers that ranked it in average terms of user satisfaction, and excellent regarding the perspicuity and stimulation.

### 7.3 Future lines of research

The field of heuristics applied to specific domains is relatively new, this work is focused on using platform guidelines as sources of information, but it could be extended using additional sources of information.

Other possible promising lines of research are:

- To experiment with the granularity of the heuristics: An experiment with a group of evaluators with different levels of experience and knowledge about heuristics could be designed, using heuristics with high and low granularity, to determine if the granularity affects the outcome of the evaluation according to the experience of the evaluator.
- To experiment with the scope of the heuristics on different domains: This study was focused on mobile applications regardless of domain, there are very specific domains that might require customization of the heuristic, for example games, accessibility applications, virtual reality applications, maps, etc. In the case of particular domains, the list of heuristics could be enriched by the principles that govern those domains.
- To include additional platforms: As mentioned above, the heuristics presented in this paper focus on the two main platforms Android and iOS. They possibly could be extended to other platforms
- To particularize to specific devices: This study was focused on applications for smartphones, the heuristics could also be focused on applications for specific devices such as: Tablets, Smartwatch, Smart TV, etc.

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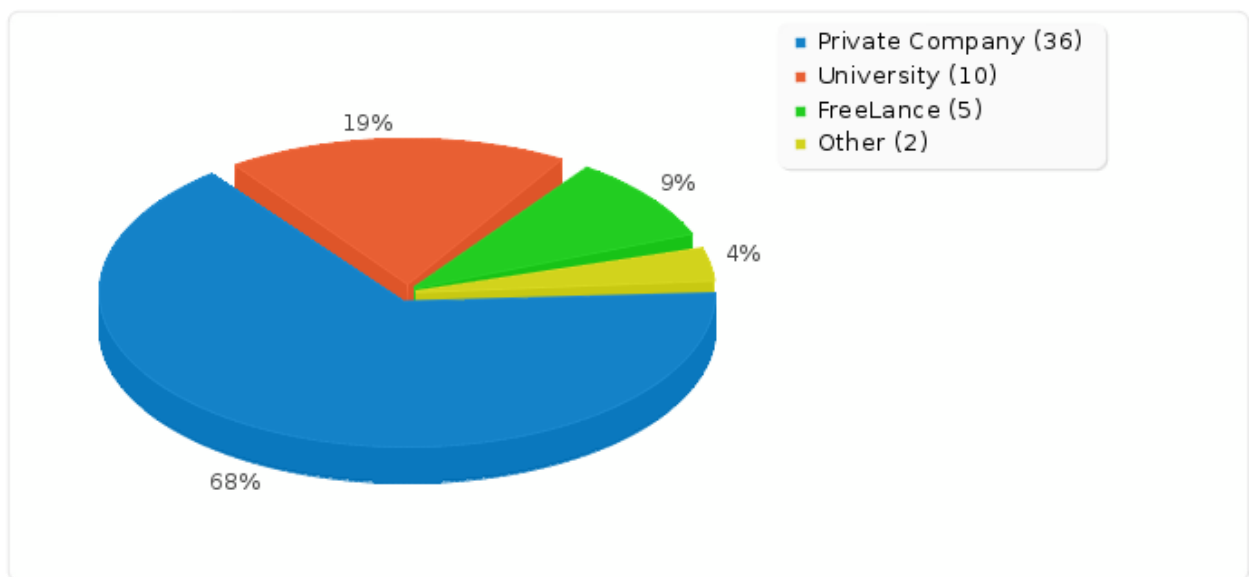
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## 9 ANNEXS

### 9.1 Result of the Survey on Usability and UX Practices in Mobile Applications Development

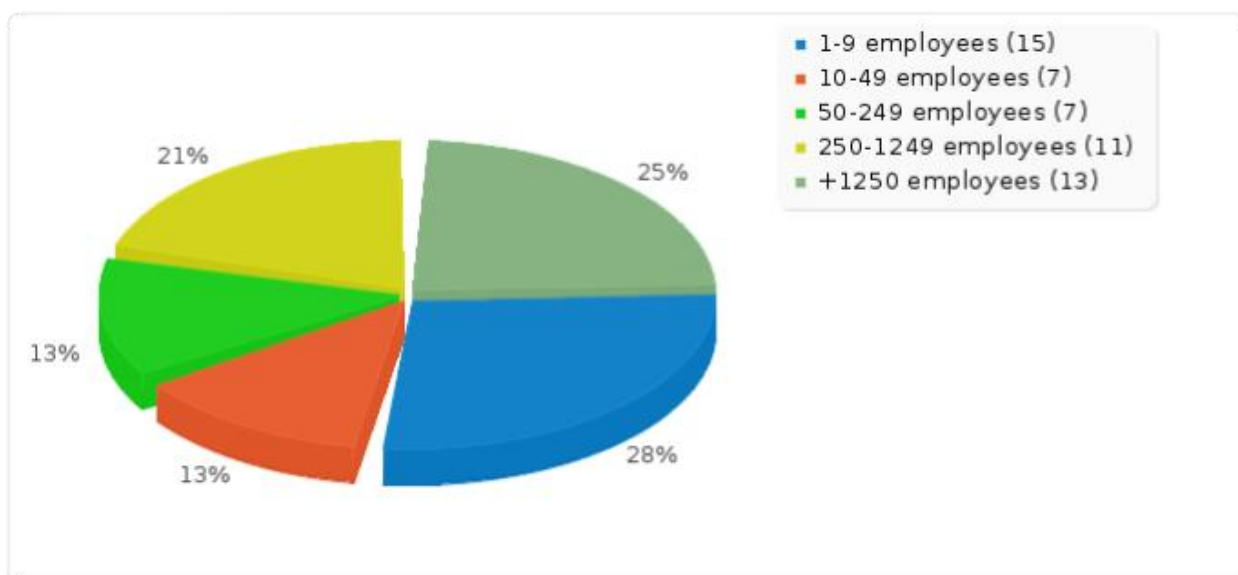
1 Please state the type of organization you work for?

Answer	Count	Percentage
Private Company	36	67.92%
University	10	18.87%
FreeLance	5	9.43%
Research	0	0.00%
Other	2	3.77%



## 2 How many people are employed in the organization? (Number of employees)

Answer	Count	Percentage
1-9 employees	15	28.30%
(+1250 employees)	13	24.53%
250-1249 employees	11	20.75%
10-49 employees	7	13.21%
50-249 employees	7	13.21%
No answer	0	0.00%

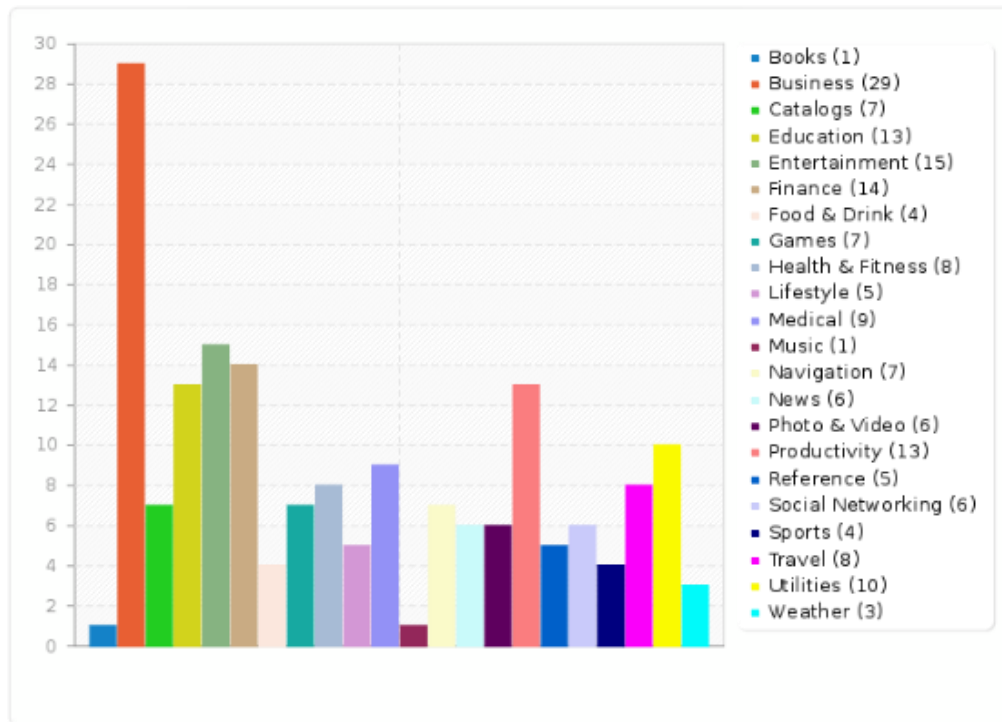


## 3 Please state the category of mobile applications developed

Answer	Count	Percentage
Business	29	54.72%
Entertainment	15	28.30%
Finance	14	26.42%
Education	13	24.53%
Productivity	13	24.53%

<b>Utilities</b>	<b>10</b>	<b>18.87%</b>
<b>Medical</b>	<b>9</b>	<b>16.98%</b>
<b>Health &amp; Fitness</b>	<b>8</b>	<b>15.09%</b>
<b>Travel</b>	<b>8</b>	<b>15.09%</b>
<b>Catalogs</b>	<b>7</b>	<b>13.21%</b>
<b>Games</b>	<b>7</b>	<b>13.21%</b>
<b>Navigation</b>	<b>7</b>	<b>13.21%</b>
<b>News</b>	<b>6</b>	<b>11.32%</b>
<b>Photo &amp; Video</b>	<b>6</b>	<b>11.32%</b>
<b>Social Networking</b>	<b>6</b>	<b>11.32%</b>
<b>Lifestyle</b>	<b>5</b>	<b>9.43%</b>
<b>Reference</b>	<b>5</b>	<b>9.43%</b>
<b>Food &amp; Drink</b>	<b>4</b>	<b>7.55%</b>
<b>Sports</b>	<b>4</b>	<b>7.55%</b>
<b>Weather</b>	<b>3</b>	<b>5.66%</b>
<b>Books</b>	<b>1</b>	<b>1.89%</b>
<b>Music</b>	<b>1</b>	<b>1.89%</b>





#### 4 What is the location of your organization?

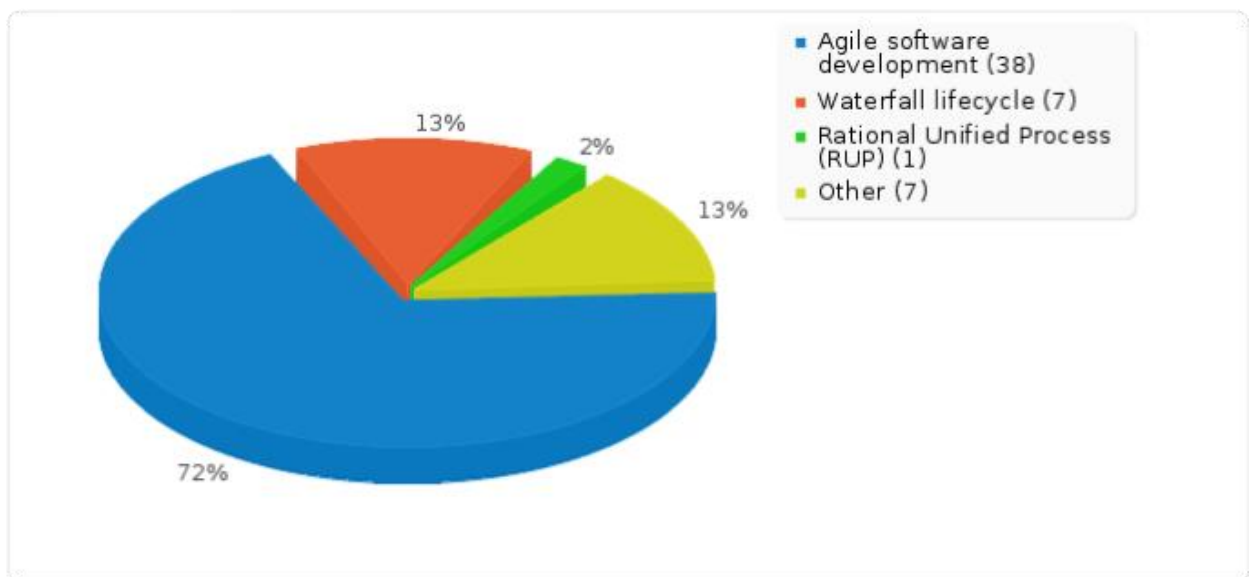
Country	# Pax
Argentina	1
Australia	2
Austria	2
Belgium	1
Brazil	1
Chile	1
Colombia	2
Costa Rica	19
Czech Republic	1
Ecuador	5
Germany	1
Greece	2

<b>India</b>	<b>6</b>
<b>Israel</b>	<b>1</b>
<b>Ireland</b>	<b>1</b>
<b>Mexico</b>	<b>2</b>
<b>New Zealand</b>	<b>1</b>
<b>Portugal</b>	<b>3</b>
<b>Slovakia</b>	<b>2</b>
<b>South Africa</b>	<b>1</b>
<b>Spain</b>	<b>25</b>
<b>Switzerland</b>	<b>1</b>
<b>United Kingdom</b>	<b>1</b>
<b>USA</b>	<b>11</b>
<b>Venezuela</b>	<b>1</b>



**5. Please state the software development methodology or approach you follow in your organization**

Answer	Count	Percentage
Agile software development	38	71.70%
Waterfall lifecycle	7	13.21%
Other ( agile + UCD UX + Agile, UML,spiral,DIU- Similar Agile it depends on the project redmine)	7	13.21%
Rational Unified Process (RUP)	1	1.89%



**6. Please state to what degree usability is managed in your organization in the different development activities [Requirement Activities]**

Answer	Count	Percentage
Never	1	1.89%
Sometimes	22	41.51%
Very Often	17	32.08%

Always	13	24.53%
No answer	0	0.00%

**7. Please state to what degree usability is managed in your organization in the different development activities. [Design Activities]**

Answer	Count	Percentage
Never	0	0.00%
Sometimes	16	30.19%
Very Often	20	37.74%
Always	17	32.08%
No answer	0	0.00%

**8. Please state to what degree usability is managed in your organization in the different development activities. [Evaluation Activities]**

Answer	Count	Percentage
Never	3	5.66%
Sometimes	18	33.96%
Very Often	18	33.96%
Always	14	26.42%
No answer	0	0.00%

**9. Please state to what degree usability is managed in your organization in the different development activities. [Deployment Activities]**

Answer	Count	Percentage
Never	5	9.43%
Sometimes	21	39.62%

Very Often	16	30.19%
Always	11	20.75%
No answer	0	0.00%

**10. How often the following usability activities are carried out in your organization? - [Product Concept Design]**

Answer	Count	Percentage
Never	4	7.55%
Sometimes	14	26.42%
Very Often	20	37.74%
Always	15	28.30%
No answer	0	0.00%

**11. How often the following usability activities are carried out in your organization? - [User and Task Analysis]**

Answer	Count	Percentage
Never	7	13.21%
Sometimes	15	28.30%
Very Often	21	39.62%
Always	10	18.87%
No answer	0	0.00%

**12. How often the following usability activities are carried out in your organization? - [Usability Requirements Specification]**

Answer	Count	Percentage
Never	9	16.98%
Sometimes	16	30.19%

Very Often	17	32.08%
Always	11	20.75%
No answer	0	0.00%

**13. How often the following usability activities are carried out in your organization? - [Prototype Usability Testing]**

Answer	Count	Percentage
Never	10	18.87%
Sometimes	17	32.08%
Very Often	15	28.30%
Always	11	20.75%
No answer	0	0.00%

**14. How often the following usability activities are carried out in your organization? - [Usability Testing with Users]**

Answer	Count	Percentage
Never	12	22.64%
Sometimes	16	30.19%
Very Often	16	30.19%
Always	9	16.98%
No answer	0	0.00%

**15. How often the following usability activities are carried out in your organization? - [Usability inspection (by experts)]**

Answer	Count	Percentage
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<b>Never</b>	<b>18</b>	<b>33.96%</b>
<b>Sometimes</b>	<b>16</b>	<b>30.19%</b>
<b>Very Often</b>	<b>10</b>	<b>18.87%</b>
<b>Always</b>	<b>9</b>	<b>16.98%</b>
<b>No answer</b>	<b>0</b>	<b>0.00%</b>

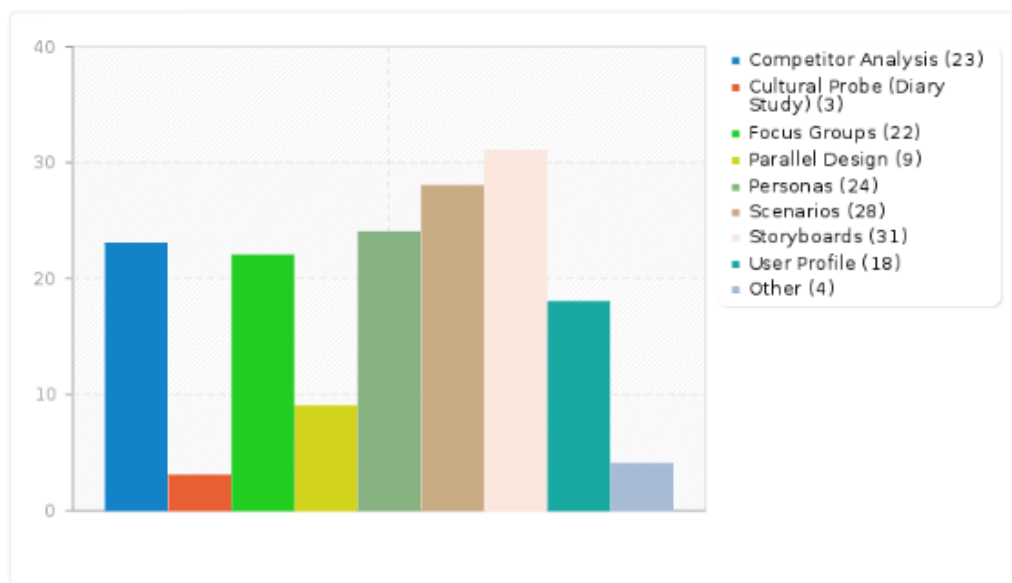
**16. How often the following usability activities are carried out in your organization? - [Usability Study of Installed Systems]**

<b>Answer</b>	<b>Count</b>	<b>Percentage</b>
<b>Never</b>	<b>19</b>	<b>35.85%</b>
<b>Sometimes</b>	<b>23</b>	<b>43.40%</b>
<b>Very Often</b>	<b>9</b>	<b>16.98%</b>
<b>Always</b>	<b>2</b>	<b>3.77%</b>
<b>No answer</b>	<b>0</b>	<b>0.00%</b>

**17. Please mark the methods used at least once in your organization in requirements-related activities**

<b>Answer</b>	<b>Count</b>	<b>Percentage</b>
<b>Storyboards</b>	<b>31</b>	<b>59.62%</b>
<b>Scenarios</b>	<b>28</b>	<b>53.85%</b>
<b>Personas</b>	<b>24</b>	<b>46.15%</b>
<b>Competitor Analysis</b>	<b>23</b>	<b>44.23%</b>
<b>Focus Groups</b>	<b>22</b>	<b>42.31%</b>
<b>User Profile</b>	<b>18</b>	<b>34.62%</b>
<b>Parallel Design</b>	<b>9</b>	<b>17.31%</b>

Other(customer journey Contextual Inquiry Use case PROTOTYPE	4	7.69%
Cultural Probe (Diary Study)	3	5.77%

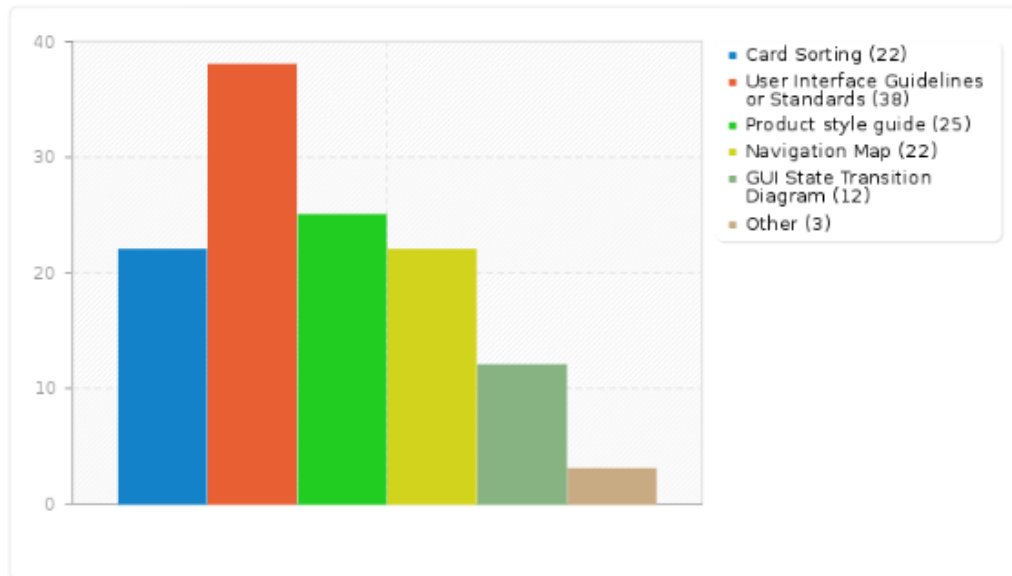


**18. Please mark the methods used at least once in your organization in design-related activities**

Answer	Count	Percentage
User Interface Guidelines or Standards	38	71.70%
Product style guide	25	47.17%
Card Sorting	22	41.51%
Navigation Map	22	41.51%
GUI State Transition Diagram	12	22.64%
Other (Content Strategy and HFP mockups)	3	5.66%

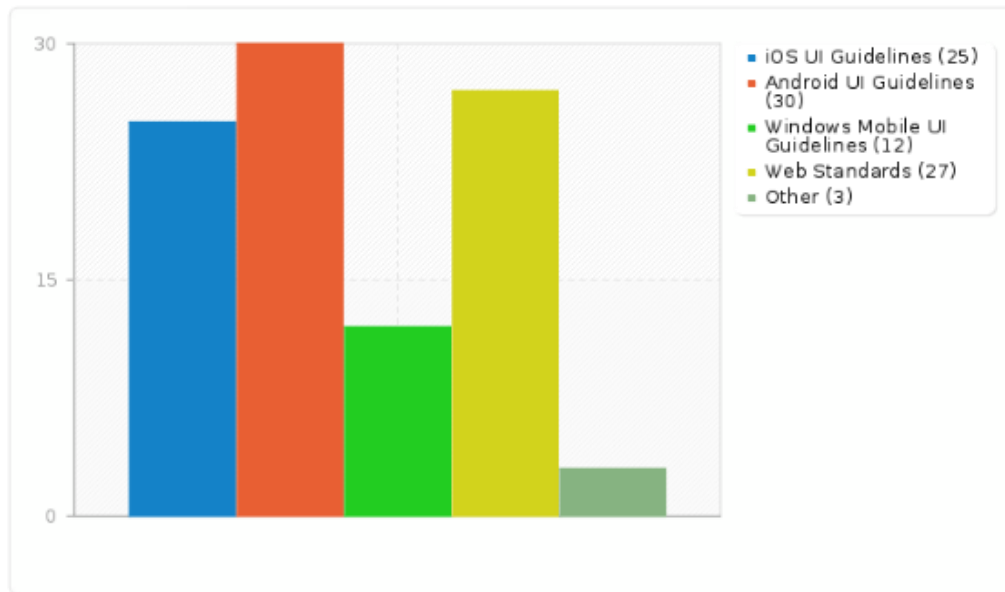


None)		
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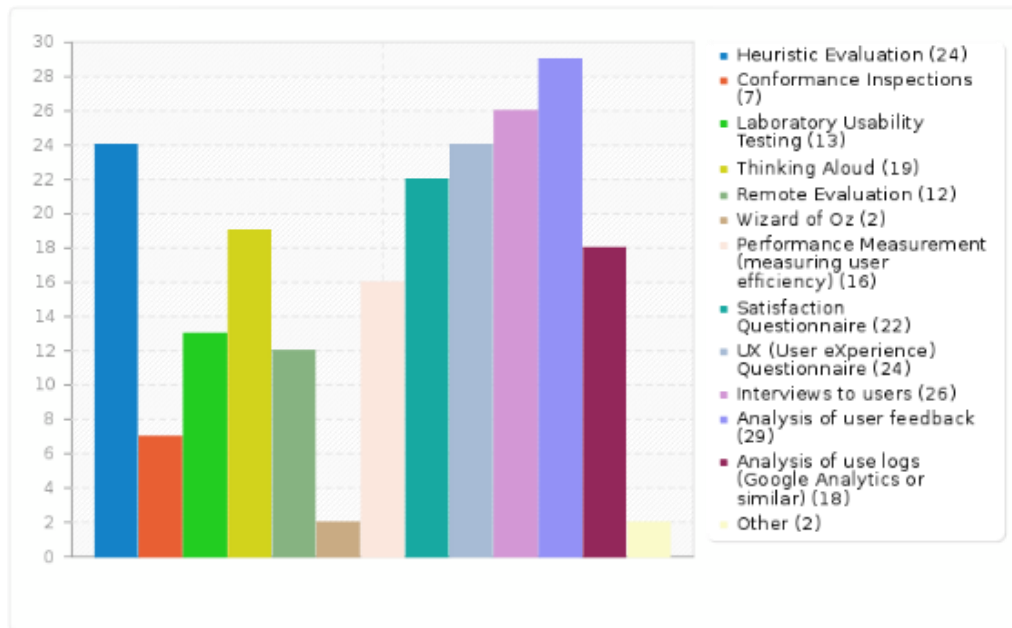
**19. Please mark the User Interface Guidelines used at least once in your organization**

Answer	Count	Percentage
Android UI Guidelines	30	78.95%
Web Standards	27	71.05%
iOS UI Guidelines	25	65.79%
Windows Mobile UI Guidelines	12	31.58%
Other ( Google Material Design Libr Blanco Siesta, sello SIMPLIT Internal standards)	3	7.89%



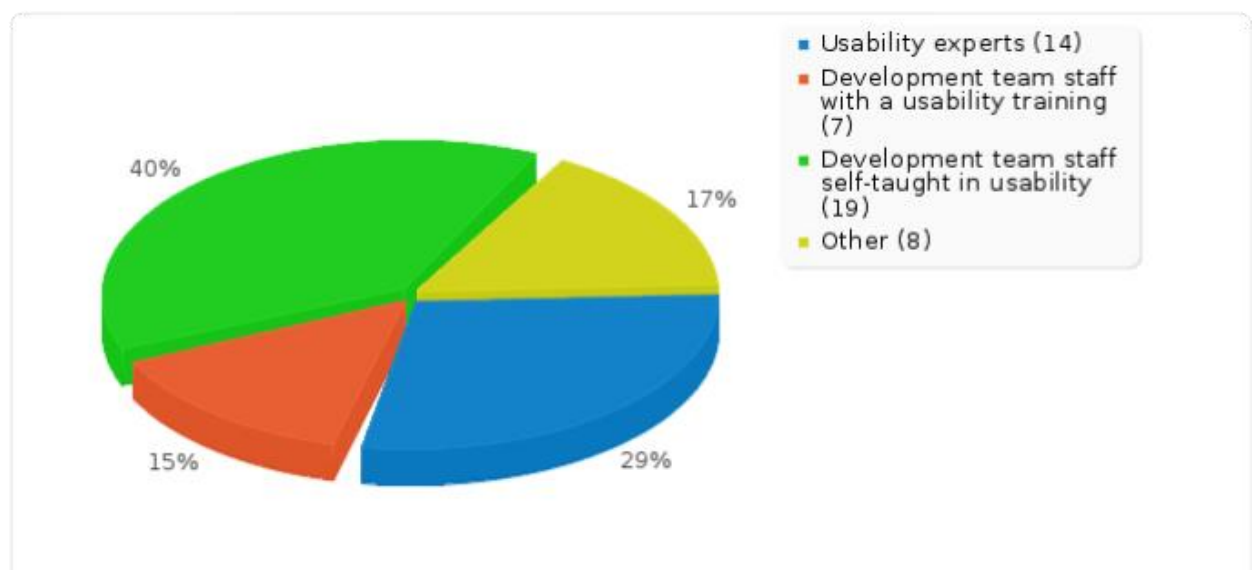
**20. Please mark the usability methods used at least once in your organization in evaluation-related activities**

Answer	Count	Percentage
Analysis of user feedback	29	58.00%
Interviews to users	26	52.00%
Heuristic Evaluation	24	48.00%
UX (User eXperience) Questionnaire	24	48.00%
Satisfaction Questionnaire	22	44.00%
Thinking Aloud	19	38.00%
Analysis of use logs (Google Analytics or similar)	18	36.00%
Performance Measurement (measuring user efficiency)	16	32.00%
Laboratory Usability Testing	13	26.00%
Remote Evaluation	12	24.00%
Conformance Inspections	7	14.00%
Wizard of Oz	2	4.00%
Other (none,usability survey)	2	4.00%



## 21. Who was in charge of applying usability methods?

Answer	Count	Percentage
Development team staff self-taught in usability	19	39.58%
Usability experts)	14	29.17%
Other (UX Designers,developer,no one - ad hoc,UX designer,Only sometimes,someone with empiric knowledge)	8	16.67%
Development team staff with a usability training	7	14.58%



**22. To what extent usability method application was integrated with the overall development process?**

Answer	Count	Percentage
Completely apart from the rest of activities in the overall development process	5	10.42%
Very low integration	13	27.08%
Low integration	14	29.17%
Highly integrated with the rest of activities in the development process	16	33.33%
No answer	0	0.00%

**23. To what extent usability method application had a positive impact in the overall development time?**

Answer	Count	Percentage
Never	3	6.25%
Rarely	8	16.67%
Sometimes	20	41.67%
Often	17	35.42%
No answer	0	0.00%

**24. How many evaluators are involved in conducting a heuristic evaluation?**

Answer	Count	Percentage
1	5	20.83%
2	5	20.83%
3	2	8.33%
> 4	5	20.83%
No answer	7	29.17%

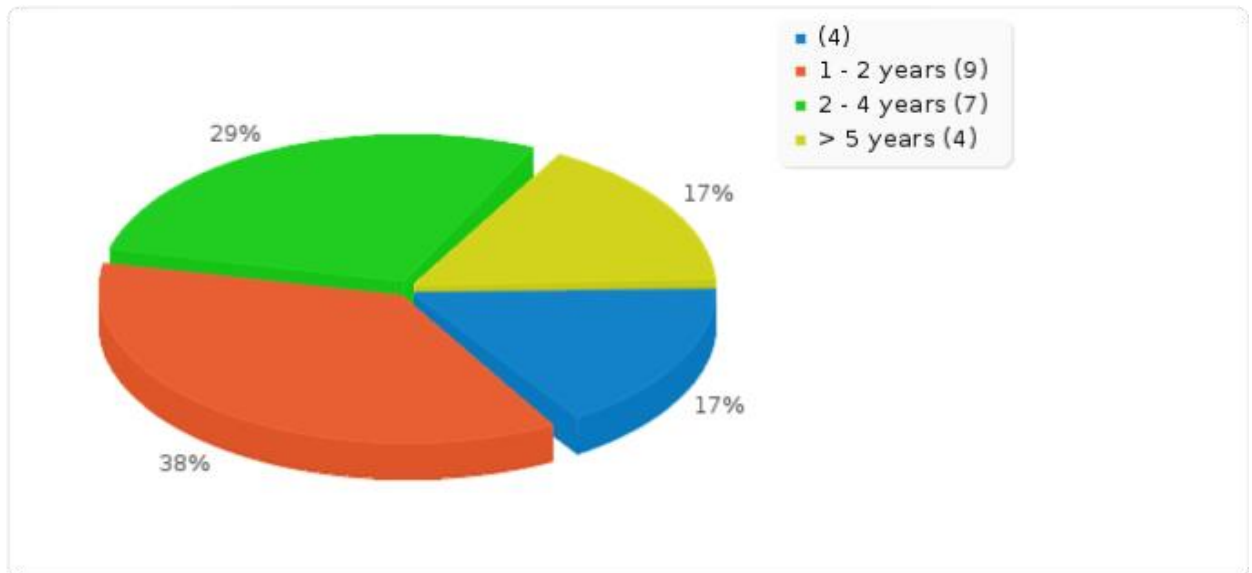
**25. List the different sets of heuristics used in the evaluation. For example: Nielsen's or Connel & Hammonds'.**

Heuristics List
Jakob Nielsen's
As suggested by NN group
Nielsen's
Nielsen, SImplit
Heuristics based on SIRIUS heuristics ( <a href="http://www.sciencedirect.com/science/article/pii/S0164121212002993">http://www.sciencedirect.com/science/article/pii/S0164121212002993</a> )
Nielsen & Pierotti
unknown
Nielsen
Nielsen's
Nielsen's
Nielsen's
Nielsen (overall), Bertini (mobile)
Nielsen's
Nielsen

**26. Which is the average experience in conducting heuristic evaluations for evaluators in your company ?**

Answer	Count	Percentage
> 1 year	4	16.67%
1 - 2 years	9	37.50%
2 - 4 years	7	29.17%

> 5 years	4	16.67%
No answer	0	0.00%



## 27. Briefly describe the process of conducting a heuristic evaluation

The answers to this question are not public

## 28. What do you think are the benefits of heuristic evaluation?

The answers to this question are not public

## 29. What do you think are the disadvantages of heuristic evaluation?

The answers to this question are not public

## 30. Do you think heuristic usability evaluation applied to mobile applications differs in some way with heuristic evaluation applied to desktop or web applications? If so, how?

Answer
Click enable and touch enabled devices respond differently. Accordingly we may add or modify some of the heuristics. Though the NN heuristics are quite valid for any kind of interactive digital device.

No
NO
Yes as heuristics has to be apadted to this particular context of use
Yes. Requires specific guidelines, which are hard to find/adapt to current developments.
Some look different animal
Si que difiere ya que se trata de contextos distintos que requieren criterios de evaluación distintos. Tambien porque al ser nuevos requieren que analicemos qué formas pueden tomas (algunas de ellas incluso las podemos desconocer a día de hoy... las tenemos que investigar!!)

### 31. What do you think is needed in order to improve the usability level of mobile applications (if any)?

Answer
1. Clarify the tasks, scope and to do's for all the team members 2. Work based in methodologies 3. Research and analysis cycles
Take the user's nerd into consideration
I think the most important focus should be on minimizing the touches need to be done on accomplishing the task. just replace click with touch but both are costlier from market/usability point of view. Touch enabled devices provides opportunity to create exciting interaction patterns which at the same time challenging too. BookMyShow and NewsHunt WhatsApp etc mobile apps are the good examples.
A better access to evaluation technique information for devs and experts
I think we need to be conscious that the usability should be considered in the app development. Some apps are developed without usability analysis.
More resources for design
The heurictics techniques are not applied in the organization
Utilizar la certificación SIMPLIT y el libro blanco de SIESTA en el diseño de aplicaciones para móviles
Better heuristics definitions, participatory heuristics evaluations
Mobile applications development should require a stage of usability testing and planning in order to develop user centered apps that meet the expectations of target users. For this, the development of personas, escenarios and performing meetings with prospective users of the app can help increase the acceptance rate of the mobile app.
More practice knowledge, common people testing the apps
A serious consideration by Business and Stakeholders of the value of a UX department in the

company, for the improvement of the app.
the mobile applications we develop are for internal employee use only - not for external users. We need to take our internal UX as seriously as we take our external UX. We don't currently apply the same rigor and importance to our internal applications as we do to our external-facing products.
the he have not been applied in mobile.
we didnot implement
More proper heuristics Better user activity logging
Hardware match
Attitude from the team a clear understanding of the common goals a clear idea for the users needs - add value! integrate the app within the other services
Awareness of using HCI principles from the ground up and not applying them just as an afterthought.
To study the reaction of the non-technological users.
Entender la naturaleza del contexto y aplicar criterios de ergonomía y accesibilidad (no solo para discapacitados o gente mayor, sino para todos). De nada sirve una interfaz bien resuelta si el aparato con el que accedemos no encaja con cómo podemos utilizar los dispositivos en situaciones de movilidad. En este sentido la interacción gestual puede tener un gran papel (y lo está teniendo mediante tecnologías de reconocimiento de voz por ejemplo)
Methods are rarely used in this organization. Usability is considered only in a very low degree. The organization is still a mall software shop with deficiencies in other areas of he SW lifecycle which are being addressed incrementally.

### 32. What do you think is needed to improve the effectiveness of heuristic evaluations applied to mobile applications?

Answer
Any heuristic evaluation should always be focused on LOOK, FEEL and USABILITY of the product. Further if it needs to be layered then LOOK can have parameters Credibility, Trust and Harmony FEEL can have parameters Interaction, Reaction Usability can have parameters Functionality, Individuality and Predictability If a product does well with these parameters then it will definitely be one of the best.
Nothing special
Realizar como mínimo 10 iteraciones con distintos tipos de usuarios, en cada iteración se rediseña y mejora el prototipo hasta que se simplifique al máximo



More proper heuristics
not always is the same
Saber comprender y trasladar estas relaciones entre criterios. entender las "escalas de grises" y saberlas transferir a una solución de UX

### **33. Please specify your job title:**

The answers to this question are not public

### **34. Additional comments**

The answers to this question are not public

## 9.2 Individual Heuristic Evaluation - Instructions

### Overview

Heuristic evaluation is a method for finding the usability problems in user interface design follow a list of established usability heuristics. The aim is to determine if the interface conform to these heuristics. These heuristics are a new list based on 10 heuristics presented by Jakob Nielsen (<http://www.nngroup.com/articles/ten-usability-heuristics/> ) and adjusted for evaluating mobile applications including the principles provided by the official guidelines of Android and iOS. The intent is to identify as issues as possible in allotted time.

### Instruction

As evaluator, you will browse through each part of a prototype or application mobile, assess compliance with each part of the design, notice if there are violations of the heuristics, identify the context in which the problem was discovered, and register your discovery.

### Materials provided for heuristic evaluation

1. **Heuristic Evaluation – Instructions:** This document.
2. **Heuristic Evaluation – Check List:** It contains a detailed list of heuristics to be used to conduct the evaluation.
3. **Heuristic Evaluation – Record Sheet:** Sheet to register issues found.
4. **Heuristic Evaluation Post-evaluation Questionnaire:** Questionnaire to be filled after completing heuristic evaluation.

### Procedure for heuristic evaluation

1. Recognize the materials provided, 4 different documents including instructions.
2. Please have your mobile device with the application will be evaluated.
3. Please read the document "Heuristic Evaluation - Checklist".
4. Check the start time.
5. If the application does not have a navigation map, identify a starting point and browse through each part of the mobile application.
6. During each navigation, assess the compliance of each part of the design, find any violation of the heuristics.
7. If an issue is found:
  - 7.1. Records the problem on "Heuristic Evaluation – Record Sheet", include it in the row related to the heuristic.
  - 7.2. Write a brief description of issue and identifies the context of how it was discovered (e.g., what screen was it on);

- 7.3. Rate the issue using one of the six values of the rating scale for severity table. (Heuristic Evaluation Checklist)
  - 7.4. Number your issue in order to match the information between columns.
- 
- 8. After the evaluation, check the end time and uses the document “Heuristic Evaluation Post-evaluation Questionnaire” to register your opinions about the process.

### 9.3 Heuristic Evaluation Check List

Evaluation Code: \_\_\_\_\_

This check list has been supplied as a reading aid to the Heuristic Evaluation method and as a reminder for the evaluation.

#### Rating scale for severity of usability issues

<b>Cosmetic:</b> Will not affect usability. Fix if possible.	1
<b>Minor:</b> Users can easily work around the problem. Fixing this should be given low priority.	2
<b>Medium:</b> Users stumble, but quickly adapt.	3
<b>Major:</b> Users have difficulty, but are able to find workarounds. Fixing this should be mandatory.	5
<b>Catastrophic:</b> Users are unable to work. Fixing mandatory.	5
<b>Not Applicable</b>	NA

#### Heuristic Evaluation Check List (Code, Description)

##### MA01. Make system status visible - Visibility of system status

- Always keep users informed about what is going on.
- Provide appropriate feedback within reasonable time.
- Give people confidence that they know their way around.
- Make places in your app look distinct and use transitions to show relationships among screens.
- Provide feedback on tasks in progress.
- Feedback acknowledges people's actions, shows them the results, and updates them on the progress of their task.

##### MA02. Offer real world objects whenever possible, that can be directly manipulated

- Allow people to directly touch and manipulate objects in your app.

- Use a metaphor to suggest a usage or experience without letting the metaphor enforce the limitations of the object or action on which it's based.
- Speak the users' language, with words, phrases and concepts familiar to the user, rather than system-oriented terms.
- Follow real-world conventions, making information appear in a natural and logical order.

#### **MA03. Let the user have the control - User control and freedom**

- Users often choose system functions by mistake.
- Support undo and redo.
- People—not apps—should initiate and control actions.
- People expect to have ample opportunity to cancel an operation before it begins
- People expect to get a chance to confirm their intention to perform a potentially destructive action.
- People expect to be able to gracefully stop an operation that's underway.

#### **MA04. Achieve consistency (internal within the app and external with other apps in the platform) – Consistency and standards**

- Users should not have to wonder whether different words, situations, or actions mean the same thing.
- Is the app consistent with platform standards and conventions? Does it use system-provided controls, views, and icons correctly? Does it incorporate device features in ways that users expect?
- Is the app consistent within itself? Does text use uniform terminology and style? Do the same icons always mean the same thing? Can people predict what will happen when they perform the same action in different places? Do custom UI elements look and behave the same throughout the app?
- Within reason, is the app consistent with its earlier versions? Have the terms and meanings remained the same? Are the fundamental concepts and primary functionality essentially unchanged?
- Discerns the functional differences, making them visually distinct rather than subtle.
- Avoid modes, which are places that look similar but act differently on the same input.

#### **MA05. Consider error-prone conditions - Error prevention**

- Even better than good error messages is a careful design which prevents a problem from occurring in the first place.
- Eliminate error-prone conditions or check for them and present users with a confirmation option before they commit to the action.
- Break complex tasks into smaller steps that can be easily accomplished.  
Give feedback on actions

**MA06. Have the app remember important stuff and not the user - Recognition rather than recall**

- Make objects, actions, and options visible.
- User should not have to remember information from one part of the dialogue to another.
- Instructions for use of the system should be visible or easily retrievable whenever appropriate.
- 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.

**MA07. Strive for high efficiency of use in default settings, but allow customization - Flexibility and efficiency of use**

- Accelerators -- unseen by the novice user -- may often speed up the interaction for the expert user so that the system can cater to both inexperienced and experienced users.
- Allow users to tailor frequent actions.
- Learn peoples' preferences over time.
- Make your app easier to learn by leveraging visual patterns and muscle memory from other apps.
- Take your best guess and act rather than asking first.
- Provide sensible, beautiful defaults, but also consider fun, optional customizations that don't hinder primary tasks.
- Make novices feel like experts by enabling them to do things they never thought they could.
- Decide what most important action in your app is and make it easy to find and fast to use.
- 

**MA08. Design for simplicity and aesthetics - Aesthetic and minimalist design**

- Dialogues should not contain information which is irrelevant or rarely needed.
- Every extra unit of information in a dialogue competes with the relevant units of information and diminishes their relative visibility.
- Use short phrases with simple words.
- Consider using pictures to explain ideas.
- Break tasks and information into small, digestible chunks.
- Hide options that aren't essential at the moment, and teach people as they go.

- People care about whether an app delivers the functionality it promises, but they're also affected by the app's appearance and behaviour in strong sometimes subliminal ways.

**MA09. When a user error happens, take the user's feelings and needs into account - Help users recognize, diagnose, and recover from errors**

- Expressed in plain language (no codes)
- Precisely indicate the problem
- Constructively suggest a solution.
- Be gentle in how you prompt people to make corrections.
- Give clear recovery instructions but spare them the technical details.

## 9.4 Heuristic Evaluation - Record Sheet

### Evaluation Code:

Please complete the next sheet with the issues information found during the evaluation.

Heuristics	Brief Description of Issues	How was the Heuristic violated?	Severity
<b>MA01.</b> Make system status visible - Visibility of system status			
<b>MA02.</b> Offer real world objects whenever possible, that can be directly manipulated			
<b>MA03.</b> Let the user have the control - User control and freedom			
<b>MA04.</b> Achieve consistency (internal within the app and external with other apps in the platform) – Consistency and standards			
<b>MA05.</b> Consider error-prone conditions - Error prevention			
<b>MA06.</b> Have the app remember important stuff and not the user - Recognition rather than recall			
<b>MA07.</b> Strive for high efficiency of use in default settings, but allow customization - Flexibility and efficiency			



of use			
<b>MA08.</b> Design for simplicity and aesthetics - Aesthetic and minimalist design			
<b>MA09.</b> When a user error happens, take the user's feelings and needs into account - Help users recognize, diagnose, and recover from errors			

## 9.5 Heuristic Evaluation Post-evaluation Questionnaire

Evaluation Code: \_\_\_\_\_

Please could you fill in this questionnaire? The answers given remain anonymous, but the results will be published and used for research.

### General Information

Date: \_\_\_\_\_

Evaluation Completed by: \_\_\_\_\_

Role: \_\_\_\_\_

### Heuristic Evaluation Information

Name of App: \_\_\_\_\_

Version of App: \_\_\_\_\_

Mobile OS: \_\_\_\_\_

Mobile Model: \_\_\_\_\_

How long did the heuristic evaluation process take? \_\_\_\_\_

**Please select the appropriate answer for each item by placing a cross in the appropriate box:**

1. Which is your level of knowledge about Heuristic Evaluation?

None	Limited	Moderate	Broad	Expert

2. Which is your level of knowledge about Jakob Nielsen's 10 usability heuristics?

( <http://www.nngroup.com/articles/ten-usability-heuristics/> )

None	Limited	Moderate	Broad	Expert

3. How useful did you find the material provided in order to perform the Heuristic Evaluation?

Not useful	Not particularly useful	Useful	Somewhat useful	Very useful

4. How useful was this set of heuristics for finding usability problems of mobile application?

Not useful	Not particularly useful	Useful	Somewhat useful	Very useful

5. How easy did you find using this set of heuristics for mobile application to find usability problems of mobile application?

Very difficult	Difficult	Neutral	Easy	Very Easy

--

6. Please write down, what is most useful about the set of heuristics?

7. Do you have any comments about this set of heuristic for mobile

--

application?

8. What would you discard?

--

**Please express your degree of agreement with the following statements:**

9. This set of heuristic is applicable to a wide range of categories of mobile applications

<b>Strongly disagree</b>	<b>Disagree</b>	<b>Neither agree nor disagree</b>	<b>Agree</b>	<b>Strongly agree</b>

10. Applying this set of heuristics I have gotten a better understanding of the design decisions to provide high usability and compliance with Android and iOS user interface guidelines.

<b>Strongly disagree</b>	<b>Disagree</b>	<b>Neither agree nor disagree</b>	<b>Agree</b>	<b>Strongly agree</b>

11. To what extent the proposed heuristic evaluation model fits in your design process?

<b>To a very small extent</b>	<b>To a small extent</b>	<b>Somewhat</b>	<b>To a large extent</b>	<b>To a very large extent</b>

- a. Please, write down how does the model of heuristic evaluation fit in

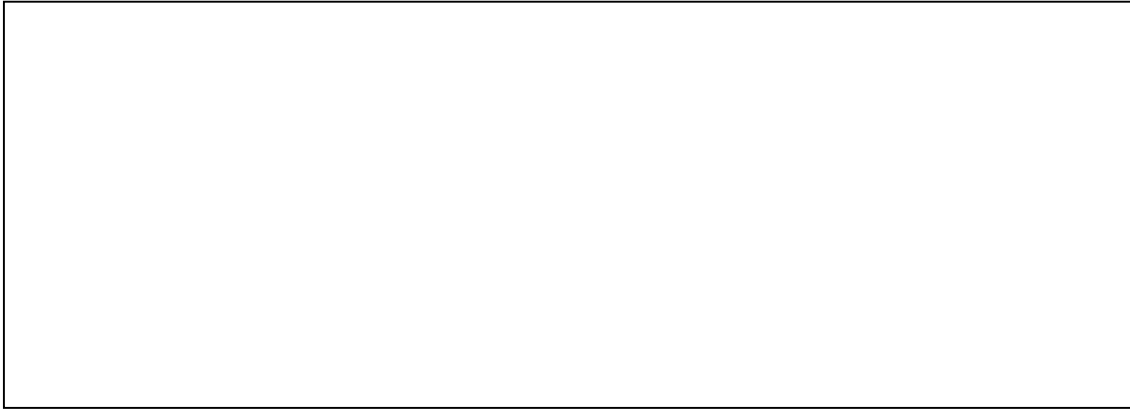
--

your design process?

12. Globally, the effort employed to perform the heuristic evaluation pays off, considering the results obtained.

<b>Strongly disagree</b>	<b>Disagree</b>	<b>Neither agree nor disagree</b>	<b>Agree</b>	<b>Strongly agree</b>

13. Comments on the applicability and usefulness of this set for performing

A large, empty rectangular box with a thin black border, intended for handwritten or typed comments. It occupies a significant portion of the page below the question.

heuristic evaluation of mobile applications.

## 9.6 Expert Evaluator Questionnaire

Please, fill in this questionnaire to the best of your knowledge. The answers given will remain anonymous. Any results published will not allow identification of individual responses, as only aggregate information will be published.

### General Information

Date:

Name:

Years of experience in usability:

Role with regard to experience in usability (professor, practitioner, etc.):

**Please select the appropriate answer for each item by placing a cross in the appropriate box:**

14. Which is your level of knowledge about Heuristic Evaluation?

None	Limited	Moderate	Broad	Expert

15. Which is your level of knowledge about Jakob Nielsen's 10 usability heuristics?

( <http://www.nngroup.com/articles/ten-usability-heuristics/> )

None	Limited	Moderate	Broad	Expert

16. How useful is the material provided in order to perform Heuristic Evaluation of mobile applications?

Not useful	Not particularly useful	Useful	Somewhat useful	Very useful

17. Please write down, what is most useful about the set of heuristics?

18. Do you have any comments about this set of heuristic for mobile

application?

19. What would you discard or modify in the set of heuristics?

**Please express your degree of agreement with the following statements:**

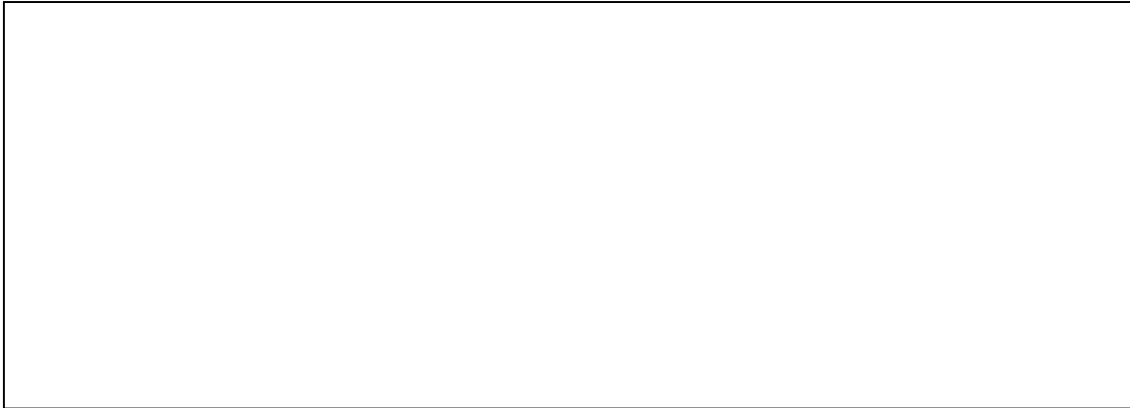
20. This set of heuristic is applicable to a wide range of categories of mobile applications

Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree

21. This set of heuristics can help mobile application designers to get a better understanding of the design decisions that provide high usability, and compliance with Android and iOS user interface guidelines.

Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree

22. Comments on the applicability and usefulness of this set for performing

A large, empty rectangular box with a thin black border, intended for handwritten or typed comments. It occupies a significant portion of the page below the question.

heuristic evaluation of mobile applications.



## 9.7 UEQ and SUS Android / iOS Guidelines Web Tool

Survey about Relationship Between Android/iOS Guidelines

Thank you for your help in evaluating the [Relationship Between Android/iOS Guidelines](#) . This test will take approximately 15 minutes. Your feedback will help us to improve the tool.

### General Information

#### 1 Do you know anything about the Android or iOS UI guidelines?

- ☐ iOS - Human Interface Guidelines
- ☐ Android - Design Guidelines
- ☐ Material Design Guidelines

#### 2 Do you have experience developing mobile applications?

- ☐ Sí
- ☐ No

#### 3 What platform have you developed for?

- ☐ iOS
- ☐ Android
- ☐ Otro:

#### 4 How many years of experience in mobile app development do you have?

### Usability Questionnaire

Please state your degree of agreement with the following statements about [Relationship Between Android/iOS Guidelines](#) Web tool

#### 5 SUS

	Strongly disagree 1	2	3	4	Strongly agree 5
I think that I would like to use this system frequently	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

<b>I found the system unnecessarily complex</b>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<b>I thought the system was easy to use</b>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<b>I think that I would need the support of a technical person to be able to use this system</b>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<b>I found the various functions in this system were well integrated</b>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<b>I thought there was too much inconsistency in this system</b>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<b>I would imagine that most people would learn to use this system very quickly</b>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<b>I found the system very cumbersome to use</b>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<b>I felt very confident using the system</b>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<b>I needed to learn a lot of things before I could get going</b>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

<b>with this system</b>					
-------------------------	--	--	--	--	--

## 6 UEQ

For the assessment of the tool, please fill out the following questionnaire. The questionnaire consists of pairs of contrasting attributes that may apply to the tool. The circles between the attributes represent gradations between the opposites. You can express your agreement with the attributes by ticking the circle that most closely reflects your impression.

Please assess the tool now by ticking one circle per line.

	1	2	3	4	5	6	7	
<b>annoying</b>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	enjoyable
<b>not understandable</b>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	understandable
<b>creative</b>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	dull
<b>easy to learn</b>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	difficult to learn
<b>valuable</b>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	inferior
<b>boring</b>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	exciting
<b>not interesting</b>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	interesting
<b>unpredictable</b>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	predictable
<b>fast</b>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	slow
<b>inventive</b>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	conventional
<b>obstructive</b>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	supportive
<b>good</b>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	bad
<b>complicated</b>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	easy
<b>unlikable</b>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	pleasing
<b>usual</b>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	leading edge
<b>unpleasant</b>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	pleasant
<b>secure</b>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	not secure
<b>motivating</b>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	demotivating

meets expectations	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	does not meet expectations
inefficient	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	efficient
clear	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	confusing
impractical	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	practical
organized	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	cluttered
attractive	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	unattractive
friendly	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	unfriendly
conservative	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	innovative

Usage of the [Relationship Between Android/iOS Guidelines](#) Web Tool for designer or mobile developers

**7 How much time have you spent using the tool ?**

**8 What have you used the tool for?**

**9 Please write down, what is most useful about this tool**

**10 Please provide any comments about this tool**

**11 What would you change or improve in this tool?**