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Extending User Interface Design Patterns with accessibility recommendations to guide mobile developers

Sorocaba, SP

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"Communication has the power to build bridges, to enable encounter and inclusion, and thus to enrich society." (Vatican.va[1], Pope Francis)

[1] https://goo.gl/Y5AY63

Abstract

With the dissemination of mobile devices and the migration of activities that were once executed only on desktop computers to smartphones and tablets, the concerns related to accessibility in this environments have increased. Accessibility barriers can directly affect the access of information: a user with difficulties on accessing important information can become frustrated, absorbing the content with difficulty or even not being able to assimilate any information. The difficulties encountered by a great variety of users on mobile devices adds new challenges to the task of creating accessible applications for everyone. However, the accessibility impact of mobile interface design patterns in the life of disabled people has not been widely addressed in academic works. At the same time, the community of mobile designers and developers has made significant advances in identifying accessibility issues with design patterns on mobile interfaces, reporting these findings in virtual spaces of discussions as forums and blogs. Against this scenario, this project proposes recommendations that will help to mitigate or eliminate the accessibility barriers created by Interface Design Patterns on mobile applications. These recommendations were created based on two main studies. The first study was an accessibility evaluation based on interaction design patterns in an e-learning application containing 21 participants without disabilities that collected the emotional response to seven design patterns and video analysis using communicability metrics. While the second study aimed to explore the experiences and knowledge of professionals through an ethnographic study in 18 virtual communities of mobile design and development with the goal of identifying issues on the accessibility of Android mobile interface design patterns. This work presents two main contributions. It presents an approach to support the employment of virtual ethnography studies in software engineering as means to observe software development practice based on the information available in online communities. It also proposes 22 recommendations of 11 Interface Design Patterns and 11 Cross-section elements of mobile applications with the goal of improving the overall accessibility of mobile devices.

Key-words: Mobile Accessibility, Design Patterns, Virtual Ethnography, Universal Design

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1 Introduction

For a long time Accessibility has been one of the focal points on Software Development along with Usability and User Experience. There are initiatives, such as the World Wide Web Consortium (W3C), that define guidelines for Accessibility on the web. The most common example is the Web Accessibility Initiative (WAI) which define accessibility recommendations for the web on desktop and mobile devices (HARPER; THIESSEN; YESILADA, 2014). The initiative also supports the study and development of solutions that help to improve the use of mobile devices as a mean of social integration, by overcoming the problems and difficulties that users might face when using mobile devices (KAPLAN; HAENLEIN, 2010).

It's also not new that the use of mobile devices for Internet Browsing has increased around the world and in some contexts these devices even started to replace personal computers and laptops due to the more attractive cost and the mobility and convenience provided. Currently in Brazil, 93 million of people own a smartphone and 68 million use the mobile device for Internet browsing according to a research released in 2016 (NIELSEN, 2016). With a population of 200 million, this means that a quarter of the population accesses the Internet through a mobile device and new research indicates that as the number of smartphones in Brazil has increased 112% since 2010, it's expected a greater increase until 2020 (MAZETTO, 2015).

Although there are guidelines that help to improve accessibility issues on mobile, these recommendations are mostly abstract (BRAJNIK, 2006). The user interface interaction is essential for accessing any content and in many cases problems with the interface may lead to Accessibility Barriers (BRAJNIK, 2008), which are conditions that make it difficult for people to achieve a goal when using the web on mobile or desktop devices. Therefore, the interaction of the user with a mobile interface needs to be deeply explored in terms of Accessibility aiming to mitigate the accessibility barriers so that any user will have access to information available in the web.

While the usual focus of accessibility is on designing for people with disabilities, the outcomes of the research in accessibility also brings benefits to everyone, including people that do not have a disability, but have situational limitations (HENRY; ABOU-ZAHRA; BREWER, 2014). Situational limitations are any kind of accessibility problem that a person without disabilities may experience due to environmental characteristics such as excess or lack of luminosity that may difficult to see the information on the screen, loud noise that will spoil the experience of listening to a music or video, limited bandwidth and small screens for example. For this purpose, Universal Design brings the process of

creating solutions that comply with the needs of the widest possible range of situations and for all audiences so that any person may use the same interface and have access to the same content (MCGUIRE; SCOTT; SHAW, 2006).

In this context, the accessibility barriers faced by users with disabilities in desktop platforms are also faced by users of mobile devices (YESILADA; BRAJNIK; HARPER, 2011a). And while smartphones provide mobility, convenience and access to information, there are physical characteristics and characteristics related to the context of use of the technology that hinder the access to information such as the small size of the screen (and the wide range of resolutions), processing limitations, Internet signal shortages and difficulties in entering information and navigation.

Interface Design Patterns (NILSSON, 2009) can be used as means to assess accessibility of mobile interfaces. Design Pattern is an interface element, that is a widely used concept on Software Development (RIBEIRO; CARVALHAIS, 2012a) and there are several Design Pattern libraries available for consultation. These patterns are defined on what already exists and what works in specific situations, however, sometimes these patterns are not given much importance in terms of user interaction with the pattern and the usability and accessibility aspects that comes along.

Given the exposed context this masters project evaluates the accessibility of Mobile Interaction Design Patterns under the perspective of Universal Design in order to contribute to developers and designers by identifying Accessibility Barriers related to common patterns and giving recommendations on how to avoid or minimize the barriers to any target group. It is believed that the results of this project will contribute to the Human Computer Interaction (HCI) area on accessibility for mobile and will be easily extended to other Design Patterns.

In order to identify the accessibility barriers related to the Interface Design Patterns and understand how these accessibility issues are addressed by designers and developers, the technique of Virtual Ethnography was chosen. Ethnography is a common research method recognized as a qualitative approach to understand social groups and work practices (SHARP; DITTRICH; SOUZA, 2016), thus, the use of Virtual Ethnography is fitted to the goal of this research as it helps to comprehend how the community of designers and developers deals with accessibility barriers on Mobile Interface Design Patterns.

1.1 Research Goals

The main goal of this project is to propose recommendations to guide developers and designers in the use of Interaction Design Patterns during the elaboration of mobile interfaces in order to minimize the insertion of Accessibility Barriers in the interaction with mobile applications. The proposal extends the description of the Interaction Design

Patterns adding recommendations about the barriers that the pattern could insert into the interaction. This project investigated Accessibility Barriers present in a selected set of Interaction Design Patterns from the Android platform, however, it's easy to extend this research to all Interaction Design Patterns.

As specific goals of this research project, can be highlighted:

- An investigation on the accessibility impact that the implementation of Interaction Design Patterns can have on mobile devices;
- A study on the use and understanding of mobile Interaction Design Patterns;
- A study to understand the solutions for common accessibility barriers related to mobile Interaction Design Patterns by the community of developers and designers;
- Propose recommendations regarding the Interaction Design Patterns in terms of accessibility.

1.2 Methodology

In order to achieve the proposed objectives, this study was conducted using bibliographic research, exploratory study and virtual ethnography (WOHLIN et al., 2012; CHARMAZ, 2014).

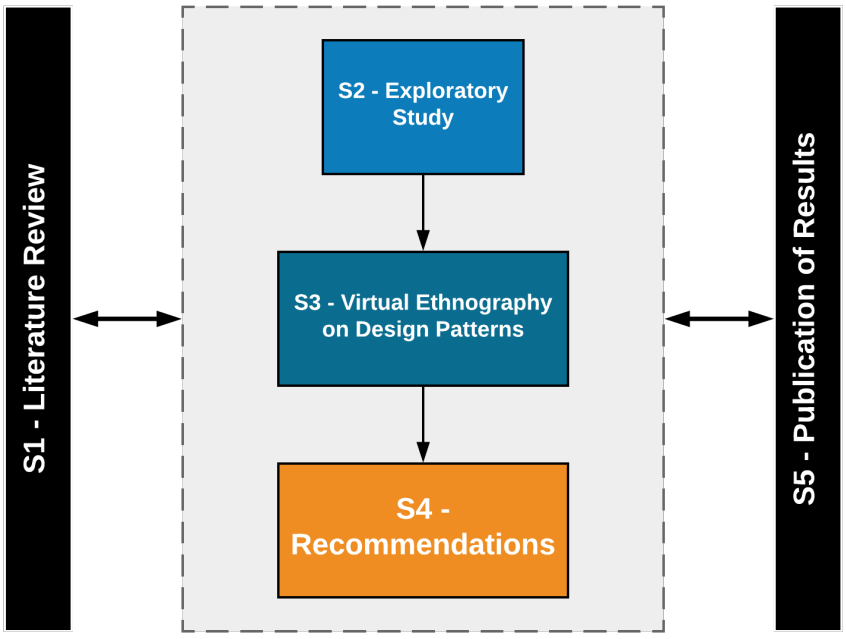

Figure 1 – Research Flow

The steps of the methodology are identified by the letter S and enumerated and Figure 1 presents the flow of the steps:

S1 - **Literature Review**: a literature review study about the main topics involving this project as a form to identify the state of the art, new trends and discoveries in the research field. This step was continuous through the research project so that the bibliography and related works are up to date and relevant.

S2 - **Exploratory Study**: this steps contains the elaboration and execution of a user experimentation. The outcomes of the study supported the identification of the main design patterns which insert barriers of accessibility.

S3 - **Virtual Ethnography on Design Patterns**: an investigation on blogs and forums of developers and designers that shall bring more light on accessibility barriers related to Design Patterns.

S4 - **Recommendations**: This step considered the results of S2 and S3 in order to outline the approach of this project.

S5 - **Publication of results**: this step was used for the publication of the results through scientific papers, conferences, project reports and the master dissertation.

1.3 Contributions

Through the related works, the exploratory study on the accessibility of the Interaction Design Patterns on mobile applications and the virtual ethnographic study, the contributions listed below were obtained:

- Elaboration and execution of a study with end users to survey the problems of interaction with mobile design patterns. Besides the findings, the study design allows its replication;
- Systematization of a process for the execution of virtual ethnography through the adaptation of the foundations of traditional ethnography and the inclusion of new elements;
- Survey of problems with interaction mobile design pattern through the execution of a virtual ethnography in virtual communities;
- Qualitative and in-depth analysis of the problems encountered;
- Elaboration of recommendations based on accessibility problems encountered.
- Publication: "CASADEI, V. et al. Accessibility evaluation of design patterns on moodle mobile. In: Brazilian Symposium on Computers in Education (Simpósio Brasileiro de Informática na Educação-SBIE). [S.l.: s.n.], 2016. v. 27, n. 1, p. 688" (CASADEI et al., 2016).

- Publication: "CASADEI, V.; GRANOLLERS, T.; ZAINA, L. Investigating accessibility issues of ui mobile design patterns in online communities: A virtual ethnographic study. In:Proceedings of the XVI Brazilian Symposium on Human Factors in Computing Systems.New York, NY, USA: ACM, 2017. (IHC 2017), p. 33:1–33:10." (CASADEI; GRANOLLERS; ZAINA, 2017)

1.4 Organization

This dissertation consists of seven (7) chapters involving an introduction to the work produced during the master's project, related works, presentation of two studies and conclusions.

On Chapter 1, an introduction to the main topics relevant to this study are presented, as well as the methodology and research goals.

On Chapter 2 important concepts are explained and the state of the art and related works to this research are presented. On Chapter 3 an exploratory experiment is presented, in this chapter a study on a mobile application was performed and the results are discussed.

On Chapter 4 an approach to conduct virtual ethnography on online communities is presented as an extended guide to aid researchers on similar ethnographic studies. On Chapter 5 a virtual ethnography study is presented and discussed.

Chapter 6 presents the findings of the ethnographic study and recommendations for the implementation of interaction design patterns on mobile applications with the goal of mitigating accessibility barriers introduced with the design patterns.

Finally, Chapter 7 concludes this work by discussing the findings of this project.

2 Fundamentals and Related Works

This chapter presents the main concepts, fundamentals and related works of this project. The search and gathering process of these related works was based in two main strategies: manual search and search for keywords.

The manual search for related works was done by exploring known conferences and scientific journals on the area of Human-Computer Interaction (HCI) such as the *Conference on Human Factors in Computing Systems (CHI)* e o *Brazilian Symposium on Human Factors in Computing Systems (HCI Brazil)* as well as the *International Journal of Human-Computer Studies*. On the other hand, the search by keywords was performed in well known electronic scientific databases such as Google Scholar[1], ACM Digital Library[2], Scopus[3], IEEE Xplore[4] and Web of Knowledge[5]. Thus, this section compiles important works used in the development of this masters project.

The following keywords were used (among others) in the process of searching for related works: Mobile Accessibility, Accessibility Studies, Accessibility Guidelines, Universal Design, HCI Accessibility, Mobile Interaction Design Patterns, Ethnography, Virtual Ethnography and Accessibility Research.

2.1 Accessibility

The Web Accessibility Initiative (WAI) of the World Wide Web Consortium (W3C) (HARPER; THIESSEN; YESILADA, 2014) presents guidelines, strategies and resources related to accessibility in various contexts. However, some guidelines defined by W3C are not applicable or adapted to mobile applications and as the web become more mobile and ubiquitous, the need for accessibility in any context and device is urgent (ABOU-ZAHRA; BREWER; HENRY, 2013).

Existing standards and guidelines (such as WCAG from W3C) do not give clear instructions for designers on how to design accessible solutions nor give developers instructions on how to create accessible systems. Because of this, in most situations, developers try to make a website accessible by simply adapting the software only at the end of the development, which tends to the existence of accessibility gaps and increased cost in the final product (NEWELL; GREGOR, 1988).

[1] Link: scholar.google.com.br/
[2] Link: dl.acm.org/
[3] Link: www.scopus.com/home.uri
[4] Link: ieeexplore.ieee.org/
[5] Link: www.webofknowledge.com/

Alongside the impairments and accessibility barriers that users encounter while using a website, their mood is directly related to the overall experience and the accessibility of a website or app is beneficial for everyone as it improves the usability for every user. This is shown by Pascual et al. (2013) (PASCUAL et al., 2013) in a study conducted with 13 participants that who were blind or low-vision users and also users without disabilities. The goal of the study was to record the mood of the users (in terms of interaction efficiency, effectiveness and satisfaction) while using websites with and without accessibility barriers and the results showed the elements with the highest rate of frustration on each group of users.

Another important factor is that people with disabilities are not the only ones that have problems using websites and mobile devices, as there is an exponential growth of the elderly population in the world that suffers from a wide variety of disabilities developed by the advanced age (LEME; ZAINA; CASADEI, 2015). In the mobile context such users have even more difficulties, as they mostly are not used to mobile technology and with the attention on this group of users, a set of guidelines was collected from various sources of the literature and presented by Díaz-Bossini e Moreno (2013) (DÍAZ-BOSSINI; MORENO, 2013) in order to help designers and developers to better understand and to build solutions that meet the needs of this growing parcel of the population.

2.2 Design Patterns

The concept of Design Pattern was first developed in the architecture field in the late 1970s with the goal of being components of language that can be used as dialog about organizations and development process. Although the concept was born on a very different field, it can be easily applied to software and interactive design. Design Patterns can be understood as best practices or some sort of heuristics of well knows design problems and its solutions as presented on the work of Hoober e Berkman (2011) (HOOBER; BERKMAN, 2011) in 76 patterns organized in 13 categories.

As there are many classifications and specific applications for Design Patterns, many studies are made on individual categories of patterns as the work presented by Sampaio (2013) (SAMPAIO, 2013) in which a tool was developed to automatically adapt web sites navigation menu in different contexts of screens, resolutions and devices according to common menu design patterns that are organized into two orders of navigation: simple navigation and multi-level navigation.

There are various pattern libraries that can be consulted during the design process of web and mobile interfaces and Ribeiro e Carvalhais (2012b) (RIBEIRO; CARVALHAIS, 2012b; RIBEIRO, 2012) presents a comparative analysis of some of the most known libraries in order to propose 21 Design Patterns for general purpose derived from studies

in mobile and web design with the objective of helping designers and developers to design mobile and web interfaces. The patterns defined are later applied to three case studies in order to ascertain about their usefulness and applicability.

2.3 Universal Design

Universal Design is the process of developing a system or product that can be used by any person with any ability, in any situation or environment. In HCI, Universal Design is mainly related to accessibility in the development of computer systems for people with and specially for people without disabilities in situations that can limit the ability to see, hear, understand, concentrate and control motor movements (HENRY; ABOU-ZAHRA; BREWER, 2014). It is important to point out that many accessibility barriers faced by people with disabilities also are witnessed by other users, however, for disabled people, accessibility is essential in order to actually have access to information, while people with situational accessibility, this concern is mere convenience (HEUMANN, 1998).

In order to present better understatement to designers and developers in the development of accessible systems by comparing problematic situations with real life conditions, Fogli, Provenza e Bernareggi (2014) (FOGLI; PROVENZA; BERNAREGGI, 2014) presents a design pattern language for accessibility based on W3C specifications and concerned with general design methods of universal access to support designers and developers since the beginning of the development and design process.

2.4 Related Works

In the academic area mobile devices present a great potential to improve the learning experience of any student by providing mobility and easy access to information alongside several benefits in one device. In order to determine the existence of academic mobile applications that aids visually impaired users and to understand the usage of these applications, a systematic review was performed in the work of Silva, Braga e Damaceno (2015) (SILVA; BRAGA; DAMACENO, 2015). As a result of this work, it was identified that the accessible mobile applications had the impact of rehabilitation and educational inclusion of visually impaired users and that this could be applied to users with other types of disabilities as well.

In order to prevent accessibility barriers to be created by the lack of conformity with accessibility guidelines defined by W3C (CALDWELL et al., 2008), a tool was developed as the result of the research presented by Gabrielli et al. (2005) (GABRIELLI et al., 2005). This tool acts as a reminder and obligates content producers of e-learning platforms to follow (to some extent) the guidelines regarding content presentation such as textual

description of images and other media files and transcripts or alternative text of video and audio contents. A similar approach focused on persons with visual impairment is presented by Ulbricht et al. (2012) (ULBRICHT et al., 2012).

Many efforts have been made in the challenge of improving accessibility on mobile devices for users with different disabilities. Díaz-Bossini e Moreno (2014) (DÍAZ-BOSSINI; MORENO, 2014) present a valuable set of guidelines to achieve accessibility in mobile interfaces for elderly users as a result of a literature review study of academic works, standards and best practices of mobile web design. Also as people with disabilities are often excluded from the society by not having access to information through technology (and older people are included in this group), the guidelines were compared with a survey of three mobile Android apps, that were advertised as accessible, where all applications showed accessibility problems.

Some efforts have been developed aiming to solve accessibility gaps to visually impaired users. A literature review was carried out resulting in the mapping of 65 existing accessibility problems in the interaction with mobile devices (DAMACENO; BRAGA; MENA-CHALCO, 2017). The accessibility issues were classified in seven groups of problems which contributed to the establishment of a set of recommendations to improve accessibility. Concentrating on visually impaired issues, Color Vision Deficiency (CVD), which means the difficulty or inability recognize a certain color or to perceive color differences, can be seen as another important disability that affects many people in the world. A solution that adapts colors preserving properties of the original colors was proposed by Zhou, Bensal e Zhang (2014) (ZHOU; BENSAL; ZHANG, 2014).

Concerning on accessibility issues for elderly, a usability testing of three mobile applications exploring navigation and interaction of older users was conducted. The evaluation results led the authors to propose recommendations regarding the design of mobile applications for older adults (BARROS; LEITãO; RIBEIRO, 2014). Similarly, Leitao e Silva (2012) (LEITAO; SILVA, 2012) investigates the optimal target and spacing size between elements in mobile applications intended for older adults. In the study, the gestures of tap and swipe were used by 40 older users in two tasks on a mobile application. From the data collected in the experimentation, the authors recommended appropriate implementations of large tap and large swipe targets for the use of mobile applications by the elderly.

The work presented by Jemni, Laabidi e Ayed (2014) (JEMNI; LAABIDI; AYED, 2014) defines accessibility in e-learning as the ability of e-learning environment to adjust to the needs of any learner with any disability, which involves content, presentation and interaction and also an extension for Moodle that seeks to improve its accessibility. Some advantages of the use of e-learning systems are pointed in comparison with the traditional classroom education for people with disabilities, which are peer support, proactivity and

flexibility in time and space. It's also important to remember that assistive technologies do not remove all the accessibility barriers of a system as some barriers are created by the lack of study and knowledge during the design.

On Virtual Ethnography the work published on software engineering and computing related practices is not numerous. However, important works have been published as the ethnographic study conducted on e-learning context that analyzed the experience of students to understand the relation between the effectiveness of the learning methods with the motivation of the students (KRUGER, 2006). And the study conducted on online message boards by Steinmetz (2012a) (STEINMETZ, 2012a) that aimed to better understand the topics of space, identity and ethics on virtual ethnography by exploring these issues on an actual virtual ethnography study.

Virtual ethnography shifts the location of observation to online spaces adapting the classical ethnography directions (BOELLSTORFF, 2012). Sharp, Dittrich e Souza (2016) (SHARP; DITTRICH; SOUZA, 2016) suggest five dimension which aid the researcher in the planning of an ethnography: (a) participant and non-participant observation (levels of participation between only observation and total participation (HINE, 2008)); (b) duration of the field study; (c) space and location; (d) use of theoretical underpinnings to support the conduction and the analysis of results; and (e) the ethnographers' intent in undertaking the study. In virtual ethnography, the first puzzle that the researcher must face is choosing a participation role in the research. While some researchers in the literature may agree that some degree of participation is necessary, the nature of the community may force the researcher to adopt an observer or hybrid position in the study (HINE, 2008).

Lastly, one important work on virtual ethnography analyzed online message boards conversations in the online community with focus and detail on three specific aspects of the research method: space and time, identity and authenticity, and ethics (STEINMETZ, 2012a).

The previous works present several approaches to the problem of mobile accessibility, however they present limitations that this work sought to approach. The work of Silva, Braga e Damaceno (2015) on the impact of mobile application in the inclusion of visual impaired users is extremely rich, however, it does not present a general approach to accessibility. Similarly, the work of Gabrielli et al. (2005) and (ULBRICHT et al., 2012) are strongly tied to the W3C guidelines and therefore cannot be fully extended to mobile devices.

Díaz-Bossini e Moreno (2014) presents a practical set of guidelines to improve accessibility on mobile applications, however, it's tied to a particula audience: elderly users, and the same applies to Leitao e Silva (2012) and Barros, Leitão e Ribeiro (2014). Damaceno, Braga e Mena-Chalco (2017) and Zhou, Bensal e Zhang (2014) present solutions for mobile accessibility of visual impaired users, and Jemni, Laabidi e Ayed (2014) attacks

the problem of accessibility on e-learning platforms.

Upon Ethnography, Steinmetz (2012a) presents an ethnographic study on message boards exploring practical issues and Sharp, Dittrich e Souza (2016) presents a set of dimensions to aid the researcher during the study, however, they do not approach the topics of historical period and storage of volatile data that are presented in this work.

3 Exploratory Experiment

Prior to the virtual ethnography, it was sought to understand in a practical manner which interaction design patterns produced accessibility problems on mobile interfaces. For this, an experimental study (LAZAR; FENG; HOCHHEISER, 2017) was conducted. Firstly, the type of application was chosen to be used in the experiment and thereafter the target audience.

Mobile Learning (M-learning) is an approach to e-learning where mobile devices are used to access educational content. Considering that traditional LMS (Learning Management Systems) were created before the dissemination of mobile devices with Internet access, there is a gap that has not been filled on exploring the application and adaptation of these systems on such devices as a way to motivate students to perform educational activities and in the exploration of new patterns of interaction (GUTERRES; SILVEIRA, 2015) as accessibility and usability studies have mainly been made on Moodle desktop (BARBOSA; OLIVEIRA; PENNA, 2015; SANTANA; NETO; COSTA, 2014).

Accessibility in e-learning is the ability of the learning environment to adjust to the needs of any learner with any disability (JEMNI; LAABIDI; AYED, 2014), which involves content presentation and interaction. Also, it's important to consider the impacts of mobile learning in the life of students and educators as presented by Abachi e Muhammad (2014) (ABACHI; MUHAMMAD, 2014).

In Education, mobile devices can be useful to enhance and support the learning experience of the disabled user and the adaptation of content to accessible by anyone. This adaptation brings several advantages to e-learning systems that complement the traditional education system as recorded classes and materials in video or audio and use of forums for discussion at any time, anywhere (MOURAO; FREIRE; SILVA, 2013).

The Web on the context of learning system has been a great channel for dissemination of information and communication. Now it's possible to attend to university classes from thousands of kilometers of distance and to graduate without having to leave the comfort of home, it has brought access to education in areas of difficult. M-learning (GEORGIEV; GEORGIEVA; SMRIKAROV, 2004) systems are platforms accessed through mobile devices and this change of perspective from desktop to mobile is another channel for learning and presenting information (ALLY; PRIETO-BLÁZQUEZ, 2014). On the other hand not all learning systems are well adapted to mobile interaction and many of them in general have serious accessibility issues that can insert barriers in the learning process, which discourages students and users of such platforms (HASHEMI et al., 2011).

The new form of learning through mobile devices (M-learning) presents a great

potential that can improve the learning experience of students by providing mobility and easy access to information. In Brazil (and in many countries) the most used M-learning system is Moodle which has more than 76000 sites over 230 countries (MOODLE.ORG, 2016).

Whilst Universal Design can be described as a framework that assists the design of environments and products, the Universal Design for Learning (UDL) is presented as a framework for the development of teaching strategies that encourage equal opportunities and in this context the M-learning emerges as an opportunity to promote inclusive, user-centered and democratic education as pointed out in the research developed by Tavares et al. (2015) (TAVARES et al., 2015) that reviews the literature on Universal Design applied to education and M-learning.

In order to understand and evaluate the interaction design patterns' accessibility on mobile adaptations, an exploratory study was planned.

The goal of this study is to present the results of an accessibility evaluation of interaction design patterns on m-learning platforms from emotional assessment of users without disabilities in the mobile application for Moodle. In the evaluation 21 participants performed 5 tasks on the mobile application that were recorded and later analyzed in order to identify possible accessibility barriers in the use of certain interaction design patterns.

The study presented in this chapter also suggests a methodology of evaluation that is interested in both the user and researcher's perspective and highlights common accessibility problems faced by users without disabilities in the mobile scenario through interaction design patterns. As a result of this study we have also identified accessibility barriers related to common interface elements, which are mapped to interaction design patterns and can serve as an input for future studies on mobile elements with users with disabilities in the e-learning scenario.

The choice of M-learning systems as domain case study in this research was not random, possible accessibility problems can spoil the learning experience of many disabled people that cannot access information due to accessibility barriers. The study and discussion of the impacts of these problems on education is a desired achievement, but not the main purpose of this project.

The methodology of the study consisted of three phases with the execution of an experiment on a controlled environment (LAZAR; FENG; HOCHHEISER, 2017) and the general overview is shown in Figure 2.

1. **Preparation** - In this phase several mobile design patterns were analyzed together with the Moodle Mobile application and its functionalities and limitations. The activities were chosen with the help of the teacher and based on which features the

Moodle application presented at the moment with eyes on the design patterns of the interface.

2. **Execution** - Here all the questionnaires were designed and the experiment was performed in a controlled environment. The users should execute the 5 activities that were compiled in the previous phase and give their feedback while being recorded.

3. **Analysis** - With the data collected from the previous phases, there are two perspectives to be analyzed: the user's and the researcher's. The discussion, results and implication of this analysis is presented in this article.

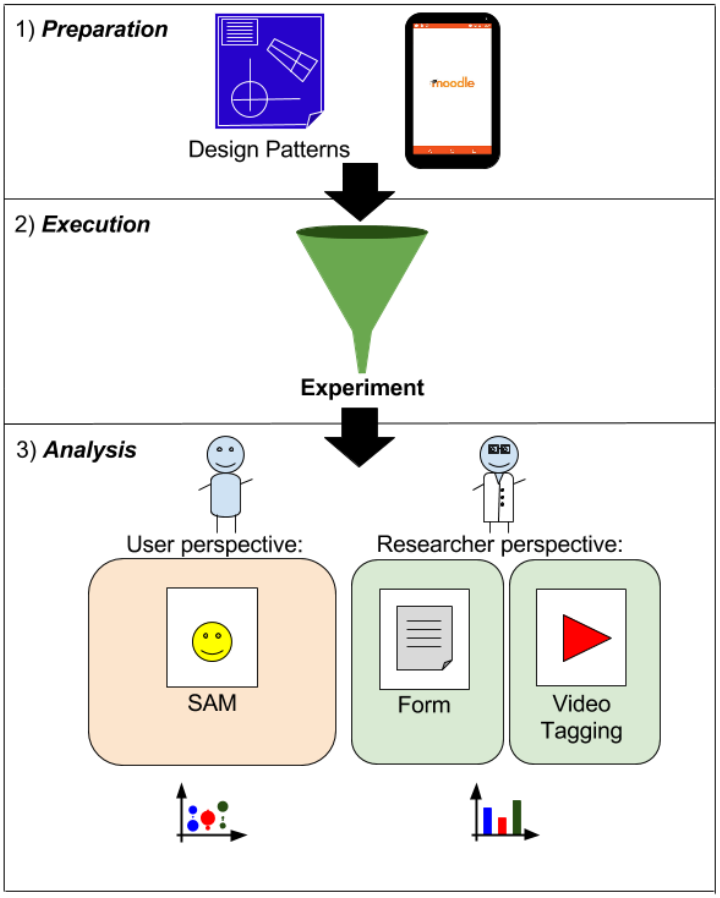

Figure 2 – Overview of the methodology

3.1 Preparation and Execution

The following subsections present the main elements of the study.

3.1.1 Participants

Twenty one participants took part in the research on April 2016 where 56% were female and 44% were male with ages varying from 19 to 24 years old. All participants did

not have identified disabilities, were undergraduate students and had a smartphone. When asked about the experience using mobile devices (smartphones or tablets) 78% stated to have 4 or more years using a device and only 4.3% had only two years of experience (the rest was in between). Also the daily usage (in hours) of mobile devices was around 2 to 8 hours and the daily usage of Internet around 2 to 5 hours.

Although all participants used their mobile device to access the Internet, only 30.4% actually preferred the mobile device over a PC to access web content and when asked to describe situations that influenced this preference we received many answers like "I can't find information or navigate in some websites", "The buttons are too small", "I can't understand the meaning of some icons in some sites" or "I have difficulties accessing my grades on the smartphone". Another important information is that all participants were users of Moodle and 48% accessed up to 3 times a week and 13% accessed Moodle daily in a mobile device.

The participants were students of a chemistry class and were chosen randomly by volunteering to participate in the research and in this initial study we have chosen participants without disabilities in order to identify accessibility barriers in Design Patterns that affect such users and doing so further explore in other experiments the affect of these barriers in different participants (with different types of accessibility) using Moodle on a mobile device.

The teacher of the chemistry class uses the desktop version of Moodle provided by the University of blind review in his class and the students were accustomed to perform the operations that were requested to be performed in the mobile version of Moodle. The tasks were chosen with the help of the teacher while preparing the activities that were related to the class material.

3.1.2 Apparatus and Artifacts

The experiment was performed in a laboratory of the Department of blind review of the University of blind review. There were used five different mobile devices, all of them with Android operating system (Nexus 5, Moto G, Moto E, Galaxy S4 and a Tegra Note tablet), screen size varying from 4 to 7 inches and Android version 5 or above. All devices had a clean desktop, containing the same keyboard layout, connected to the Internet and to a power source and had the two applications that were used in the experiment installed: the Moodle Mobile[1] and the Lookback[2] apps.

The mobile devices and questionnaires were distributed in separate desks in the laboratory and the participants were seated in 5 different locations with a comfortable space between them in order to provide privacy in the execution of the experiment.

[1] www.download.moodle.org/mobile
[2] www.lookback.io

Each participant received a copy of the Terms of Consent for image and data usage, an Accompaniment questionnaire (Appendix C) containing the description of the activities and questions related to each activity and a page with screenshots of the Moodle Mobile application grouped by each task containing enumerated elements of interface and a mobile device tat was assigned randomly to each participant. The experiment had the participation of 4 observers that would be distributed between the participants and monitor their actions by taking notes of problems and difficulties that occurred during the experiment (Appendix D).

The Accompaniment questionnaire (Appendix C) consisted of five activities and, for each activity, the participants would evidence their satisfaction and feeling of dominance (that should be indicated in a scale of one to nine based in the Self-Assessment Manikin (SAM)) about interface elements that were highlighted and enumerated in the page with Moodle Mobile screenshots. The observers were instructed to not interfere in the participant's interaction and the participants were told to perform all activities and ask for help from the observer only when strictly needed.

The participants were also asked to fill a form where demographic and general information about usage of mobile devices and e-learning systems were collected (Appendix B) and presented in this section in order to characterize the participants.

The Lookback application that was also installed in each device was used to collect video data of the experiment in order document the participant's interaction with the screen and to capture their facial expressions using the front camera of the mobile devices.

All sessions were recorded using the mobile app Lookback[3] that records the screen interaction and video and sound from the front camera of the mobile devices. The recordings would start in the beginning of each sessions and end when the participants would signal the completion of all activities. Each recording was identified by the participants unique login information in the platform and were uploaded to a cloud platform also provided by the Lookback service. These recording would be used again the the analysis phase as described in Section 3.2.

All 4 observers that participated in this study are master's students in the field of Human Computer Interaction (HCI) and two of them had experience working with accessibility on mobile devices. The other two develop research in the usability area (also on mobile devices). For the experiment a new installation of Moodle version 3.1 was performed in a server using the default theme. This was needed due to the fact that the Moodle Mobile app present some limitations with older versions of Moodle.

[3] www.lookback.io

3.1.3 Procedure

The 21 participants performed the experiment in 5 sessions (4 with five participants each and the last one with one participant only) due to the number of mobile devices available for the experiment (5 devices), which means that, apart from the last session, the devices were used evenly by the participants during the sessions. Figure 3 illustrates a participant performing an activity during the experimentation alongside with the artifacts described in the previous section.

Figure 3 – A participant performing an activity

In the beginning of each session the participants received general information about how to use the artifacts provided, how to fill the forms and what activities they should perform. It was given special attention to the explanation of the Self-Assessment Manikin that was applied in the Accompaniment questionnaire. The participants were also asked to think aloud about their progress, doubts and problems while performing the tasks.

The SAM is a non-verbal pictorial assessment technique that aims to measure emotion in terms of satisfaction, arousal and dominance that are associated with the reaction of a person to some sort of stimuli (BRADLEY; LANG, 1994). The SAM technique used in this experiment aimed to capture only the participant's satisfaction and dominance of each element of interface that was actually used by the participant. The icon representation of both satisfaction and dominance was adapted from the original version as can be seen in Figures 5 and 6.

The five activities performed by the users would force the participants to explore the application and use the interface elements that were evaluated in the SAM questionnaire and had a correct order and description. The first activity was to check a specific event in the calendar, then in the second activity, the participant should check the grade received in a questionnaire that was answered in the chemistry class of the previous week; the third activity consisted of finding an specific student enrolled in the class and initiate a chat by

sending a private message; in the fourth activity the participant should find and read a chapter of a chemistry book; finally in the last activity the participant would answer a question about an upcoming event of the class.

The participants were advised to freely perform the tasks without any intervention or any tips on how to perform an operation or screens that should be used. At the completion of each activity they would indicate their satisfaction and dominance of some selected interface items that were highlighted and enumerated for each activity (the participants should do this only for the elements that they used during the task). On each task the participants were also asked to report any difficulties or problems of usage or understatement of any interface element and they were also asked to inform their level of agreement in a Likert scale on the number of steps and localization problems in the general execution of the task.

At the end of the experiment, each participant was asked to give feedback on the execution of the experiment and also about the satisfaction with the adaptation and usage of the Moodle e-learning system on mobile devices.

3.2 Analysis

The data collected after the experiment contained the satisfaction and dominance of each participant about to the studied interface elements. A work of mapping and grouping the interface elements into mobile interaction design patterns was then performed by analyzing each element with the help of the patterns presented by (HOOBER; BERKMAN, 2011) and (RIBEIRO; CARVALHAIS, 2012b; RIBEIRO, 2012).

After mapping and grouping the interface elements into design patterns from the data collected in the SAM questionnaire, we had identified 7 main design patterns used by the participants that are Toggle Menu, Icon, Infinite List, Vertical List, Input Area, Button and Form Selection and collected the satisfaction and dominance for each of the seven design patterns. This data is represented in two bubble charts: one for satisfaction (Figure 5) and another for dominance (Figure 6).

Another output of the experiment was the recording of the screen and front camera video of the mobile devices during each session for every participant. With the recording (and because the participants were asked to think aloud) it was possible to better understand the interaction with the interface and which problems each user had encountered and how they performed each one of the activities. With this, it was possible to analyze in deeper detail the interaction with the Moodle Mobile app and identify situations that could not be perceived by the observer during the session.

The video recording were stored in a cloud platform provided by the same tool

used to record screen and front camera of the devices. With the cloud platform we could identify each participant by the video, add tags and comments into the recording, identify the duration that each participant took to perform the 5 tasks and discuss these findings. The interface of Lookback as a collaborative tool can be seen on Figure 4.

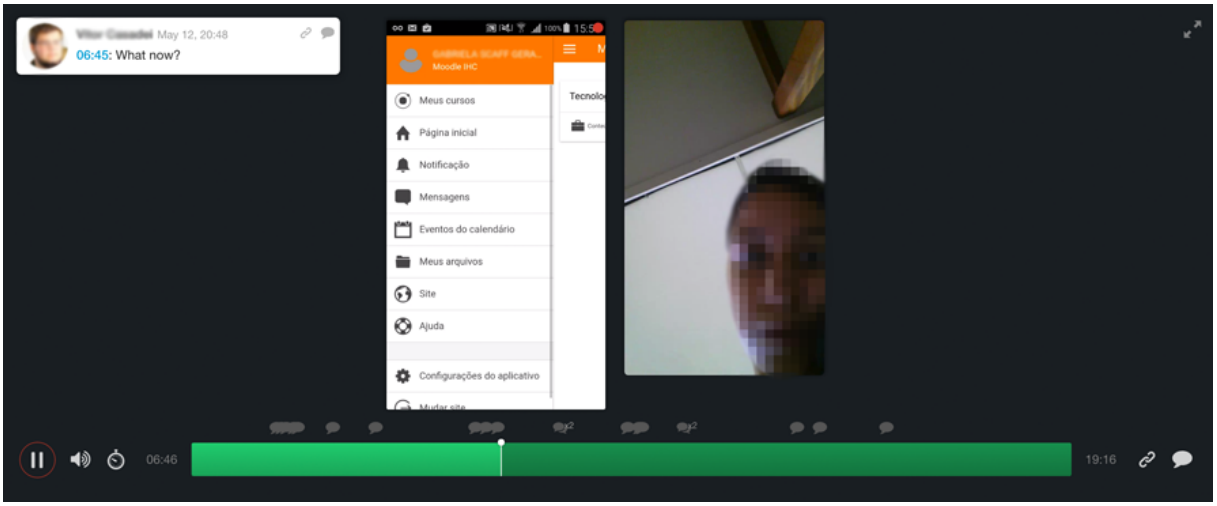

Figure 4 – Lookback's interface: video analysis with CEM tags

To catalog and analyze the recordings we used the Communicability Evaluation Method (CEM) tags (CAPELÃO et al., 2011) as communicability directly impacts in the understanding of the user about the interface and therefore impacts in accessibility and usability because if a user had problems communicating with an interface, he will have problems using and understanding the same interface. However, we did not use the whole CEM method, but only used the tags in order to identify accessibility problems during the interaction with the interface that are presented as communicability ruptures.

The tags were chosen because it was possible to easily add comments in parts of the recordings in the Lookback platform, due to the possibility of grouping the problems identified with the technique and because the tags of the CEM method are widely used and make the analysis process easier. The tagging process was a collaborative work performed by two evaluators in the cloud platform. In order to achieve more reliable results and instigate the discussions of issues encountered by the participants, each evaluator would tag all videos and discuss the tags of the other evaluator when having doubts or some observation to add. Doing so, each video recording was analyzed twice.

After this tagging process, we had a set of videos with each one containing several tags, then a work of grouping these tags by activity was performed and, with this information, it was possible to better understand which factors had influenced the participants during the experiment and even relate some of the results with the results of the SAM questionnaire. The data collected in this step is represented in a chart which contains the occurrence of CEM tags by each one of the five activities performed by the participants on Figure 7.

3.3 Findings

After the analysis of the results of the experiment we could analyze and discuss the findings of this study. This section presents the point of view of the participant that answered the SAM questionnaire and the point of view of the researcher related to the observation form and video analysis with CEM tags presented in Section 3.2.

3.3.1 User Perspective

The user perspective contains the satisfaction and feeling of dominance that were indicated by the participants in the SAM questionnaire. By looking at Figure 5 that presents the data distribution of satisfaction for the seven design patterns we can observe that three of the patterns (Input Area, Button and Form Selection) did not have negative scores of satisfaction (below 5) and had a high concentration of positive scores around 9 and 8. The same scenario can also be observed in Figure 6 about the dominance of these patterns.

On the other hand, it is possible to see a higher incidence of negative scores of both satisfaction and dominance on the other four design patterns (Toggle Menu, Icon, Infinite List and Vertical List). These patterns still have high satisfaction and dominance, however we can see that the scores are distributed in the scale, which means that some of the participants were not satisfied or had trouble using such elements.

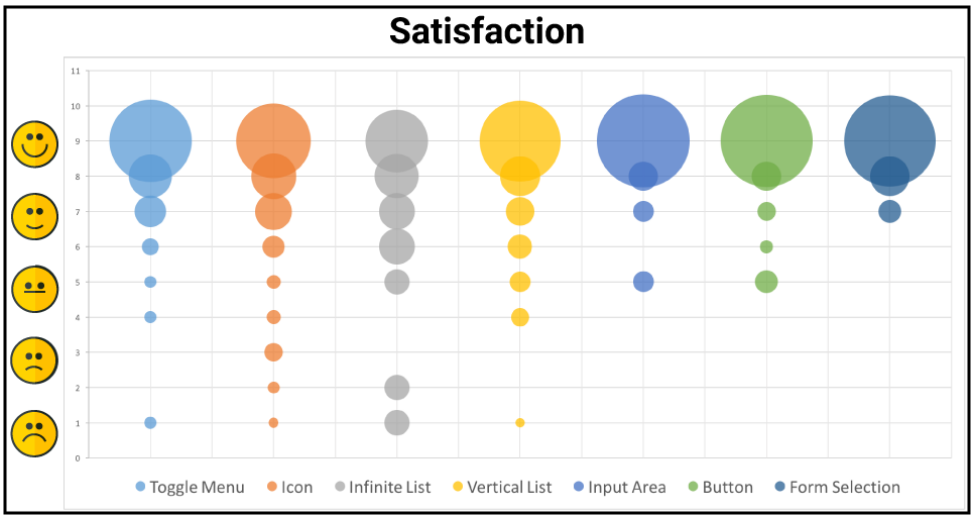

Figure 5 – User satisfaction by Design Pattern

Based on these results it can be observed that in all patterns the majority of answers given by the participants float around 9 and 8, which meas high satisfaction and dominance regarding the seven design patterns. However this is expected due to the fact that the participants did not have disabilities and were familiar to mobile devices. Because of this, only a small portion of the participants would in fact encounter barriers in the design patterns while using the mobile application.

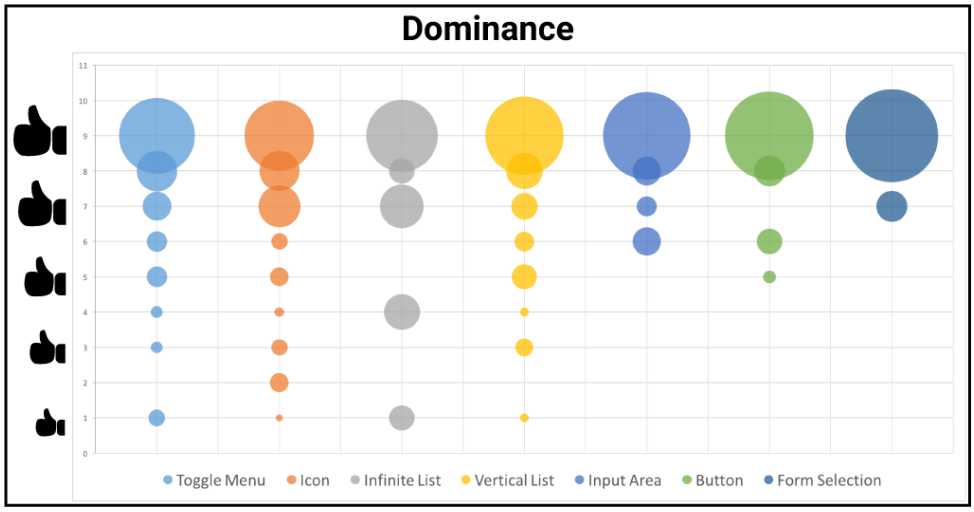

Figure 6 – User dominance by Design Pattern

It is also clear that the same patterns that had poor satisfaction also had higher incidence of negative dominance, which means that the overall emotion of the participants while using these patterns was negatively affected.

3.3.2 Researcher Perspective

In contrast to the user perspective, the researcher perspective is oriented by activities and not by patterns, although the correlation with the user perspective can be easily noticed. Activity 1 had the highest occurrence of the Help tag which can be explained by the fact that it was the first contact with the application and many questions about localization would arise. Also, when comparing to the SAM results of the design patterns and the video recording, it is possible to understand that due to the fact that to complete the task the participants needed to navigate through the menu (Toggle Menu) of the application, they would not know which options would be available in the menu and which screens would be presented on each item.

Still on the first activity, there is a significant high occurrence of Where am I? and Where is it? tags, which reinforces the argumentation that the users had difficulties understanding their localization in the app, which actions they should perform to complete the first activity and what operations were available.

On the second activity there was a high occurrence of Where is it? tag followed by Where am I?, What now? and Oops. While analyzing this activity through the video recordings, it was possible to understand that occurrence of the CEM tags were mainly related to the Icon design patters, where the participants had great difficulty understanding the meaning of the figures used to represent actions and functionalities in the application, even in some cases where there was present a textual hint alongside with the icon, which made it difficult for the participants to find actions and complete the activity.

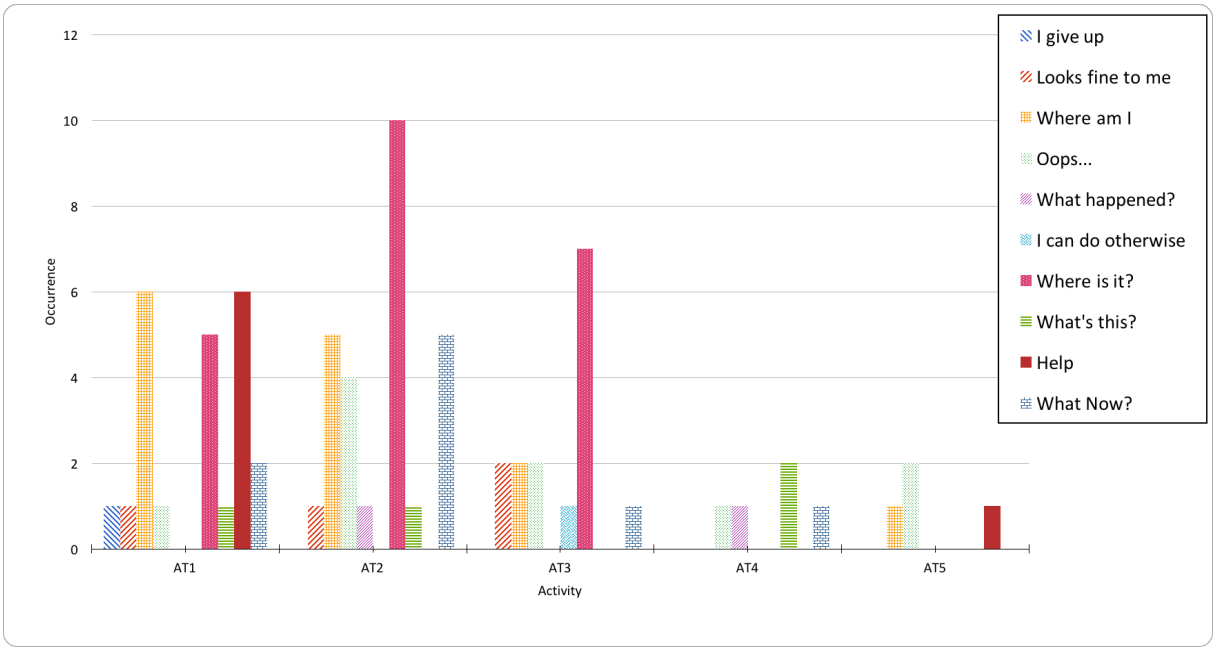

Figure 7 – Occurrence of CEM tags by activity

In the third activity the participants should look for a specific student and send a private message and one way of doing this was to iterate over an infinite list to find the student. In Figure 7 we can see that this activity had a high occurrence of the Where is it? tag, which means that the participants had difficulties using the infinite list and finding the specific item of the list (that was conveniently located near the end of the list). By looking at Figures 5 and 6 it is possible to identify that the Infinite List pattern had the worst satisfaction and dominance signed by the participants, which means that they had trouble using the design pattern, which negatively affected their interaction and the completion of the activity.

The fourth and fifth activities did not present high occurrence of any tag, but some isolated cases of What's this?, Oops and Where am I? tags. This can be explained by two factors: (i) these activities where the last ones and by the time the participants had completed the first three, they already had explored great part of the applications and had an idea of where to look and what to do and (ii) the design patterns related to three activities were the ones with highest rates of satisfaction and dominance (Input Area, Button and Form Selection), which leads to the conclusion that the users were used to the adaptation of these patterns on mobile devices.

Finally, the observations made during the experiment by the evaluators was analyzed and we could find important annotations that could not be identified in the recordings and helped to better understand the occurrence of tags and the correlation to the emotion feedback of the SAM questionnaire.

3.4 Discussion

From both user and researcher perspectives it can be observed that there weren't identified major problems with the patterns Input Area, Button and Form Selection. One of the reasons for this to happen is that these patterns are well known interface elements that can be found in most web pages and thus, the participants were used with the mobile adaptation of such elements as reflected with positive satisfaction and dominance and also by the lack of CEM tags identified in the videos and problems related by the observers which indicates low accessibility problems.

On the other hand, the Infinite List pattern: this patterns presented lower satisfaction and dominance amongst the participants and a high concentration of Where is it? tag and from the video analysis it was identified that a good portion of the participants did not understand the continuous loading for new information at the end of the list and were frustrated for not being able to find the correct list item (several participants gave up the task of looking for an specific item and chose randomly). This represents a serious accessibility barrier that the participants had to face and directly affected their mood during the experiment.

Also, participants were troubled by the Toggle Menu: although it has mostly good satisfaction, it presented worse results in terms of dominance and can be seen on Figure 5 and Figure 6. In the recordings it was possible to see that the participants would open and close the menu several times in order to find the desired option in its Vertical List. These problems impacted in the time consumed during the tasks and also in the mood of the participants: it was possible to see the frustration of not finding an option and the need for help from the evaluator in order to complete the task.

The Icon design patterns can also be highlighted as it had the highest occurrence of *"Where is it?"* and *"Oops"* tags. It was possible to identify in the recordings that the participants had trouble understanding the meaning of some icons and would do and undo an operation in order to know what the icon represented. In Activity 2 (AT2) the participants should check their grades on an assessment performed in a previous week that was in the main page with an Icon and text representation, however as the image presented in the Icon was a bar chart, the participants would not identify themselves with the icon and ignored the text, trying to look somewhere else for the grades. This also reflected in their satisfaction and mostly in the feeling of dominance, as it can be seen that there is less concentration of points on 9 and more on 8 and 7 (and a good amount below 5).

All issues reported impacted directly and indirectly the interaction of the participants with the mobile application. For instance, we can relate the time consumed performing the experiment with difficulties found with the elements Toggle Menu and Infi-

nite List where the participant would spend most of the time looking for an option instead of actually performing the activity: most participants took around 22 minutes to complete all activities, however, in a few situations, some participants took more than 30 minutes to complete the same activities. Also accessibility and usability barriers encountered by some users caused frustration and irritation that were noted by the observers and during the video analysis.

A possible comparison between the problem of finding information in a Toggle Menu with visually impaired users can be identified: when a blind user or a user with low-vision access an application, he doesn't know which options a menu offers and needs to access item per item to understand the available features; when a user without disabilities access an interface with a toggle menu, he also doesn't know which features are present in the menu, in fact the user needs to identify the icon or text that represent the trigger for the menu and only them he will be able to see the which options are available (YESILADA; BRAJNIK; HARPER, 2011b).

The accessibility barriers encountered by the participants during the experiment are problematic as they can directly impact the usage of the e-learning platform in a mobile device. One must consider that during the experiment the participants could ask for help when they had issues with some interface element, but that this help would not be at hand if they were using the application in a real life scenario which could spoil their learning experience and prejudice their educational performance.

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Another important fact is that none of the participants had identified disabilities. This is important to be noticed due to the fact that disabled people have serious issues with the traditional education system because it is not adapted to their needs and sometimes they seek aid in technology to help overcome their limitations. The presence of accessibility problems related to design patterns in a m-learning application can create more problems than it solves and discourage such users to continue with the learning process while in the case of participants without disabilities, the problems are mostly situational and can be overcome with some effort, using another platform or asking for aid.

While the use of mobile devices to access educational environments provide easy access to information anywhere, anytime, accessibility problems as the described can jeopardize the process of knowledge acquisition, leading to further issues that could discourage users from using m-learning platforms. Also, by the time this article was

written, we could not find any work that analyzed the accessibility of Moodle for mobile devices which makes this study an important contribution for developers and designers that work with Moodle on mobile.

3.5 Conclusions and Contributions

This study presented an accessibility evaluation of interaction design patterns on the m-learning platform Moodle based on emotional assessment with users without disabilities. The initial idea that accessibility barriers could be identified using design patterns and that such barriers would also affect the experience of users without disabilities while using the a m-learning platform was confirmed and the emotional impact of such barriers can be identified in the user interaction as well.

The problems related to the seven design patterns analyzed in this study were the result of an emotional assessment using the SAM technique as feedback from the participant and by the analysis of video recording from each participant's interaction with the mobile app.

The accessibility barriers identified are diverse: the participants had trouble to identify the meaning of icons present in the interface, which lead to errors while performing the activities; there were reported problems of localization where the participants would spend a long time looking for one information in the application menu or would not understand the behavior of an infinite list, which would implicate in the increase of time needed to perform an operation and lead to frustration and even abandonment of the activity.

The results also show possible impacts of accessibility problems on m-learning platforms in the learning process as users can be unmotivated to continue studying due to barriers that are imposed by the lack of adaptation of the platform. This impact should be later verified in further studies.

The 21 participants performed five common activities that were parts of a chemistry class in a controlled environment where none of them had identified disabilities and all were familiar with the Moodle e-learning platform for desktop. Due to the characteristics of the participants (young, used to mobile devices and e-learning platforms and without disabilities) the results presented here are not as expressive and they would be if the experiment had been performed with disabled users, however this was intentional as the principle of Universal Design is to design for everyone. Thus, it is important to analyze the impact of accessibility problems to any person.

There were noticed problems with the interaction with the application and these problems were mapped to Interaction Design Patterns and later investigated using record-

ings of the screen and face of the participants. The major issues were related with finding information or identifying the meaning of interface elements that directly affected in the participant's performance.

Lastly, the use of interface design patterns is a form of identifying problems and proposing viable solutions that can be replicated by any developer or designer and used in any situation and context to a wide variety of users and devices, promoting in its way a form of design for all.

4 Virtual Ethnography approach for studying online communities in software engineering

Due to the difficulty in finding information and practical examples in the literature about virtual ethnography studies in Software Engineering, this chapter presents an approach to conduct ethnography studies in online communities where developers usually share and discuss practical issues of software engineering.

4.1 Fundamentals of Ethnography and Virtual Ethnography

The path to understand a social group, its culture, institutions, interpersonal interactions and beliefs is challenging and may seen even more inaccessible when not using the appropriate research method (ANGROSINO, 2007). Ethnography may help in situations where the goal is to understand a community by analyzing it's behavior and social interactions as it is a qualitative research method that combines observation, participation, interview and document analysis as tools to aid in this discovery.

Ethnography is a descriptive technique that uses raw data collected from observation or participation in a community or group and identifies common patterns that are present in the raw data and produce general theories that explain such patterns (HAMMERSLEY; ATKINSON, 2007).

In the literature there are not many ethnographic studies on Software Engineering (SHARP; DITTRICH; SOUZA, 2016) and there are even fewer studies conducted on virtual spaces. However the necessity of solving problems that frequently arise from the market practice is one of the motivations for which Software Engineering and other sciences produce research and the link between the practice and academy is essential for the development of new research (SANTOS et al., 2012).

Although ethnography is being used recently in the area of Human Computer Interaction and Software Engineering in order to help to improve the software development practice, it has its roots in social sciences and anthropology where it was first used in studies that aimed to understand new cultures and civilizations (LAZAR; FENG; HOCHHEISER, 2010).

4.1.1 Virtual Ethnography

While classical ethnography research focuses on the study of social interactions of communities that take place in physical spaces, virtual ethnography transfers the research

site to socials spaces in the Internet (HINE, 2008).

Since the beginning of popularization of personal computers with access to the Internet in the 1990s, interesting social formations started to emerge in the digital world (BAYM, 1995) and this scenario caught the attention of many researchers that wanted to explore and understand the interactions in this new form of communication. The first ethnographic studies of virtual communities that emerged in mid-1990s analyzed conversations, documents and interviews with group members as would happen in a traditional ethnographic study, however important questions about the importance of presence and other dilemmas were not yet discussed (HINE, 2000).

With the emergence of new forms of interaction on the Internet as online multi-player games and social networks as Myspace, Orkut and later Facebook, different settings for ethnographic studies appeared with new challenges of data collection from chat logs and different types of media as pictures, video and audio files. Also the researcher needed to be comfortable with the new reality and develop strategies to interact with the communities (BOYD; HEER, 2006).

As on classical ethnography there are several dilemmas that ethnographers face in deciding how to conduct an study, however, in virtual ethnography some concepts may seem more complex and have more ramifications that have not been widely discussed (BOELLSTORFF, 2012). One of the first puzzles that the researcher must face is choosing a participation role in the research: there are several levels of participation between only observation and total participation (HINE, 2008) and, while some researchers in the literature may agree that some degree of participation is necessary, the nature of the community may force the researcher to adopt an observer or hybrid position in the study.

Also, with the participation role defined other challenges also arise as the concern with authenticity aspect regarding the disclosure of the researcher's identity and intentions and other ethical issues as the use of informed consent form and protection of privacy of online users (DRISCOLL; GREGG, 2010).

4.2 Virtual Ethnography Approach

Based on the fundamentals of traditional ethnography and on the particularities of the Software Engineering field, the approach may be considered a guideline for supporting researchers to investigate the development practice. The approach for virtual ethnography presented in this chapter aids the researcher in all stages of an ethnographic study, from the planning to the execution and data analysis.

An important feature of the approach presented is the definition of a protocol to answer and define important questions that arise during ethnographic studies focusing in

the characteristics that are intrinsic to studies performed on online communities and virtual artifacts as the selection of a historical period (that is a time frame in which information in the Internet will be accepted for the research) and the definition of strategies for storing and organizing volatile information from the Internet in order to preserve it's availability and original content.

Another significant aspect of both the approach is that in the literature one can find a few examples of virtual ethnography in areas related to the software development practice, however, these studies use as primary source of information the analysis of interviews with participants of the online community. However, direct interviews may fail to extract concerns and issues from the daily life of software development.

Therefore, research that considers the information and discussions publicly available on forums and blogs (that are not directed to a person, but to the community) have the opportunity to observe the interaction between developers and understand how the creative process of software development and problem solving happens with the collaboration of colleagues in its natural habitat: the virtual world.

The proposed approach for virtual ethnography in the study of the practice in Software Engineering consists of 3 steps (1 - Planning; 2 - Ethnography Execution; 3 - Data analysis) that are discussed in the following subsections and presented in Figure 8.

4.2.1 1st Step: Planning

The planning step consists of two phases which are the Definition of an Ethnography Protocol and the Selection of Information Sources (steps 1.1 and 1.2 in Figure 8). The phases are connected and executed in order, also, at the end of the second phase, the researcher must decide whether it's necessary to return to the protocol definition for adjustments.

In the literature HINE (HINE, 2008) presents a set of dilemmas and practices of online ethnography that includes several characteristics of ethnographic studies in virtual communities as the participation role of the researcher among others characteristics. While SHARP; DITTRICH; SOUZA (SHARP; DITTRICH; SOUZA, 2016) compiles five general dimensions of ethnographic studies in Software Engineering containing key topics to help the researcher in the planning and execution of the ethnography. These definitions together are used to advise the researcher about key points of an ethnographic study.

However, in our study we've identified the urge of new dimensions that are specific for ethnographic studies in virtual communities. A structured discussion of the dimensions present on the literature alongside with the specific characteristics for virtual ethnography are presented in the following sections as recommendations and definitions that the researcher should account for previous to the ethnographic study.

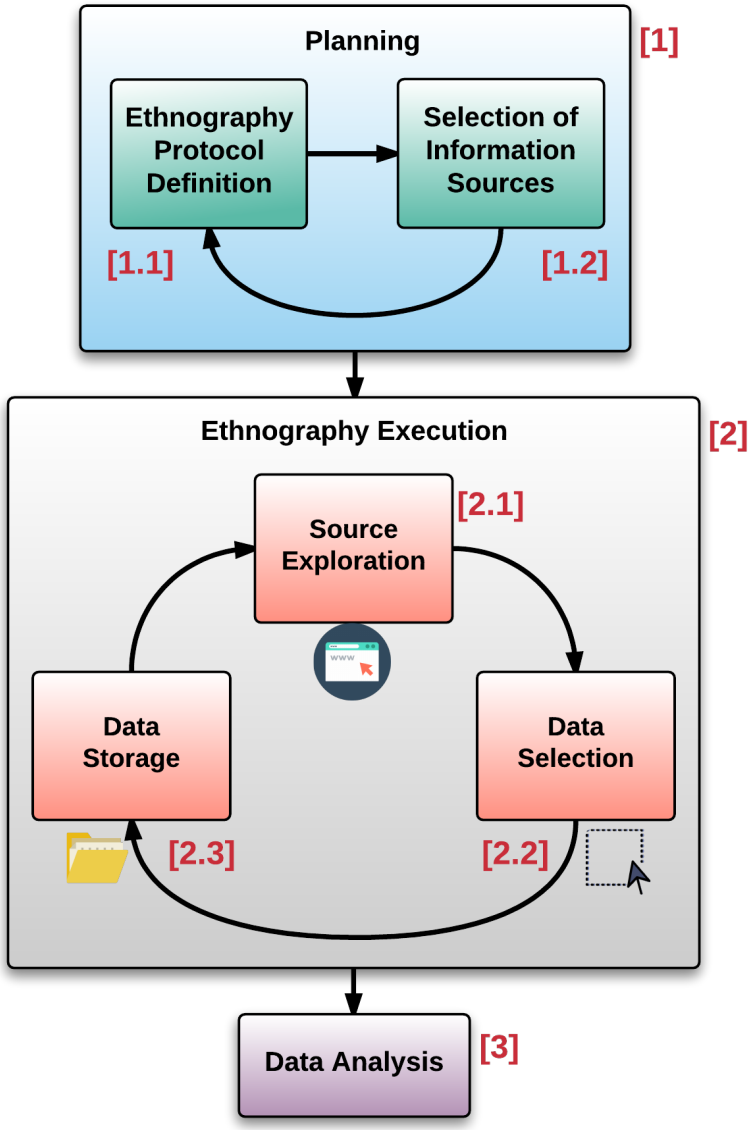

Figure 8 – Virtual Ethnography Approach

4.2.1.1 Ethnography Protocol Definition

The definition of a protocol for an ethnographic study may differ according to how the study will be conducted and what will be the approach adopted by the researcher. However, it is advised because it will aid the researcher to think ahead about important aspects of an ethnographic study as the participation role and ethical aspects. This is the first phase of the planning step represented in Figure 8 and here we present a discussion of the 5 dimensions of ethnographic studies proposed by SHARP; DITTRICH; SOUZA (SHARP; DITTRICH; SOUZA, 2016) in the context of virtual ethnography and propose 2 more dimensions (Historical Period and Storage of Volatile Data) elemental to ethnography in virtual communities that need to be addressed by the researcher in the definition of a protocol.

Participation role - On online communities the aspect of participation is of great importance, as it defines the role that the researcher will take as a participant of the group or as a simple observer that does not take direct actions in the group's activities. As ethnography is the science of describing and understanding a human group (WOHLIN; HÖST; HENNINGSSON, 2003), the observation of social interactions between members of a group is an essential data collection method alongside with other forms such as interviews, document analysis and log analysis.

There are mainly two participation roles in ethnography: the participant observer (or participant) and the non-participant observer (or observer). In the first case, the researcher participates in daily actions of the studied group and directly interacts with the subjects, becoming a member of the social group and participating in all activities in order to observe the practice by becoming part of the interaction. In some environments the participation can be challenging, as sometimes the group may not accept or receive well new members which can impact their natural behavior or the researcher may not be allowed to participate in all activities due to legal reasons.

The other participation role, called observer is when the researcher does not directly interacts with the group and do not participate in the group's activities, but observes the subjects in their daily interactions. The observation role of participation may be helpful on situations where direct participation is not allowed or not possible. Thus the observation role is a valuable approach and it may allow the researcher to conduct its research on environments that do not allow participation, but observation may also demand more dedication in order to capture the essence of the community only by looking at it (HINE, 2008).

Other details also need to be addressed and defined by the researcher when choosing a participation role in an ethnographic study as of being clear about his role and identity as a researcher when joining a group which may be considered ethical in some contexts, but also may cause the subjects, members of the studied group, to feel uncomfortable knowing that they are being analyzed or may cause rejection by the group, directly interfering in the research. There are other ethical questions that have been widely debated in the literature (HINE, 2008; HINE, 2000; STEINMETZ, 2012b) and that the researcher needs to be aware of as the use of informed consent of age in virtual environments and the implications of preserving the privacy of participants of sensitive online communities.

Duration - In the social sciences area, a traditional ethnographic study would require a long-term dedication in the phases of field participation and data analysis as the researcher would have to visit the community studied and depending on the location and the community, the journey and the duration of stay may be extensive in order to actually understand the culture and social interactions of the group. In Software Engineering there are also examples of long-term researches as LOW et al. (LOW et al., 1996) that conducted

an ethnographic study of 15 months interacting 4 days of the week and other studies that have taken several months but had interactions of 1 time per month for example, which illustrates that the researcher does not need to be located every day of the week, every week in the study site, but can dedicate fewer days in site and have time to early analyze the data collected.

Both on classical ethnography and virtual ethnography, there isn't a metric that can be used as reference by the researcher regarding the duration of an study. Usually, ethnography in computing related areas takes less time than social sciences (SHARP; DITTRICH; SOUZA, 2016) for example, as the goal is to understand the practice and social interactions of small groups and not from a civilization for example. On virtual ethnography the scenario is the same: while there are conveniences as easier access to information, there may be more information available or it may demand more time to filter through the information that is available.

Location - The location in ethnography is where the studied community is, where it communicates and interacts and where the researcher will be able to extract information from the group. With the globalization and dissemination of Internet and technologies the location became a more abstract concept where the site where the group communicates and interacts may not be a physical space or there may be more than one site (physical or digital ones) (HINE, 2000). In Software Engineering it is becoming common to find studies that are conducted in multiple field sites, in what is called a hybrid approach, where the researcher observers in physical settings but participates and collects data in virtual environments (JORDAN, 2009).

On virtual ethnography the location is somewhere in the Internet: it may be blogs, forums, mailing lists, private groups, chats, online games, email or other forms of electronic communication. The researcher do not choose the location in which the community interacts and because of that, it's necessary to know how to behave in different environments and how to correctly participate and collect data in every setting. For that the location should be studied in order to obtain better results. If the researcher doesn't know how to search and interact in a forum, the data collected may be insufficient or inadequate for a correct analysis of the community that's being studied.

Theoretical Underpinnings - Theoretical Underpinnings are the basic foundations for a research. Ethnography as many other research methods is not presented with a strict framework that every study must follow because it is a broad method for qualitative analysis and the plurality of studies, communities and goals of all ethnographic studies make it impossible to develop such general framework. Therefore there are several theoretical frameworks that are commonly used in ethnography as Ethnomethodology (GARFINKEL, 1991) and Activity Theory (ENGESTRÖM, 1999).

The choice of which framework and whether or not to use one depends on the

intentions of the researcher and the nature of the research (SHARP; DITTRICH; SOUZA, 2016). On Software Engineering and on Virtual Ethnography it is not different as many frameworks may not be applicable to the study, settings or nature of data collected in the study.

Ethnographers' intent - The intent of the ethnographer, the motives that provoke the researcher to do research, and, in this case, to investigate a community and understand its social interactions usually is the primary intent of the ethnographer and not how the information collected can be used to exploit the group's values (GOH, 2007). In Software Engineering the simple achievement of understating the practice can be extremely valuable for empirical researchers as it may help to instigate the evaluation and improvement of processes and methodologies.

However, other empirical software engineering researchers may not be satisfied by simply understanding the practice without actually proposing improvements, new methodologies or tools that would aid the software development practice. Thus, it is important for the researcher to understand that his intent in the research may affect the interaction with the community (DITTRICH, 2002) and that its actions can interfere with the studied group and with the research. The researcher then needs to be clear about his interests in the research in order to avoid future confusions.

Historical Period - New concerns and characteristics arise when dealing with online data in virtual ethnography, one of which is the preoccupation with a well defined scope that will help to filter enormous amounts of data that are available online. It's not possible for the researcher to collect and analyze all information produced by an online community in the course of time and also a great part of the data will not be valuable for the study as it's not related to the intention of the research.

Therefore it's important to know how to filter information in a way that valuable information is selected and useless data for the research is not collected. In virtual worlds trends and technologies are highly time sensitive: a discussion on development of solutions for smartphone bluetooth 2.0 technology from 6 years ago may not be relevant for an ethnographic study that intents to understand the use of current bluetooth technology compared to other wireless protocols as the bluetooth protocol has advanced in speed and power and the researcher wishes to study the interaction with recent technologies.

On other contexts the researcher may have access to historical records of conversations and may need to limit the scope of the research for a specific time frame. In this and other several cases, the definition of a historical period is essential for the ethnographic study and it will help to provide more precise data for the research.

The definition of a historical period on virtual ethnography was a necessity identified during the planning and definition of the protocol in the study as the literature (HINE,

2000; HINE, 2008) do not mention this characteristic of ethnographic studies on online worlds (perhaps the reason of this lack of information is the fact that usually ethnographic studies consider interview transcripts as data input and not articles or historical chat logs to be analyzed).

Storage of Volatile Data - Online information is volatile (STEINMETZ, 2012b) and as ethnography in virtual communities often deals with historical data, it's important to store and catalog such information in order to preserve its integrity: a blog post that was accessed and analyzed two weeks ago may not be available anymore or may have been edited since then.

There are several strategies for dealing with volatile data from the Internet as saving digital or physical copies of all necessary documents. However, there are key concerns that the researcher needs to have while defining the strategy to preserve information content: if the researcher chooses to hard copy all relevant information from a virtual ethnography study he will probably have difficulty managing and organizing all information, also searching for specific parts of information can be challenging. Another strategy is to save *.pdf* files of every relevant information, however, as good as it may sound, there are also possible problems with this approach as the browser's pdf print service may not produce a faithful representation to the actual page being printed, which may cause overlay of important pieces of information.

Saving information in picture formats alone is also not advised when dealing with textual information as it may prove almost impossible to use qualitative research tools in the data analysis of text. Thus it's important that the researcher understands the nature of the data that is being captured and adopts an effective approach in order to lower the chances of data loss by adopting more than one approach for data storage, even if this means redundancy of information.

Another concern with data storage is the organization of information. After collecting all information, the researcher needs to review all data and analyze the connections that may exist between different pieces of information that may have originated from different sources, thus the information must be cataloged in a meaningful way for the study. The processes and strategies for cataloging data may differ according to the research's topic and data and the researcher must understand how to properly storage all information as this can save time and effort on future steps of data analysis.

4.2.1.2 Selection of Information Sources

Selecting reliable and valuable information sources is essential for achieving relevant results in ethnography and in any other research technique that receives data from different sources as input. Therefore, this planning phase is extremely important as all the later work will use the information extracted from the sources selected in this step. There are

different strategies for gathering relevant data sources from the Internet and each one has its advantages and disadvantages as presented in this section.

One strategy is to use personal previous knowledge of the online community studied and choose the sources from the experiences that the researcher already had while studying or interacting with online groups. This strategy depends solely on the researcher's point of view and background to select the information sources used in the ethnography and, although this strategy provides agility and efficiency, it also raises concerns about the relevance of up-to-date information as the researcher may know where to find the information in the web, but may not be updated with new trends in the community and important new sources can be left out of the research.

Another strategy is to consult experts and people with knowledge and experience with the online community being studied in order to identify the information sources relevant to the research. This strategy is useful when the researcher does not have a deep knowledge of the online group or when the researcher wants to have plurality of information from the experiences of other people that can be done by using techniques for collecting information such as surveys or interviews. The use of this strategy may result on more reliable and updated data, however, it takes more time as the researcher needs to talk to other people and scheduling and analyzing these interactions can take time.

After gathering a set of information sources, many times it is necessary to select the most reliable or valuable sources for the research as it would take a long time to analyze everything that exists on the web about a topic. The researcher can adopt any criteria that may help to rank the sources and then select the most relevant, one of which can be the classification rank on search engines or conduct a quick analysis in each source in order to determine the relevance.

4.2.2 2nd Step: Ethnography Execution

Having defined the protocol and selected the information sources for the study, the next step is to iterate over all sources and gather information and whether the researcher will perform interviews with selected audience or analyze data logs and conversations, the researcher shall follow the three stages presented in Figure 8: (2.1) source exploration, (2.2) data selection and (2.3) data storage.

Source Exploration - While visiting a source of information, the researcher needs to have an efficient way of searching for information, and, in most cases, this can be done by building search queries that are used in the search engines of each forum or blog and paying attention to the period of time defined in the protocol. Most search engines do not accept sophisticated search queries, therefore the search string is applied generally to the raw data and the researcher needs to define one or more sentences that represent the

intended result. On other cases in which the researcher will perform interviews or analyze data logs this process of defining search queries is not necessary.

Data Selection - The second stage is to perform a preliminary analysis of the data in order to select only relevant data for the study as the amount of information tends to be substantial when dealing with information available in the web. Here the researcher must access every document, page, conversation, interview transcription or data log and analyze it's relevance to the research.

Data Storage - Having gathered and selected all relevant information from one source, the researcher needs to safely store and catalog this information in order to prevent data loss as all information in the Internet is volatile (STEINMETZ, 2012b). There are several ways of storing online information as creating *.pdf* files or images or even text copies and the choice depends on the preference of the researcher that was defined in the protocol. With all relevant information extracted from one information source, the researcher shall begin the same process with the next source until all sources have been consulted.

4.2.3 3rd Step: Data Analysis

The last step of the approach is to actually analyze all the data of the ethnographic study. In this step the researcher usually deals with large amounts of data and the preliminary analysis performed in the previous step is deepened and compared with all the information sources and documents used in the study. Any qualitative data analysis methodology can be used to study the data collected in the ethnography and the preference must be defined by the familiarity of the researcher with the research method and by the data type and structure in order to obtain better results.

4.3 Conclusions and Contributions

The literature presents preparations that are proposed for the researcher in order to plan and execute its ethnographic study. BOELLSTORFF (BOELLSTORFF, 2012) introduces valid questions in the discussion of selecting a group or activity to study, understanding the fieldwork and planning ahead the interaction with the studied community. LAZAR; FENG; HOCHHEISER (LAZAR; FENG; HOCHHEISER, 2010) presents general recommendations of how to prepare and execute an ethnographic study in the context of Human Computer Interaction. SHARP; DITTRICH; SOUZA (SHARP; DITTRICH; SOUZA, 2016) describes the five dimensions of ethnographic studies that delivers a good understanding of some important aspects and details that the researcher needs to address and be aware before the execution of the study. None of them actually presents a check-list or a plan of work containing specific information about ethnography in virtual worlds.

However the first step in the proposed approach, called Planning in Protocol (Figure 8), instigates the researcher to think and plan ahead its actions before actually starting the study and contemplates specific topics that are present on the study of online information: the selection of historical period for data collection and the storage of volatile information. The definition of the protocol for the ethnographic study was found exceptionally useful in the study presented in this paper and there were rare cases of doubt regarding behavior and actions that were necessary when dealing with sensitive data from the web and having a document containing already discussed aspects of participation and ethics for example was important to avoid unnecessary and redundant discussions.

Analogously, CRABTREE (CRABTREE, 2012) and LAZAR; FENG; HOCHHEISER (LAZAR; FENG; HOCHHEISER, 2010) presents similar discussions on the selection of a site or group of interest to research with emphasis on the Human Computer Interaction context, outlying possible barriers that may occur in the task and advising correct behavior on different contexts. Also LAZAR; FENG; HOCHHEISER (LAZAR; FENG; HOCHHEISER, 2010) introduces the notion of convenience in the selection of communities to the study and advises in situations where several candidates for the study are available and the researcher needs to choose the most valuable ones for the research.

Despite these and other characteristics being covered in the literature, little is said about the selection of information sources and communities in virtual worlds where the situation may seem akin, however there are complications particular to the virtual world as the large amount of similar data and the wide variety of sources and formats in which the information is available. The second step in our approach gives special attention to intrinsic characteristics of the task of selecting information sources from the Internet that we found to be effective and appropriate in the study that was carried: with the use of a survey to identify possible sources of information from experts of the research topic, we had the opportunity to witness different views and opinions regarding the same subject and could select sources that were valuable and fundamental to the research.

The second step presented on Figure 8 proposes a cyclic approach consisted of three actions of visiting sources, collecting data and storing and cataloging documents. This is not different from the strategies of data collection and historical and archival research in virtual works presented by BOELLSTORFF (BOELLSTORFF, 2012) where the focus is shared between various types of virtual artifacts from interviews, wikis, logs transcripts, blog posts, forum conversations and other documents.

What distinguishes the proposed approach for virtual ethnography is the plan of three self-contained actions that work together in the task of collecting documents and the recommendation to catalog and organize data in a way that would simplify the process of data analysis. As we had to deal with large amounts of data in the ethnographic study, the organization of publications by information sources (domains) and the redundancy in

storing the data in different formats contributed to reduce the time spent subsequent to the data analysis where metrics were necessary to better understand the quality of data extracted from each source. Also when using different tools for qualitative analysis, the option of having different formats of the same document was helpful as not every page saved *.pdf* carries content in the same disposal layout and by the time that this paper is being written, some of the links that were used in the research are no longer online.

There is no secret in analyzing qualitative data from ethnographic studies and, although HINE (HINE, 2000; HINE, 2008) are vague when describing techniques for data analysis, other references present different methods to analyze data from different natures as participant observation data, interview transcripts, image, video and textual data (CRABTREE, 2012; BOELLSTORFF, 2012; SHARP; DITTRICH; SOUZA, 2016; LAZAR; FENG; HOCHHEISER, 2010).

Nevertheless, the approach presented in this chapter is both generic enough to be adapted in different contexts without chaining the researcher to a strict research protocol that would limit its ability to improvise and innovate, it is also sufficiently complete to be used on virtual ethnography studies in Software Engineering supporting the researcher by conducting and aiding the researcher to plan and execute the research following a well defined plan and protocol.

5 Investigating accessibility issues of interaction design patterns

This chapter presents an investigation on accessibility of interface elements (design patterns) of mobile applications in the form of a virtual ethnography. The study was conducted with the goals of identifying accessibility issues and recommendations to better understand the problems faced by disabled users when using interface mobile design patterns and understand the impact that using interface design patterns can cause for the accessibility of the mobile applications.

In this study were considered only information related to Android interface design patterns. Thus, were discarded iOS and other mobile operating systems due to the fact that Android has 81.7% of the smartphone market share in the world (GOASDUFF; FORNI, 2017) and 93.2% of the smartphones in Brazil are Android (CARVALHO, 2017).

The virtual ethnography study presented in the following sections was based on the approach for ethnography in virtual communities introduced on Chapter 4.

5.1 Virtual Ethnography in Practice

This section presents a case study in which the approach for virtual ethnography proposed on Chapter 4 is used. The goal of the study was to investigate the problems and solutions involving the use of interface design patterns in the mobile context by analyzing public information available in forums and blogs and not present on academic articles. The choice of using Virtual Ethnography was made due to the existence of few articles in the literature on accessibility of mobile interface design patterns and the importance of knowing the practical experience of developers who have faced accessibility problems in the context on mobile interfaces and proposed improvements to surpass these barriers.

The following sections will present each step of the virtual ethnography study that was performed.

5.2 Contextualization of the research

The idea of looking into the market and listen to developers and designers that deal with mobile accessibility arose from an initial study where the literature was searched for articles on the relationship of mobile interface design patterns and accessibility. A second step was to produce a previous research where a set of Android mobile interface design

patterns where evaluated in terms of accessibility in an e-learning platform (CASADEI et al., 2016). In that study was identified with user experimentation that some mobile design patterns presented accessibility barriers to users without deficiencies and also identified that there aren't many updated works in the area of mobile interface accessibility (and almost none related to interface design patterns).

With the lack of information on academic sources, it was decided to search for the information on different channels and found several articles on blogs and useful discussions on forums about designing mobile interfaces for people with different disabilities and decided that this information was useful for our research and that it deserved to be analyzed, cataloged and presented in academic format.

Due to the fact that the virtual ethnography success is directly linked with the online locations where the study is carried out, it was conducted a pre-planning phase in order to collect relevant references to be investigated.

5.3 Pre-planning

The identification and choice of sources of information with trustworthy and relevant data is a crucial requirement for the success of any virtual ethnography study. Because of this, it was decided to question active designers and developers in the community about which places they used to gather information about mobile accessibility and design patterns.

In order to achieve this, a quick survey was created in Portuguese and English with questions about experience working with mobile technologies and accessibility and a last question where any source found relevant to the topics should be informed (see Appendix E).

The survey was shared (in mailing lists of universities, partners and on social network groups dedicated to design) during three weeks in November 2016 and reached a total of 44 participants (designer and developers) from 14 countries (Brazil, Colombia, Chile, Germany, USA, Ireland, Japan, Spain, Portugal, France, England, Mexico, Peru and Italy). Although the participants of the survey were anonymous, some professional questions were asked and it was possible to find that 56% of the 44 participants were developers (which means that the survey reached a similar amount of designers and developers). Also, 32% of the developers and 58% of the designers have between 5 to 10 years of experience working in their profession and 63% of all participants "knew" or "knew a lot" about Mobile Interface Design Patterns and Accessibility.

The survey resulted in 72 websites, forums and blogs informed by the participants. However a preliminary analysis was done and all sources were accessed and searched

in a process that resulted in 54 sources being eliminated due to several reasons: some addresses or names were not found, other sources were documentations or had focus on iOS development or nothing on mobile accessibility and design patterns was found. Which resulted in the selection of 18 information sources that were used in the study and will be reported in analysis section.

After gathering sources where the information would be collected, the planning step was initiated.

5.4 Planning

Before starting to search the web for information regarding mobile accessibility and interface design patterns accessibility, there were defined several aspects of an ethnographic study and compiled these aspects in our research protocol that is part of the Planning process (step 1 on Figure 8).

5.4.1 Ethnography Protocol Definition

The protocol was defined for all 7 dimensions presented on Chapter 4.

Participation role - The first aspect that needs to be discussed is the role of presence in the ethnographic study. Although the adoption of any presence role brings advantages and challenges to the researcher and due to the nature of our research goal (the wish was to examine public information available in the Internet), it was decided to adopt the role of observer.

Regarding the concern with the researcher's identity, it was decided to adopt the position of not informing the subjects of our research intentions. This decision was made because it was not wanted to influence the online community with our study and due to the fact that was our intention to analyze data publicly available on the web.

Another important aspects of ethnography is the ethical position of the researcher regarding the anonymity of the participants and the informed consent and age. Forum and blog users, even of public content, often assume that anonymity is secured on the Internet and that information and opinions posted online will not be traced back to their real identities (STEINMETZ, 2012b).

Although our goal was to gather information that is public and shared in the Internet without restrictions of reproduction and use, it was decided to maintain the subject's identity intact by not sharing citations linked to a username. Also the use of informed consent and age was discarded as the information is public and each online platform (blogs, forums and sites) already require its users to agree with terms of use and disclosure of information.

Duration - The duration of the study cannot be foreseen by the researcher, however, the researcher can trace a plan of work that determines the time spent in the field site and doing data analysis. For this research it was defined to take an approach where the analysis of data would be done after a source had been completely scanned as several sources of information were going to be used.

Location - The choice of the location (or locations) of this virtual ethnography came as an improvement form the phase of Selection of Information Sources and it was decided to search blogs, forums and other virtual references given by researchers, developers and designers (see Section 5.3).

Theoretical Underpinnings - The theoretical underpinning adopted in this study came from my previous work on accessibility of mobile design patterns (CASADEI et al., 2016) and from a technical report that assessed a set of design patterns in terms of usability and accessibility barriers for the web (YESILADA; CHEN; HARPER, 2009).

Ethnographers intent - The intent in this research was to identify the practice of developers and designers regarding mobile interface design patterns and understand issues faced in the development of mobile application and solutions that are proposed.

Historical Period - This unique characteristic of virtual ethnography studies was identified and had to define a period in which the information would be accepted in the research. As its often deal directly with technology on Software Engineering it's important to have in mind the relevance and popularity and usage curve of the technology in order to select a space of time where information about this technology will be relevant and not obsolete while dealing with mobile web that has changed broadly in the last few years and continues to change, it was decided to consider a window of 5 years of data. This means that only articles or conversations that were published after 2012 were considered to this study as it was perceived that most interface patterns had suffered modifications with the dissemination of smartphones in the world, that started to be expressive in this period of time.

Storage of Volatile Data - In the study with accessibility and mobile design patterns was adopted the strategy of redundancy when storing articles and forum conversations by generating a *.png* image of the entire page with the help of a plugin for Chrome browser in order to maintain the original state of the page and two other copies of the information in *.pdf* files (one generated with the browser's pdf saving tool and another with a special plugin that generates ready for print *.pdf* files) alongside with a *.txt* file containing the URL of the page.

The choice of adding the redundancy of *.png* and *.pdf* files was due to the fact that some pages do not adapt well when saved in *.pdf* and some information could be lost or overlaid by images or other elements and also because the data analysis would be

performed using the *.pdf* files and in our experience, some pdf readers do not perform well with selecting and copying information from these files.

5.4.2 Selection of Information Sources

Although we already had background knowledge on mobile accessibility from previous research and developing mobile applications with focus on accessibility, we believed that for this study a valuable approach to gather information sources was consulting the community of designers and developers from different parts of the world and ask which blogs, sites and forums were they used to improve their knowledge on mobile design patterns and accessibility.

In order to achieve this, we created a quick survey in Portuguese and English with questions about experience working with mobile technologies and accessibility so that we could better understand the participants of the survey and a last question where any source found relevant to the topics should be informed.

With the amount of participants reached in this survey, the good coverage in different countries and the information indicated related to work experience and knowledge in the topic of the survey, we believe to have achieved the goal to gather information sources from actual developers and designers.

The survey resulted in 72 websites, forums and blogs informed by the participants, however a preliminary analysis was done and all sources were accessed and searched in a process that resulted in 54 sources being eliminated due to several reasons: some addresses or names were not found, other sources were documentations or had focus on iOS development or nothing on mobile accessibility and design patterns was found. Which resulted in 18 information sources that were used in the study (see Table 1).

5.5 Ethnography Execution

With the protocol well established and the 18 sources selected, it was time to start the second step in our approach presented in step 2 of Figure 8, the Ethnography Execution. This step consists of three cyclic actions that were executed to each one of the information sources.

It's also important to notice that this process took most of the time of the research: the first cycle of this step was started on December of 2016 and the last cycle happened 14 weeks later.

5.5.1 Source Exploration

The first action was to access a source and search for content that was valuable to the study and, in order to do this, we had to create search queries that would express the topics we wished to find. As many web pages, all 18 sources had content and title based search engines with no sophisticated search controls, which means that we had to create a set of expressions in plain text and search for each expression.

The definition of these search strings is not random, the researcher shall have previous knowledge of the topic studied and know which expressions are often used to refer to each specific topic. In our study, as we reached professionals from several countries in the survey, (we had sources in three different languages: Portuguese, English and Spanish), we had to adapt our search strings to the correct expressions used in each language.

The list of search strings used in this research consisted of 10 expressions and small variations of these expressions: Mobile Design Patterns, Mobile Accessibility, Design Patterns, Inclusive Mobile, Inclusive Design Patterns, Android Accessibility, Android Design Patterns, Mobile UI, Mobile UI Accessibility, interface design patterns.

5.5.2 Data Selection

Each information source was then accessed and explored using the search queries where every blog post or forum discussion that matched the criteria was analyzed in order to evaluate its relation with the topic, importance and value of both its raw content and comments. Also, it was verified if the publication date matched the time criteria defined in the protocol, that is, if the information had been published after 2012.

5.5.3 Data Storage

If the information was considered relevant to the study it needed to be stored and cataloged. In our protocol we had defined that the documents would be saved in *.png* and *.pdf* formats in order to preserve the original content from the date it was visited and collected.

However it is also necessary to establish a set of criteria to catalog and organize all documents. Usually in a classical ethnographic study where interview transcripts are analyzed, the researcher organizes the transcripts by subject and date, in our study we decided to adopt a similar approach adapted to the nature of Internet information: we decided to create a structure of files containing domain folder, sub-domain folder (if present) and publication title. With this approach we were able to organize all documents and identify its origin, also, we chose to not catalog the publications by date because all of them were published in the last 5 years and because this information was not considered relevant to the study.

Table 1 – Number of publications by Domain (Information Source)

Domain	No. publications
medium.com	46
smashingmagazine.com	21
nngroup.com	12
stackexchange.com	10
reddit.com	9
creativebloq.com	7
uxpin.com	6
torresburriel.com	2
grihotools.udl.cat	2
uxmovement.com	2
usabilitygeek.com	2
bradfrost.com	2
androiduipatterns.com	1
visualhierarchy.co	1
lmjabreu.com	1
mobile-ui-design.ionicthemes.com	1
linkedin.com	1
jamesarcher.me	1

After analyzing all 18 information sources, we had selected 127 publications (presented on Appendix A). The distribution of publication by domain (information source) can be seen on Table 1 and it's clear that some sources as *medium.com* and *smashingmagazine.com* presented a greater concentration of documents extracted and this is explained by the fact that these pages publish articles from different authors, thus having higher publication rate compared to other sources.

5.6 Data Analysis

The process of analyzing the data collected in the ethnography can be done using several different qualitative analysis methods. In our study we had a large amount of data (127 documents) and we wished to understand the point of view of developers and designers who work with mobile UI and accessibility without the interference of personal opinions and knowledge that the researchers could have.

Therefore it was decided to use Grounded Theory, that is a qualitative research method used to develop a theory about something based only on data analysis (CHARMAZ, 2014), based on the theoretical knowledge that we had. Despite the core essence being the same, there are more than one approach to Grounded Theory and we decided to follow the version presented by CHARMAZ (CHARMAZ, 2014) as it is a practical and common approach.

Different qualitative techniques can be used with the purpose of carrying out of results analysis. One of them is Grounded Theory (GT), a method that uses a systematic set of procedures in order to develop and to derive inductively a theory grounded about a phenomenon based solely on the data collected (STRAUSS; CORBIN, 1997). Based on the collection of qualitative data, the researcher reviews the data and analyze concepts and ideas that are classified in the form of codes. Coding is a process where data is segmented on small fractions that can be conceptualized and integrated in order to form a theory. This way, codes are aggregated in concepts. Later, these concepts are organized in categories, that are the base to build the theory. The analysis and coding process reaches its end when theoretical saturation is reached, that is, when nothing new emerges from the process of analysis and categorization of the data (ALLAN, 2003).

As a result of the Grounded Theory method, many artifacts can be created an one of the most important artifacts is the Memo. Memos are notes about the data, codes, relationships between codes or even conclusions that the researcher finds useful to better mold the theory (BIRKS; MILLS, 2015). The creation of memos is extremely important as these annotations are the first attempt to communicate in textual format the results of a Grounded Theory.

5.6.1 Grounded Theory process

As described on Section 4.2.3 the process of analyzing the data collected in the ethnography can be done using several different qualitative analysis methods. In our study we had a large amount of data (127 documents) and we wished to understand the point of view of developers and designers who work with mobile UI and accessibility without the interference of personal opinions and knowledge that the researchers could have.

There are different methodologies with small differences of how to conduct Grounded Theory research as the classical definition (CORBIN; STRAUSS, 1990) and more recent and practical approaches (CHARMAZ, 2014). Despite the core essence being the same, there are more than one approach to Grounded Theory and we decided to follow the version presented by CHARMAZ (CHARMAZ, 2014) as it is a practical and common approach.

There is more than just one method for coding. One popular coding technique is called word-by-word coding. In this technique each word (or small groups or words) receives a code in the open coding step and it's usually used on extremely dense documents. Another technique analyzes and assign a code to each line or each sentence, called line-by-line (CHARMAZ, 2014). The coding technique that we adopted in this GT study is called incident-to-incident coding. In this approach, any amount of text in any location of the document can be coded. Incident-to-incident coding is mostly used on documents that have low density, that is, documents that are not derived from direct interviews and

may contain portions of text that are not relevant to the research as they address other subjects.

On the Open Coding process (incident-to-incident coding), each document was analyzed in order to identify text snippets that meant something and could be assigned to a code. This snippet could be a line, a sentence, several lines or an entire paragraph. After doing this for all documents, 243 codes were created.

The second step, called Axial Coding, reorganizes the data and established initial connections or relationships between the codes. This means that new codes can be created and also that existing codes can be deleted or merged into new ones. While on the first coding step (open coding) 243 codes were created, by the end of the second step 189 codes were left.

On the Axial Coding all previous codes were reviewed and all documents revisited. In this process it was possible to identify codes that were too similar or had intersection of codings in the text. In these cases, some code were created, some were deleted and other were merged.

In the third coding step, Selective Coding, the codes created on the two previous steps were refined and analyzed in order to identify main subjects in which the codes would be categorized. In this step, the 189 codes were organized in 27 categories. During this process, all codes were analyzed and were identified a set of categories were the codes could be classified.

Lastly, but of utmost importance, several memos were created based on the discoveries that were made from the coding process and relationships that were found between the codes. This resulted in 21 memos that detail several accessibility problems cited on the documents identified in the virtual ethnography. These memos also contain important thought and conclusions about possible solutions that might improve the accessibility of content and design patterns on mobile devices.

Table 2 – Relationship connectors on Nvivo 11

Symbol	**Relationship**	**Name**
$\longrightarrow$	A *one-way* relationship can be used to demonstrate a relationship between items which has a definite direction..	Leads to
——	An *associative* relationship can be used to demonstrate that items are in some way affiliated.	Associated with
$\longleftrightarrow$	A *symmetrical* relationship demonstrates a two-way activity between the items	Is related to

In this research, the qualitative research software Nvivo 11 (RICHARDS, 1999) was used. Also, in this study all three coding steps from the GT method were used. Once

each category is defined and all codes are refined, it's possible to determine relationships between categories and between codes. These relationships are defined with the use on connectors that are provided by Nvivo 11. These relationship types are presented on Table 2.

After analyzing the data through the Grounded Theory research method with the creation of all needed codes and memos, it was possible to better understand the problems faced by developers and designers in the field of mobile accessibility of design patterns and also learn from the creative solutions proposed to some of the accessibility issues.

In the end, the nature of the data and the familiarity of the researcher defines the technique or methodology adopted. In this study, the use of Grounded Theory was essential to achieve results that reflected the point of view of professionals in the field of mobile development without interference of personal preferences or previous knowledge from the researcher.

Mobile List Navigation

On Desktop List navigation is usually implemented with a wide range of options in the bottom of the list where the user can chose to go back and forth one, two, three or more pages and usually, there are options for the first and last pages too.

On mobile, a pattern that is widely used for list navigation is the Infinite scroll, where by reaching the end of the loaded items, new items from the list are loaded and displayed automatically for the user that continues to scroll until he or she reaches the end of the list.

There are several problems with the infinite list pattern:

- On situations with low bandwidth, the loading of new items may cause lack of responsiveness
- While scrolling down, and loading new items, a loading icon must appear and the user may have problem identifying the meaning of the icon
- Infinite list does not provide any information regarding the position on the items in the list
- As Infinite List doesnt have pagination, it's difficult to share or save the position of an item in the list
- The concept of loading new items when reaching the end of the list may be difficult to understand by some people
- Infinite Scrolling on large lists may discourage users
- It's difficult to find an item in a ordered infinite list (even more difficult when the item is at the end)

With these problems it was found that in terms of accessibility it is better to adopt a different pattern, similar to the desktop pagination pattern, however simplified for small screens, something like:

<prev current **next>** **#jump_to#**

Figure 9 – Example of Memo on Mobile Pagination Interface Design Patterns

5.7 Findings

At the end of the study several issues involving interaction design patterns were found and the relationship between discussions in different sources allowed the elaboration of Memos, that are the description of the analysis of data or codes that can be done during and after the coding process (CHARMAZ, 2014). With the productions of memos it's possible to better organize ideas and discoveries from the Grounded Theory method.

One important discovery of the case study is shown in Figure 9 in the form of a memo that discusses the use of the interface design pattern *List Navigation* in terms of mobile accessibility. In the study we've identified that the navigation in lists on mobile devices is usually implemented in the form of an infinite list of items in which new items are loaded each time the user reaches the end of the current list. Although this implementation, called *Infinite List*, may seem appropriate and simple, it has several accessibility and usability problems that were identified in the research as the lack of responsiveness in low bandwidth scenarios and difficulty to find items in an ordered list. Also, from the stories collected in the ethnography, we were able to propose a possible solution for a better implementation in terms of accessibility.

Other important findings were also made from the analysis of data as a better understanding of different types of visual impairments related to color blindness. It was common to find developers and designers presenting how people actually see colors with different varieties of daltonism and discussing or proposing solutions for better use of color combinations in order to provide a better experience for such users. One common problem found in many e-commerce sites for example, is choosing the color of a product without supplementing the selection with the name of the color. This causes serious problems for the colorblind as they will not be able to identify which color an item is if the name of the color is not specified.

Another relevant accessibility barrier was identified with the use of the interface design pattern *Icon*. In many contexts, icons are used to represent a functionality, action or type of information. However, the use of icons is problematic as the association between a graphic representation and an action, for example, depends on previous knowledge from the user. Therefore, the use of icons alone to represent information can cause confusions that may preclude the user from using an interface due to the difficulty in understanding the icon.

5.8 Conclusions

Still in the subject of disabilities we could understand how design choices of fonts and element positioning can be harmful for people with dyslexia.

In summary, it was possible to identify accessibility and usability problems with various mobile interface design patterns. It was also possible to find similar discussions around the same topic in different sources of information and with different perspectives, which helped in the process of defining new memos in order to document the findings of the study.

This chapter presented an ethnographic study on online communities that used the approach introduced on the previous chapter (Chapter 4). It shows in more detail the challenges of collecting, analyzing and storing data available on the Internet and gives a notion of how designers and developers are currently addressing accessibility issues on mobile applications.

The next chapter will present the detailed results from the analysis and the accessibility recommendations for the Interface Design Patterns.

6 Interaction Design Pattern Accessibility

From the GT in the data analysis phase a total of 189 codes were created and organized in 27 categories (with 12 categories being interface design patterns) with 21 Memos.

In the end, the categories that resulted from the GT method consisted of Interface Design Patterns and also other aspects related to accessibility (which are called "Cross-Section Elements"). For example, the most coded category is *Navigation* with 130 codes where this category contains citations related to navigation mobile UI elements such as *hamburger menu* and *tab navigation*.

Each category has relationships with other categories and these relationships are important to better understand the affect that "Color" has on the Interface Design Pattern "Icon" for example.

These relationships are represented on Figure 10. In this image it's possible to see that there are three types of arrows, that represent the kind of relationship (see Table 2). Also, from Figure 10, it's possible to see the relationship between the Interface Design Patterns studied (solid in red) and also the connection between the patterns and other aspects (the cross-section elements - dotted in black) and thus, understand that accessibility is a complex subject that is affected by many other elements.

In this image it's possible to better understand the relationship between the Interface Design Patterns and the cross-section elements. For example, the Design Pattern "Icons" is related to "Color", that is associated with Errors and is related to "Contrast" and "Content Accessibility", thus, "Icons" is related to "Content Accessibility".

In the following sections, the categories that were created during the data analysis are presented as well as the accessibility recommendations related to each category.

6.1 Interface Design Patterns

This section presents 10 recommendations to improve the accessibility of Interface Mobile Design Patterns.

Usually in the description and presentation of an Interaction Design Pattern some elements are presented such as the pattern name, a description, a context of use, a solution for the problem and examples. As in this work the patterns are not defined, but simply extended and therefore if all elements were presented it would be similar to the Android definition guidelines, it was decided to present only the elements that were necessary.

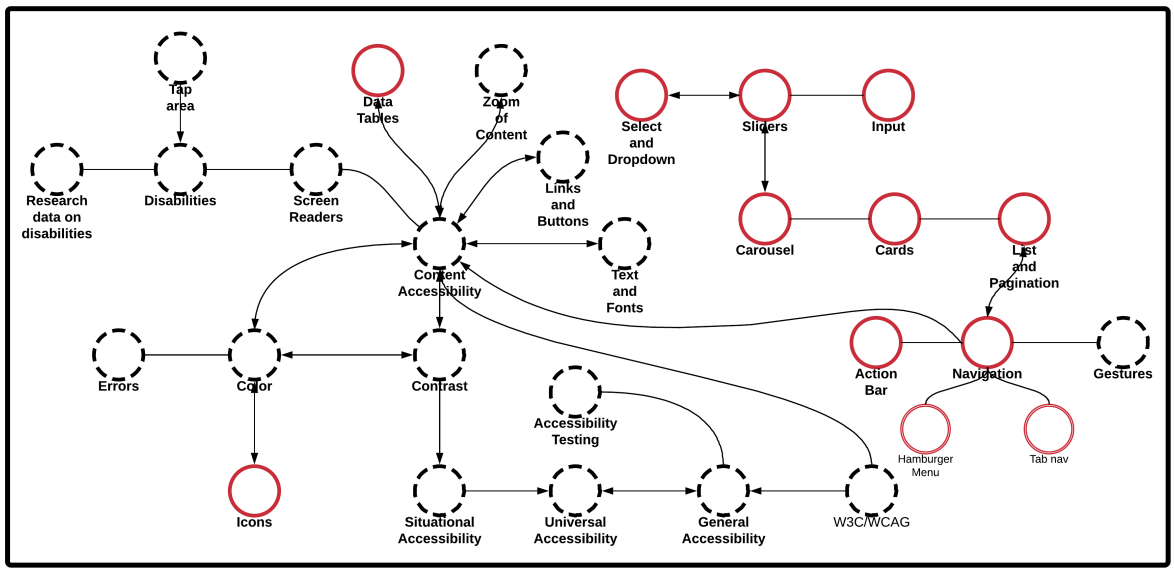

Figure 10 – Relationships between categories

Each design pattern is then presented through a **description**, followed by **accessibility barriers** or accessibility problems related to the pattern on mobile devices and, finally, the **recommendations** to mitigate or eliminate the accessibility barriers.

6.1.1 Navigation

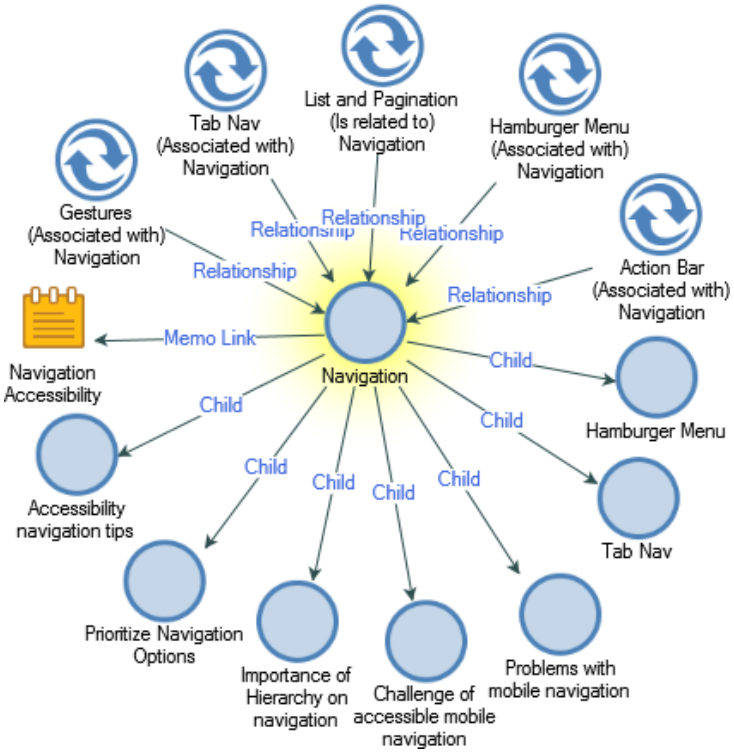

Figure 11 – Relationships of category *Navigation*

6.1.1.1 Description

The Navigation category was present on 28 documents with a total of 130 coded sentences. Thus, navigation is the most frequent subject found in this research.

From the analysis of the codes identified for "Navigation", it was uncovered that only two mobile interaction design patterns were discussed in the 28 documents where the theme was found: the *navigation drawer* (or *hamburger menu*) and the *tab navigation*.

In Figure 11 we can see that the Navigation category has relationships with other five categories that are *Hamburger Menu*, *Tab Nav*, *Action Bar*, *Gestures* and *List and Pagination*. These relationships are important as they evidence that navigation accessibility problems are affected or affect the interaction with mobile devices through gestures for example.

Also, the navigation category has 7 child nodes represented by circles filled in blue, these are some of the codes that compose this category. Although the software used to in the GT method (NVIVO 11) doesn't allow to show, the child nodes *Hamburger Menu* and *Tab Nav* are also subcategories of navigation and contain 5 and 7 child codes respectively. Similarly, navigation contains a memo containing key information about accessibility issues on mobile applications and the subcategories *Hamburger Menu* and *Tab Nav*, also contain memos reporting specific concerns about each design pattern that are not shown on Figure 11 due to limitations on the qualitative data analysis software.

From the analysis of the codes in the category Navigation and its relationships, it's clear that the concern with accessibility in this category is focused on general navigation interaction with mobile interfaces. It's then possible to conceive recommendations to improve or implement accessibility for general navigation in mobile applications.

6.1.1.2 Accessibility Barriers

When dealing with complex processes on mobile application, many times there is a big number of steps that the user must follow in order to complete a task or achieve a goal. Although it may seem more organized and appropriate to split actions in multiple steps, on multiple screens, this segmentation of information requires the memorization of previous actions. The problem is that people with cognitive deficiencies may struggle to remember previous actions or information as they often suffer from short memory loss. Also, elderly users also have problems locating themselves and remembering something they did only moments ago. Even users that do not suffer from any disability may have difficulty following actions that are split in multiple screens when using the mobile device on busy environments where the user must be aware of its surroundings (in a bus for example).

6.1.1.3 Recommendations

One simple but effective solution for improving the general navigation experience of users and provide accessible feedback to any user is to use breadcrumbs or hints of some sort that inform the current location. Although breadcrumbs are a common practice on web development, it's rarely used on mobile. With the information of the current location, older users that often get lost on mobile applications and are insecure about how to undo some action for example, will be able to understand better where they are. However, the developer or designer must understand that, by providing more information, more space is occupied and less space is available for the content. Thus it's important to find the appropriate place to display such information, as for example an action bar or a simple field above the page title.

There are also other concerns with mobile navigation accessibility that are specific to implementations of mobile navigation. The sections below provide more detailed conclusions about the categories *Hamburger Menu* and *Tab Navigation*.

6.1.2 Hamburger Menu

6.1.2.1 Description

Hamburger menu is a kind of navigation interface design pattern mostly used on mobile applications that consists of presenting navigation options that are initially hidden and that can be triggered by the click of a button.

6.1.2.2 Accessibility Barriers

The problem with this approach is that the navigation is hidden from the user that needs to have previous knowledge to understand that the menu can be accessed by clicking a button. The menu icon has low information scent, and, even with a label called "Menu", users may still not use the navigation as they do not know which options are available and don't even click the button.

In the documents analyzed several use cases were presented about big companies that initially adopted the hamburger menu, but soon changed to Tab navigation. Some companies as Facebook and BBC used the drawer navigation, but due to the low discoverability that this type of menu provides, they identified that users had problems locating sections and menu options.

6.1.2.3 Recommendations

When dealing with patterns that directly affect the discovery of content, the solution is not always simple. However, some recommendations are effective:

- When using hamburger menu, use appropriate and explanatory terms for menu items;

- Avoid creating too many menu items. This can lead to an extensive list of options that are easily ignored and, sometimes, not well displayed on mobile devices;

- Although the menu is there, it's positive to tell the user what are the main navigation options available on the front page.

6.1.3 Tab Navigation

6.1.3.1 Description

The main advantage of the tab bar is that it doesn't hide the navigation options, they can be available all the time and the user has easy access to the navigation bar without needing to open a drawer in order to locate which navigation options are available.

6.1.3.2 Accessibility Barriers

Although tab navigation may seen the perfect navigation element for mobile devices, it can hold only up to 5 navigation options in order to be able to fit in the screen with appropriate font size.

6.1.3.3 Recommendations

Another important contribution of tab navigation is that the tabs communicate the user about the current location by visually featuring the current position in the related navigation option. This simple feature makes the user capable of visually understanding the current location and also gives more control to visually impaired user who use screen readers and also to users with cognitive deficiencies who struggle with short term memory.

In situations where the number of navigation options are too big, there are two approaches to still use a navigation tab bar: the first approach is to add a last option called "more" or other appropriate label that will open a navigation drawer.

The second approach applies the use of a horizontally scrollable navigation tab bar. In this approach, the navigation bar can hold more options while keeping the optimal touch-target size. The downside of both approaches is that they still have discoverability issues.

6.1.4 Input

6.1.4.1 Description

Inputs were probably one of the first interface interactions that were designed in the early days of graphical computing and they have not changed much ever since.

In Figure 12 we can see all relationships and codes related to the Input category. One of the accessibility concerns that were most present in this category is the correct use of placeholder and labels on input fields.

6.1.4.2 Affected Barriers

The use of placeholders alone saves the designer space for more elements. However, when an input field does not have a label, the hit area of that element is reduced. This is harmful for older users or users with motor disabilities that may limit they movement, for instance.

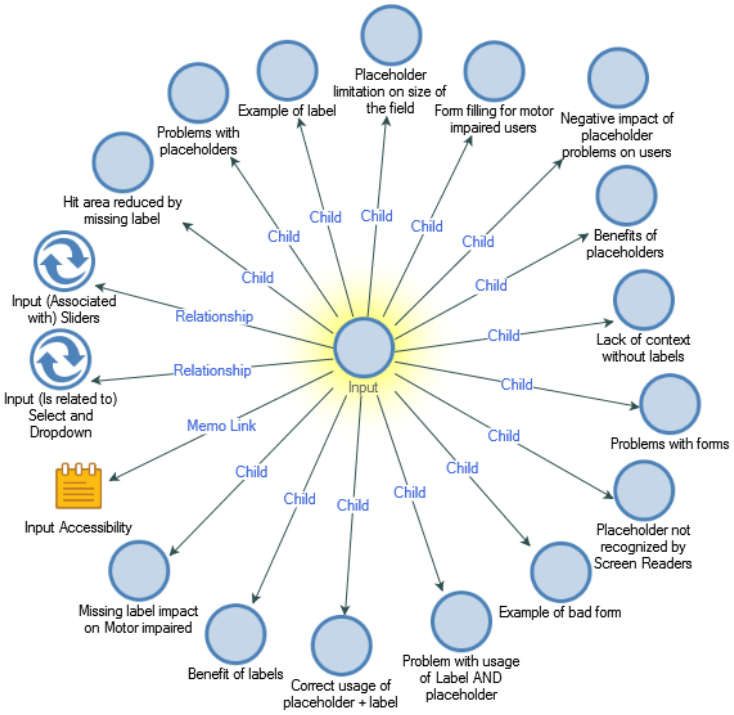

Figure 12 – Relationships of category *Input*

In addition, a placeholder disappears when the user starts typing, which instantly removes all the context of the input field. This problem is also harmful for people with cognitive deficiencies as they may struggle to work with short term memory. Placeholders are presented with low contrast to the background, which may spoil the experience of users with visual impairments or users with situational disabilities caused by screen reflection in the screen. There is no solution for this problem because if the contrast is higher, the user may confuse the placeholder with actual content of the input, for example.

6.1.4.3 Recommendation

A solution for most of these problems is the appropriate use of label and placeholder together. Labels are not help texts and thus should be succinct, short and descriptive so that users can quickly identify what information is required. Also, labels must present the necessary information for the user, for example: on a login form where the user can use a username or an email to access the account, the label must contain “username or email".

Placeholders that are used with labels must be meaningful and contain information about the format expected in the input field or other necessary information. Both on placeholders and on labels, the text should never be in all caps, as it’s more difficult to read and harder to quick scan.

6.1.5 List and Pagination

6.1.5.1 Description

From Figure 13 we can see that the category "List and Pagination" is related to the "Navigation" category which is explained by the fact that the user navigates through the items in a list.

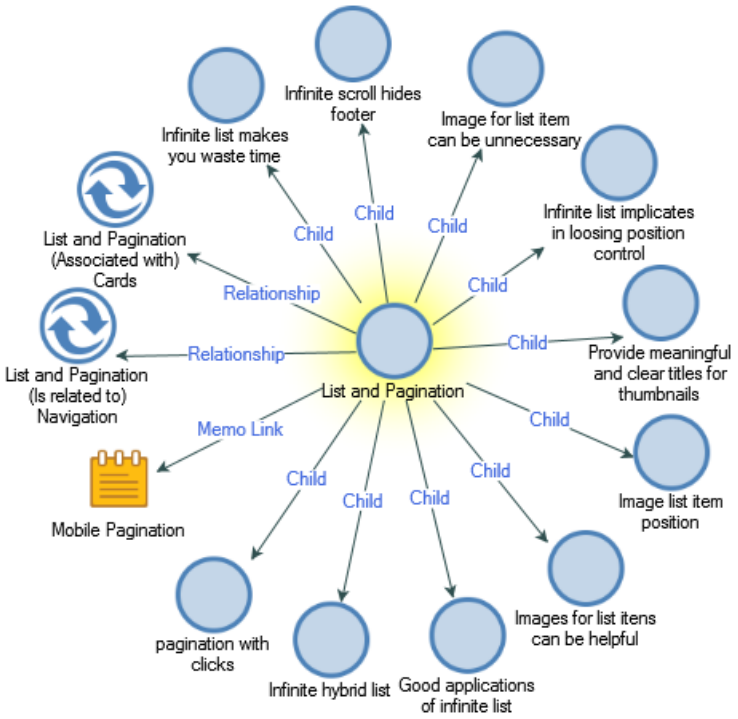

Figure 13 – Relationships of category *List and Pagination*

On web desktop list navigation is usually implemented with pagination controls at the bottom or top of the page. With these controls, the user has variety of actions to choose as skipping pages, jumping to the end or returning to the first page.

On mobile applications, a interface design pattern that has been widely used for list navigation is the infinite list. In this pattern, the user does not have to click on any button in order to load more items, instead, when reaching the bottom of the page, a new set of results is automatically loaded and displayed to the user. This process continues until the end of the list is reached.

6.1.5.2 Accessibility Barriers

Although the infinite list may seem like a good alternative of minimalist and practical design, it raises serious accessibility concerns. On situations of low bandwidth, that are common when using mobile devices outside a Wi-Fi network, infinite list may present long waiting times while loading for new items to be displayed. This long wait may cause the user to think that the application is not responding or think that the list has reached its end. Also, visually impaired users may not understand what is happening because the screen reader may not be able to correctly inform the user that the application is loading new information.

One of the major problems with infinite scrolling is that it does not provide any information regarding the position on the list. The same way that the lack of information about location in the navigation of mobile applications (Section 6.1.1) can cause serious problems for people with different disabilities (and even people without disabilities). It also may cause confusion and uncertainty for many users that are not sure of their current position, to how they got there and how to share or save the position of an item in the list for example.

Also, on some implementations, the infinite list is sorted by date or alphabetically. This situation causes a new problem where it's extremely difficult and tiresome to find an item at the end of the list as it's not possible to jump to the end of the list. Many times, list implementations do not provide any kind of filtering options, which contributes to these issues.

6.1.5.3 Recommendations

With these issues, it was found that, in terms of accessibility, the better list navigation pattern is still pagination, even on mobile devices (of course that with fewer controls due to the small viewport). Also, it's important to provide filtering and ordering options in order to lower the number of items in the list.

Although in theory pagination requires more clicks and actions from the user, it provides more control. Also, as pagination is controlled by buttons, screen readers are able to correctly parse the elements in the page.

6.1.6 Icons

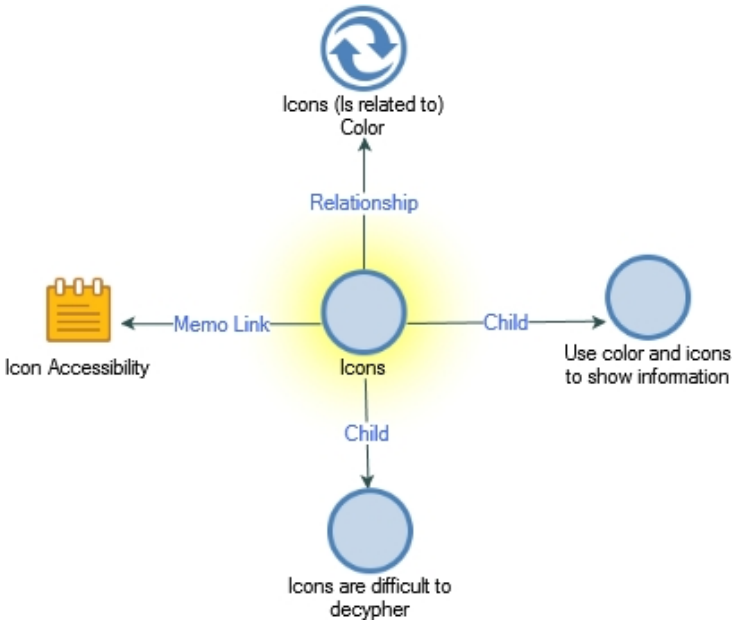

Figure 14 – Relationships of category *Icons*

6.1.6.1 Description

Icons are pictographic representations of actions or things and are widely used in the everyday interaction with any computer or mobile device. And, as can be seen on Picture 14, it's strongly related to the category "Color".

6.1.6.2 Accessibility Barriers

However, many times, icons are used and inserted in the life of users without further explanation and are even not representative. One great example is the On/Off button 15 present on any computer. The symbol is actually formed by two other symbols: a line (POWER ON SYMBOL) that indicates that the device is fully receiving energy (I means 'on') and a circle (HEAVY CIRCLE) that indicates that the device is disconnected from the energy. Together, the symbol that is well known by everyone means a switch that will turn on and off the device without permanently interrupting the power supply. It's different from the I/O symbol found on switches for example that indicates full energy or absence of energy.

There are also icons that are legacies from everyday objects of the past that are incorporated by new users that do not correctly understand it's meaning. The perfect example is the floppy disk icon that means saving a file: this icon was relevant as floppy disks were the main source of data sharing for a long time, however, new users do not even know what a floppy disk is and simply associate the icon with the common use.

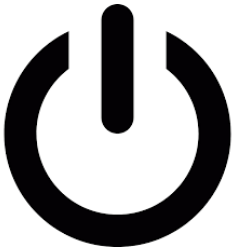

Figure 15 – On/Off button

The downside is that if someone would not explain to the user that a floppy disk means ‘save’ and the power button is the power button, the user would not know its use and would have to guess, which harms the user experience and rises accessibility concerns of whether the icon is helping the user by providing a pictographic representation of a real object of is confusing the user.

6.1.6.3 Recommendations

It’s necessary to correctly choose meaningful icons that will actually help the user. One great way of doing this is choosing icons that are available in the mobile platform, because they appear in more places in the same interface and most of the times were already tested with real users.

There are also other concerns that may arise with the use of icons, as the use of colors to help the user to understand an icon. Colors are not reliable to give information as people with difficulties to see some colors may be confused. Thus, in most cases, icons must not be used alone, but with the aid of explanatory text.

Also in some interfaces that use only icons for a search box for example, where the input box appears only after the user click on the search icon, the hit area is extremely reduced, with is bad for many people and also if not provided alt text, screen readers will not know how to parse such element.

6.1.7 Data Tables

6.1.8 Description

Data Tables is strongly related to the category "Content Accessibility", as can be seen on Figure 16 and several are the problems involving table accessibility.

6.1.8.1 Accessibility Barriers

The more common issue found while dealing with displaying large amounts of data on form of a table, is the space that the table requires. In some cases, even when viewing

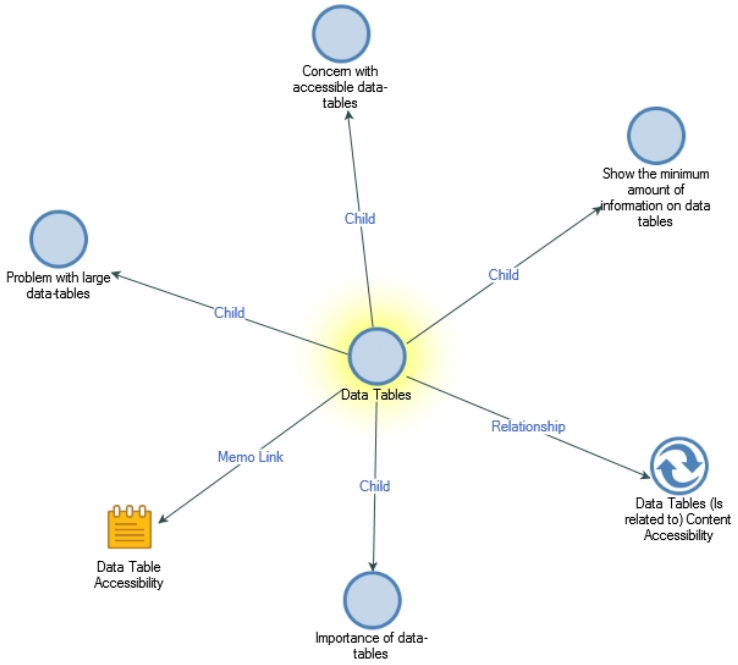

Figure 16 – Relationships of category *Data Tables*

a table on desktop, the viewport and resolution of the computer may not be sufficient to display the whole table in the page.

On mobile, the problem is more evident as the screen is significantly smaller. Displaying data tables on mobile is already a challenge and making them accessible is an even greater challenge.

6.1.8.2 Recommendations

Leaving the issue of correctly displaying the data, there are several other problems that are not apparent but has been always present:

- Table borders are used by screen readers for identifying a data table. This means that if a screen reader finds a table that does not have defined borders, it will possibly parse the table as a layout table and will not read its contents correctly.
- Some screen readers have difficulty identifying commonly used operands and characters usually used in data. One example is the use of hyphens to demonstrate negative numbers (for example -99.99). The screen reader will not read the hyphen in most cases, for this, it's necessary to use the correct minus Unicode character.
- On some framework implementations, tables are not defined with the usual <table> HTML tag, but defined with or custom tags. With this, the screen reader will not be able to understand the content.
- Data tables as any other content must have well defined ARIA attributes

- There are other issues with how to present a data table so that screen readers can read it that are presented on http://webaim.org/techniques/tables/data

Returning to the problem of correctly presenting a data table on mobile, there are several recommendations found on the research as selecting only the necessary and pertinent information to be displayed, thus, reducing the number of columns. This approach is valid, but it does not solve the whole problem, as many times, all information is necessary.

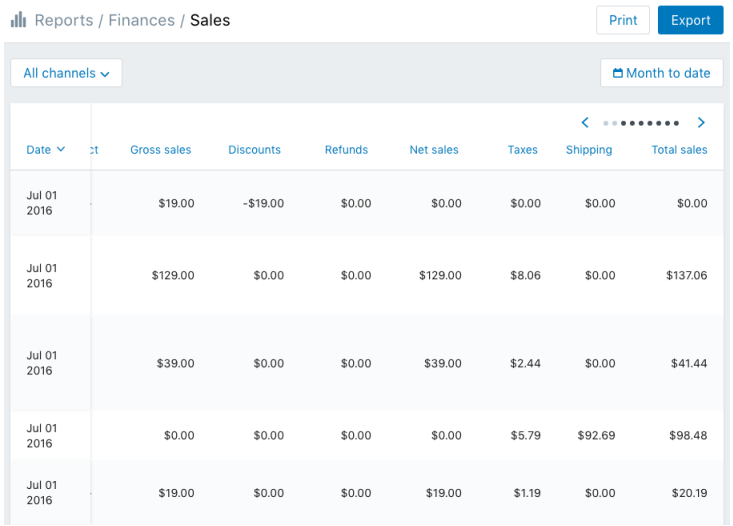

Figure 17 – Data Table design proposed on “Lessons from building mobile-friendly, accessible data tables”

As mobile phones are usually used on portrait mode, the bigger problem faced while showing data is displaying vertical information and maintaining the necessary spacing between rolls. One solution for displaying data tables on mobile is presented on the article “Lessons from building mobile-friendly, accessible data tables”[1] and can be seen on Figure 17.

The solution consists of following the accessibility recommendations of WebAIM and displaying the table by sticking the first column of information in the leftmost part of the screen and adding a vertical scroll-bar to the following columns, but maintaining the fist column in sight in order to prevent loosing context while showing the rest of the data.

This solution works well with both desktop and mobile devices and solves the problem of displaying data tables on mobile without loosing context or harming screen reader usage.

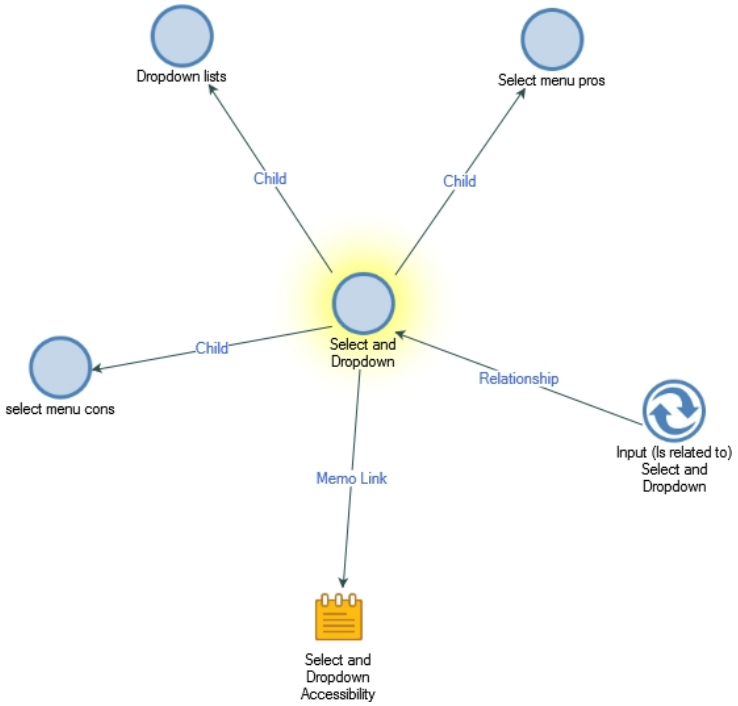

Figure 18 – Relationships of category *Select and Dropdown*

6.1.9 Select and Dropdown

6.1.9.1 Description

Select and Dropdowns are well defined interface design patterns, however, in some situations, the adaptation for mobile is not effective and accessibility and usability is affected.

6.1.9.2 Accessibility Barriers

Especially when a dropdown has a large number of items, problems start to arise regarding how to present the list on mobile devices with limited space on the screen.

6.1.9.3 Recommendations

Some possibilities of adaptation were identified in the study:

- Dropdowns items can be affected by context. For example, in a list of drugstore, the list should be ordered by proximity to the user. In a list of airports, the same idea may apply. On other contexts, the list could be ordered by the most selected item or any other classification or rank that may be reasonable.

[1] https://ux.shopify.com/lessons-from-building-mobile-friendly-accessible-data-tables-1e05c6924eaf

- Another solution for a large number of items is to split the list into two or more selects. This approach is not the best and many times cannot be meaningful, but it's a valid one on some cases.

- A different approach to the dropdown situation with many items is to provide filters or categories in order to reduce the number of items displayed. This approach is already used on many examples found, however, it increases the number of clicks that the user needs to perform.

- Lastly, one more approach is a hybrid search plus select implementation where the select box is also a search input and the user may type in order to filter the items. This approach is extremely valid as searching for the item may be faster than manually searching. One downside is that on mobile devices input entry may have complications for some users due to the small screen.

6.1.10 Sliders

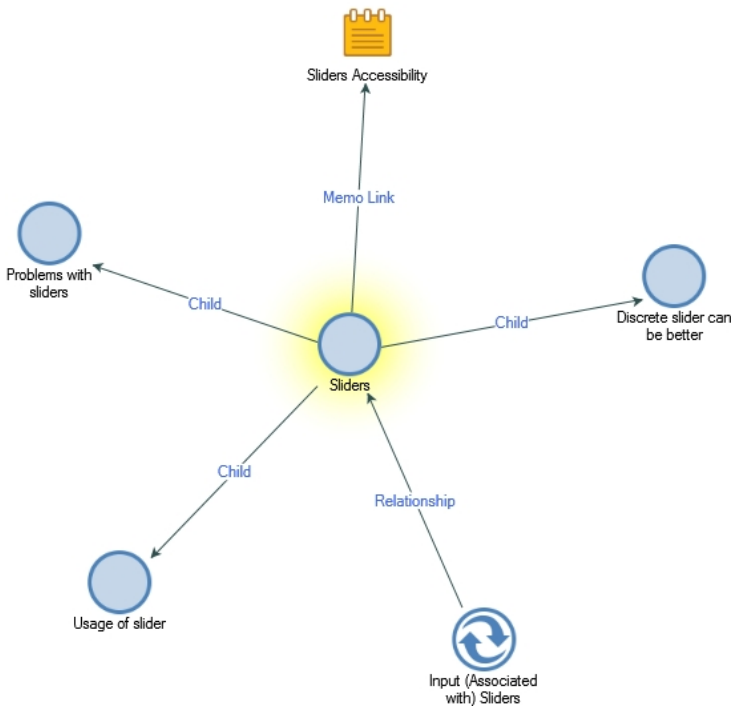

Figure 19 – Relationships of category *Sliders*

6.1.10.1 Description

Sliders are intuitive in terms of touch interaction because they mimic the interaction obtained in the real world. Thus, the common slider implementation is usable both on mobile with touch screen and desktop with the precision of the mouse.

6.1.10.2 Affected Barriers

However, there are some problems with the correct way to present the slider.

Firstly, there are two possible implementations of sliders: the continuous and the discrete slider.

The continuous implementation of a slider gives the user more control over the selection of range, however, this control can also spoil the usage as many times, it's difficult to select a specific value in a large interval, so with continuous slider, the precision may not be satisfactory.

Also, another issue that rises with continuous sliders is that the user has no idea of sizes and values that are currently available. This can lead to unwanted results.

6.1.10.3 Recommendations

Another variation is the slider with two selections. In this implementation, the user may select using the same interval a lower and higher boundary for the filter. The problem with this implementation is that in some cases, when the range of values is too big, the user has trouble selecting a small interval as the slider selection icons can be overlaid or it cannot be possible to perform such action.

Discrete sliders are preferred over continuous sliders, but there are also considerations about this implementation. On discrete sliders, the user is given the choice of predefined values and so, the user will not have precision problems that could happen in a continuous range. With discrete sliders, it's also possible to have a slider implementation with two selectors in the same range bar.

However, in a simple range of prices that is divided by units of ten for example, the user may select an option that does not have products and is presented with an empty list. This is problematic as it hurts the user's expectations. To fix this, the slider must contain only intervals where there are products to be displayed. With this, values such as zero and maximum must also be changed by the minimum and maximum price of products in our example.

Other considerations are also necessary when implementing any kind of slider:

- The values of the slider selection should appear above the pegs, with this, when the user clicks to select, the user's fingers will not cover the value

- There should be an alternative form of selection that is different from sliding a peg. This can be done by adding a input element on top of the slider where the value can be manually changed by typing a new value or the value can be automatically

changed when moving the selection along the slider's range. This option is useful for many disabled users with motor impairments and for those who use screen readers.

- In order to give the user more control over the selection, the slider could provide more information regarding the number of items available in a position (for example, the inventory counts). A way of implementing this is by dividing the slider positions by number of items in a range. With this, a certain distance of movement on the slider's axis represents and equal absolute change in value.
- Another way of presenting the user with more information regarding quantity if results, is to present a histogram based on the number of items in stock attached to the slider.

6.1.11 Carousel

Figure 20 – Relationships of category *Carousel*

6.1.11.1 Description

The Carousel design pattern is used to show featured items in a vertical list of items with pictures and descriptions, but unfortunately, many mobile app implementations do not offer satisfying carousel experience.

In this pattern the user is able to view several images of products across a row with horizontal swipe to navigate from one product to another. Typically, an arrow indicates the direction of the carousel and apart from the featured item, there are other items partially hidden.

6.1.11.2 Affected Barriers

The carousel is a typical pattern that shows the use of gestures to swipe and navigate through the carousel's items in a mobile device. The functionality is intuitive, however, it's necessary to provide visual information regarding the direction of the carousel and also button alternatives for the swiping gesture.

The pattern works well on small devices because it uses screen space efficiently, but there are some implementations and variations that have serious accessibility and usability problems.

6.1.11.3 Recommendations

In the following items problems and solutions are described for the carousel pattern:

- At the end of a carousel, it's necessary to give the user the opportunity to see more results. A "See more" link can be added and redirect the user to a page listing more products.
- Some implementations present vertical scrolling that are not smooth. The scrolling of this pattern must regard the user with the option of fast and precise scrolling without keeping the user stuck and limiting the user's navigation.
- The implementation should always indicate the scrolling direction. Also, the carousel shall provide a unique starting point, presenting the far left item first.
- An infinite carousel makes the user tired and is not recommended. A good amount of items varies from 8 to 20 items. When the carousel is infinite or has too many items, the user feels bored or tired.
- A carousel does not replace any kind of list of items.
- It's important to maintain consistency in the item's structure, so if one item has image and description, all items must have the same information. Also, the items must have meaningful images and descriptive texts in few words.

6.2 Cross-Sectional Elements

The following subsections present other elements that arised from the data analysis. These aspects are strongly related to the Interface Design Patterns and cannot be ignored.

Therefore, these concepts are explained and recommendations are also proposed in order to improve the general accessibility of mobile interfaces.

6.2.1 Contrast

Good color contrast on web and mobile applications does not mean to use only black elements on white canvas, what is truly necessary is the correct usage o colors and differentiation of color that respect an appropriate contrast ratio. When two colors are of the same temperature or lightness, its difficult to list them apart.

One common issue on most pages is the use of images as background for texts. Text overlaid on imagery is tricky because some or all of the image may not have sufficient contrast in relation to the text, so it's best to avoid or to provide a separate background for the text (text highlight).

Placeholders in input fields are another common problem with contrast. Usually, placeholders are auxiliary information that are greyed out or have low contrast in comparison with the background of a form field. The insufficient contrast of placeholders makes it hard for people with vision impairments to see. Also, if the contrast of placeholders is too high, users may be confused and think that the field is already filled, skipping important information.

On modern websites and mobile applications, it's common to find grey text on slightly darker grey background. Although it may look beautiful and clean on the designers' computer, people with visual impairments may have difficulties to see the text. The same applies to older screens from older computers that do not differentiate colors well and not provide satisfactory contrast.

The WCAG standards define that contrast ratio should be a minimum of 4.5 for any fonts smaller than 24px and if the font is larger than 24px, the contrast ratio drops to a minimum of 3. On mobile, although there are still discussions about the appropriate number, the contrast ratio should be at least 7:1.

This happens because it's more difficult to maintain correct color contrast on smaller portable devices as they are used on a wide variety of situations and environments. For example, the smartphone screen contrast and ability to display colors is directly affected by the incidence of direct sunlight. Thus these guidelines of minimum contrast benefit not only the visually impaired but also regular users that are exposed to situational disabilities.

Also, on mobile devices, the size of the font, icons, context of use, size of the screen, definition and scratches on the screen may also affect the way that color and contrast is displayed.

High contrast is also necessary for people that suffer from other kinds if disability that are not related to eye sight. For example, users who suffer from dementia are affected by low contrast as they have difficulties identifying and remembering elements on the screen.

One alternative to ensure that users will be able to differentiate colors and contrast of forms and graphics on any screen is the use of patterns and textures to enforce the contrast differentiation. For example, graphs and charts are most of times a challenge for colorblind users and textures may be used to help users differentiate colors.

When the contrast is too low, users experience eye strain as they try to decipher the words. Research has also shown that people are less trusting of text that is hard to read — a carryover from the age of "fine print".

Accessibility is severely reduced for users with low vision or cognitive impairments. As we get older our vision degrades. Millions of people around the world have some type of vision impairment, including presbyopia (difficulty focusing on close objects), macular degeneration, glaucoma, and cataracts. But not only low-vision users are affected: cognitive conditions that impact short-term memory and ability to maintain focus make using hard-to-see text extremely difficult.

6.2.2 Color

Colors have a lot of responsibility on accessibility of websites and applications as different variety of colors can be used and there are a lot of people in the world who have difficulties seeing colors or combinations of colors.

On a website that sells different products for example, it's important to name colors and use common names for colors. While buying a cool blazer or a T-shirt, colorblind users usually have to take a second opinion from a friend about the color.

In other situations, users may also have issues understanding a color that does not have its name while choosing the color of a product as there are external factors that contribute to color representation (as the capacity of the screen in differentiating colors and contrast).

One important fact is that color blindness doesn't mean that a person sees the world without color, it's actually a decreased ability to distinguish particular hues from one another. It's also much more common in men than women: around 8-10% of the male population has some sort of color blindness.

It's advised to use colors in the shades of opposite colors on the color wheel, also mix cool and warm contrasts, dark and light and different hues, which allows more people to have the experience of correctly seeing the information.

Another important tip is to test the website or application in gray scale mode. If all elements are distinctly visible there is a pretty good chance that it will be good for the color blind users as well as it shows that the color differentiation is being done right.

One worrisome new trend is the use of dark grey font on light grey background or

vice-versa on interfaces. While it may see good and readable to you, the contrast is not enough for many users.

Also, for many reasons, color should not be used as the only means of conveying any kind of information, indicating an action, prompting a response, presenting context or meaning or distinguishing a visual element.

Sometimes it's useful to use colors together with icons for example to display error, warning or info messages as appropriate icons may help to give the user more context even when the user do not correctly see colors. Still on error messages, it's important to use text or prefixes to such messages that will indicate the meaning of the message as "Success" or "Error".

On other situations, using colors with the aid of patterns or textures may help users to see the difference between two colors. For example, graphs are usually a problem for the colorblind, however, when using different textures for each color this problem can be solved.

Also links should be easy to spot without relying on color, for that it's important to use both underline and hover on links so that all users can easily identify and differentiate links from the rest of the text.

On forms it's also important to not rely only on colors to indicate fields with problems as many users will not be able to see the difference. For that user a combination of colors and icons.

Finally, daltonism is not the only reason to take colors and contrast seriously when designing an interface: there are other forms of visual deficiencies as eye cataract and low vision, that are common on older users, who are a growing number of users. And, even on users with normal vision, the context may affect how people see colors as the brightness and contrast of the screen as well as the illumination of the environment and time of the day.

6.2.3 Content Accessibility

If a website or mobile application is accessible or not depends on them implementation of the UI and mostly on the content presentation. When talking about content accessibility W3C has good definitions, but they are not practical.

Content is the main aspect of any application and therefore, the accessibility of the content is essential to the application.

Many are the problems that can arise with badly formatted content, such as the difficulty of understanding the contents of a website that uses technical words. Another example of accessibility barrier related to content is when the text is not correctly adapted

to screen readers and other assistive technologies.

This concept is extremely important, and the accessibility barriers that are consequence of problems with content are serious as they affect other elements and interaction design patterns.

- All images must have alt text with descriptive information. The only exception is when an image is only for decoration purposes.
- When writing text avoid making reference to images in order to explain things. This reduces readability for screen reader users as they need to listen the text and then search for the image (and be at the mercy of the developer that might have remembered to add alt text to images). Also, users with normal sight might also have difficulties trying to understand the image because it depends on resolution and several other factors.
- Pop-up and messages displayed at the top or bottom of the screen cause serious issues because these messages require the user to click on close buttons that most times are represented by icons and may not have good contrast. Also, on small screens, lightboxes and pop-ups may not adapt well.
- ARIA mark-up should always be used in order to improve the semantic experience of screen readers. ARIA enables us to build universal accessibility at scale because it attacks the problems of web accessibility for people with disabilities in a way that parallels how web engineers are solving them for people who do not have a disability, harvesting user expectations, paradigms, technologies, and lessons learned from the desktop GUI world.
- One of the challenges of using ARIA is that it's invisible. Unless you use a screen reader, there is no way to tell whether ARIA has been used or whether it has been used correctly. The Visual ARIA tool helps developers overcome this problem, by visualizing ARIA roles and attributes on the page.
- Content must be clear and concise on mobile devices.
- All pages must be correctly printable as it helps people with visual and cognitive disabilities.
- It's important to provide subtitles or transcripts for video or audio contents.
- All links must have meaningful texts and title properties.
- Always provide <label> tags for inputs, textareas or any other information input HTML tags.

- If native inputs can't be used (with good reason), create custom checkboxes with role=checkbox , aria-checked , aria-disabled and aria-required , and wire up keyboard events

6.2.4 Screen Readers

Screen Readers are currently the only option that visually impaired users have to interact with a computer or smartphone. The basic idea is that the screen reader will read out loud everything there is in a page in an ordered way and receive commands for the interaction with interface elements.

One of the most use features of a screen reader is to navigate on a page by jumping through the links in order to find something interesting for the user to click. This functionality is important as listening to a whole page is tiresome and the users do not have the visual aid for skipping parts of the page.

Thus, it's important to have well defined link texts, so that users will know what they are clicking.

Also, if an image contains a text, the screen reader will not be able to read it as it's an image and not plain text. Thus the screen reader relies on alt tags to understand and give to the user the meaning of images and other medias used on pages.

Also the use of hover to activate of reveal information must be discouraged as many people use assistive keyboards to navigate through a page and will not be able to trigger the hover effect without a mouse or touch, thus making information inaccessible.

Other HTML elements that contain high density of information must also be labeled in the appropriate way. For example, when a screen reader focuses on a table, the table's caption is automatically read. That makes it easy for a blind person to understand what the table contains and to determine if the table's content will be accessed of skipped.

For tables it's necessary to explain on captions more than what the table represents, but also what conclusions the table brings or what is the highlighted information.

On forms, the screen reader also relies on label tags to identify input fields, thus, it's necessary to have label HTML tags and not rely on placeholders (as they are most of the times not parsed by screen readers).

On mobile devices, there are built-in screen readers where VoiceOver is available on iOS and TalkBack on Android. However, as well as desktop screen readers, it takes a lot of practice to actually understand the usage of a screen reader and to get used to it.

For example, some screen readers use table borders to differentiate a table that is part of a page's content to a table that is part of the page structure. Thus, tables without borders will be considered layout and not be read.

Another characteristic of screen readers is that some of them require the correct use of mathematical symbols on equations. For example, if a negative number is represented with an hyphen for the minus operand, the screen reader might read the positive number as it does not semantically comprehend the hyphen as a mathematical operand. Thus it's necessary to use the correct Unicode symbols.

People who are blind or have low vision must rely on their memory and on a rich vocabulary of gestures to interact with touchscreen phones and tablets. Designers should strive to minimize the cognitive load for users of screen readers.

6.2.5 Universal Accessibility

As we design experiences, we ought to remember that the internet is a part of everybody‘s lives, including those who are visually impaired or blind.

One thing that is highly overlooked, is assuring that the web design is accessible for people who are visually impaired. Some may think of this as being “extra” work, but not only is there an ethical element but it can also pay off in the long run.

Designing a new page or web app can be challenging, but the development and design team must consider any user and consider people who are blind, color blind, or have low vision, those who are deaf or have hearing difficulties, people with mobility impairments which may be temporary or permanent, or people with cognitive disabilities as potential users. Design for people who are young, old, power users, casual users, and those who just enjoy a quality experience

In simple words, accessibility is the design of products for people with disabilities. In the context of mobile apps, these disabilities could be visual, hearing, physical or mobility related. Based on what your app does and your target user segments, you might need to include support for some or all of these types.

Also, it is easier to design and develop apps that support accessibility than to introduce the support later during the product life cycle. And being responsive does not mean being accessible.

Furthermore, many disabilities are temporary, those called situational disabilities. Even a mother holding a baby in one arm, is one arm down. If we can create something great for people with one arm, then we'll be creating something even better for people with two.

When proposing accessibility in the market practice, it's common to hear from the stakeholders that this or that group of disabilities are not the target (“You know, we don't have blind people as customers”), however, it's important to explain that anyone can suffer from sight loss for example, even temporally.

Ultimately universal design promotes the development of products that are used by the greatest amount of people and is composed of a series of principles, as equality in use, flexibility, simple and intuitive interface, error tolerance, minimum effort and adaptability.

6.2.6 Text and Fonts

When displaying text, there are several accessibility concerns that need to be addressed and some of these aspects are more apparent as the size of the font and assure high contrast between the text and background. While other characteristics as the selection of the correct font for example are usually not taken into account.

Many modern design fonts are clean and thin and although lightweight fonts are good looking, they are not accessible for the visually impaired, so it's important to choose fonts that are not too thin and well spaced.

It's the relationship between stroke and counter that determines letter recognition. If a letter has extremely thick strokes with small counters, it takes longer for the eye to decode. The same is true for thin strokes and small counters. The height ratio between capital and lowercase letters is also critical in determining overall legibility. Typefaces with tall x-heights are thought to be easier to read because they appear larger. This doesn't mean we need to choose these typefaces, but it's something to consider. Another ratio to consider is width-to-height . Letters that are too wide or too narrow impede legibility.

Another concern regards the choice of text alignment. Justified text for example is not only difficult to read by dyslexic users, but for non-dyslexic users as well because it creates large uneven spaces between letters and words. When these spaces line up above one another, a distracting river of white-space can appear.

This can cause dyslexic readers to repeatedly lose their place when reading. You can avoid creating the river effect by using left-aligned text, instead of justified text for your paragraphs. Also, long blocks of unbroken paragraph text are also hard for dyslexic and non-dyslexic users to read as it's easy for dyslexic readers to lose their place with long paragraphs.

Serif fonts have hooks at the ends of the letter strokes. They may look decorative, but they can cause reading problems for dyslexic users. Serifs tend to obscure the shapes of letters, making the letters run together.

Italics are sometimes used to highlight text. But you shouldn't use italicized text because they make letters hard to read. The letters have a jagged line compared to non-italic fonts. The letters also lean over making it hard for dyslexic users to make out the words, prefer using bold text instead.

When representing numbers on texts, use multiple forms of presentation of that

information (with numerals and written with words) as dyslexia users have trouble processing numbers and words together.

6.2.7 Tap/Touch area

When designing mobile applications, a constant concern that must be on the developer and designer head is the correct size of screen elements in order to provide adequate touch target size for screen elements that receive touch interactions. Although this concern exists on desktop web, on mobile the problem is even more critical due to the size of the small screens.

There are many definitions on minimum size on pixels, some say that touch targets must not be smaller than 44x44 pixels, however, older users and users with limited vision may still have problems seeing and interacting with those elements.

Another importance concern is the distance between interface elements: On form fields for example it's difficult for users to correctly click on small targets that are too close to other targets. Usually it's said that a minimum distance of 2 millimeters is required.

Elements that are too big on mobile devices are not aesthetically good (the average thumb size varies from 45 to 57px), so it's necessary to design and size elements with caution. However, it's of no use a clean and small interface if people are not able to use it.

Lastly, another important consideration regards the use of clearly defined boundaries for form fields and other interface elements.

Some UI elements have low contrast compared with the background and may not be visible to the user that will have to guess the boundaries of the element if it doesn't have well defined borders or shadows.

The lack of well defined boundaries is problematic because the user will not be able to see the are available to click and also because some screen readers use borders to semantically identify the correct usage of UI elements.

6.2.8 Zoom of Content

While using mobile devices every person must have had the challenge of using zoom in order to access some sort of content. In fact, a survey from WebIM shows that 42% of users require a minimum magnification level of at least 300% in order to be able to read comfortably on the web. This survey also shows that WCAG has established 200% of zoom, which is not enough.

Also, modern browsers natively support text resizing, however as sometimes the pages are not prepared, parts of the text stay hidden, truncated or overlaid by other screen elements. In fact, text resizing brings more problems and may not be a viable option.

If allowed by the implementation, browsers also provide a native zoom functionality, which might seem a goo solution. But what user testing regularly reveals is that zooming a page makes content more difficult to read by low vision users due to content overflowing the viewport as the scroll-bar forces users to pan left and right every time there user jumps to the next line and this constant interruption in reading breaks concentration.

Also zooming brings another problem for users who depend on screen magnification as they can only see a small portion of the content at once, which means that it's impossible to get a full view of the screen and it's more likely to miss important clues and not understand correctly the context.

An aggravating problem of screen magnification emerges when a page is designed to have large amounts of white-space between related objects. This issue is more common on forms, where the spacing between fields is too big, making it difficult for low vision users to connect related form fields. Also, the positioning of submit buttons that are too far from the rest of the form also creates problems as the users will have difficulty finding the button.

Unfortunately, on some mobile implementations, it's a common practice to lock zooming of content by developers. Screen magnification must never be blocked, and the web page must be tested with zoom.

Font size control can also be used as a form of providing better experience to users, however, it must be done the right way: there must be a text control flow that will guaranty that the text does not stay hidden and do not overflow the viewport, which can be done by testing and defining a max font size for example.

6.2.9 Gestures

Gestures are widely used on mobile devices as the touch interaction provides good opportunities. We use gestures for the simplest actions as sliding the keyboard instead of typing, sliding and email to delete or dismiss a notification by swiping.

Although for the experienced user gestures provide fluent interaction with small devices, other users face problems understanding and remembering those gestures or have difficulties with old devices that are not able to correctly respond to gestures and provide fluent interaction.

Also, gestures are hidden features that depend on the user's memory, cognition, understanding and motor abilities which also makes it difficult for users with various disabilities to use the application. Thus, no application must depend only on gestures.

Another concern about gestures is regarding the use of natural gestures, which are gestures that are intuitive for the user. If you hide an option or feature (for example, the

hamburger menu), less people will use and perceive it.

Also, still there is no consensus about the appropriate gestures. For example, there are different gestures for zooming content and images: some implementations use pinch-zoom others use double tapping for zooming content.

Other gestures have implications with users with motor disabilities. For example, older users or users with reduced mobility may have problems with press gestures (when the user needs to press and hold elements) as they may have different perceptions of time when pressing and holding.

After all considerations, it's advised to use gestures, however, studies are necessary to identify the necessity and correct usage of such gestures as well as it's necessary to provide alternative interaction to gestures that are more common and visible for all users: tapping and clicking.

6.2.10 Errors

Errors, regardless of the cause, becomes a problem for users that may block them from moving forward in the experience with the interface. Thus the best way to handle errors is to prevent errors from happening or to early identifying an error.

6.2.10.1 Error Prevention

For example, it's usually hard to correctly fill out a form in the first attempt and even if all data is valid, sometimes network problems may occur (even more on mobile phones with 3G connection for example) and data can be lost.

The path to prevent users from making errors consist of offering suggestions, using constraints and being flexible with data. One example of form filling error that is extremely simple and happens too often is when uploading data from .txt or .csv files.

Usually a .csv files contains several rolls that will be stored in a database and each row in the CSV is a new entry in the database. However, let's say that the third row of the CSV file has an error, a missing field, and the submission returns an error. With a meaningful message the user fixes the error and submits again, however, the back-end implementation of database storage had not executed a rollback in the database after the error in the third line, and thus, new errors will be returned to the user regarding the first and second lines that are already stored in the database. This example shows that we need to prevent errors and avoid inducing the user to more errors.

One example of error prevention in a hotel reservation system is to display only dates available (past dates must be disabled for example). Another way of preventing errors is by validating fields as the user fills them, however, validating a field on each

keystroke can confuse the users, the error (if found) must be displayed after the user finished typing, when the focus has leaved the current field.

6.2.10.2 Error Handling

If the error is imminent and there is nothing to be done without sending the data to the back-end and receiving an error, there are some considerations regarding error presentation and handling that can make the experience less painful to the user:

- Error messages must be clear. An "email is invalid" error message is not enough; the error should contain what caused the error. On some occasions, as when dealing with passwords, it's interesting to provide some context to the user, but not too much information that may rise security issues.
- Also technical messages are not to be used such as "error 2 has occurred" or "segmentation fault". Such error messages will only scare the user.
- All data typed in a form must be kept safe. If an error occurs, the data must be saved and the user should not have to redo all his work.
- Do not rely on color to show error states. Simply applying a red border to the input field is not enough as many users will not be able to perceive the color. Use icons that indicate error states.
- Keep error messages near the place where the error occurred. With this the user will have no trouble identifying which field has errors.
- Dead-end error messages are only harmful to the experience. When an error occurs, the user must be informed, but also, the message must be helpful stating what went wrong and what to do about it.
- Error states are an excellent opportunity to use pertinent icons and illustrations as people usually respond better to visual information than plain text. However, it's necessary to provide the user with tools to leave an error state.

6.2.11 Links and Buttons

Although links and buttons are well defined and diffused patterns, there are still misconceptions regarding accessibility and usability that may be harmful to users.

- Links and buttons texts must be contextual to the content and descriptive. Sentences like "more" or "click here" do not give the user a real understanding of the action apart from the rest of the content. For screen reader users, it's essential that links

and buttons are descriptive as sometimes they navigate through a page by listening to all actions (i.e. buttons and links) available.

- Consider using appropriate size, placement, boldness, borders and contrast that actually make a button look like a button and a link look like a link. On links, for example, it's necessary to have both hover and underline alongside with color differentiation from the rest of the content.

- Buttons must follow WCAG definitions on color and contrast. Also, the text should be sufficiently independent of color or context as visually impaired users may not experience the visual design of the page.

- Do not use images for styling buttons.

- Use the appropriate HTML tags to represent buttons (<button>)

- Do not insert button or link destination using JavaScript injection as some browsers and assistive technologies may disable JavaScript usage.

6.3 Conclusions and Contributions

This chapter presented the results of an investigation of issues on the accessibility in mobile interaction design patterns and the appropriate recommendations to eliminate or mitigate the accessibility problems related to the interaction mobile design patterns.

A total of 22 categories were presented in this chapter as they were repeatedly cited by the 127 documents analyzed and were strongly connect with each other. Therefore, the categories "Research data on disabilities", "Disabilities", "Accessibility Testing", "Situational Accessibility", "Cards" and "Action Bar" were not presented not because they are less important than the other categories, but simply because there was so little information about these topics on the set of documents, that the information available was not considered representative.

The results of the study presented in this chapter shows the importance of studying the practice of software development in order to help to understand issues discussed in the academia and learn from solutions proposed by practitioners (developers and designers). Therefore, it's clear that the collaboration between industry and academia should be strengthened.

The qualitative analysis based on Ground Theory supported the findings of many accessibility concerns with special attention to the use of interaction design patterns. The main contribution of this work was to bring up the issues of using popular interaction mobile design patterns which can introduce accessibility concerns. The results can aid the

developers' community on concentrating efforts in the improvement of these patterns as well as in being more careful in their use in order to avoid accessibility problems.

7 Conclusion

This master's project sought to investigate the accessibility of mobile interface design patterns in order to mitigate or eliminate accessibility barriers that might be created in the use of such patterns.

To conduct this project, it was determined that the first step was to better understand the problem and, therefore, have a strong basis to conduct another in-depth study in which more information was unveiled and shaped this dissertation.

On the Exploratory Study (Chapter 3) it was possible to notice the first accessibility problems regarding the implementation of some of the interaction design patterns studied and the affect that the accessibility barriers imposed in the lives of users with and without accessibility.

This study was a foundation to the whole research presented in this project as it showed, in the user's and researcher's perspective (Section 3.3) that in a simple e-learning application, multiple accessibility barriers were present by simply containing a specific implementation of an interaction design pattern. Also, it was visible from the video analysis conducted that these barriers directly affected the users and sometimes became prohibitive while performing an action on the application. The results of this study were published on the paper "CASADEI, V. et al. Accessibility evaluation of design patterns on moodle mobile. In: Brazilian Symposium on Computers in Education (Simpósio Brasileiro de Informática na Educação-SBIE). [S.l.: s.n.], 2016. v. 27, n. 1, p. 688" (CASADEI et al., 2016).

It's important to remember that the participants of the exploratory study did not have any disability, and even so, there were noticed numerous accessibility problems related to the design patterns in the interface of the application. Thus, it might be appropriate to say that if this study had also been conducted with participants with any kind of disability (visual, motor or auditory for example), the results would show the same barriers and possibly even more.

As the results of this first exploratory study were intriguing and during the research in the literature for previous works on the accessibility of interaction design patterns on mobile devices returned only a handful of results, a more in-depth exploration was needed in this topic.

The best way found to do so then was to hear from the community of designers and developers about their discoveries and advances on the improvement of the accessibility of mobile interaction design patterns. Evidently, this second part of the project could be

done by only talking with the professionals that were geographically near, however, with this approach, the information collected might not be representative of the community as a whole, regarding costumes and traditions of other groups and nations.

Therefore, it was decided to explore the Internet for international and national forums, blogs and general discussions regarding accessibility, interaction design patterns and mobile development and design. On Chapter 4 an improved approach for conducting virtual ethnography was proposed on online communities. This approach and the results of its application resulted on a publication of the paper "CASADEI, V.; GRANOLLERS, T.; ZAINA, L. Investigating accessibility issues of ui mobile design patterns in online communities: A virtual ethnographic study. In:Proceedings of the XVI Brazilian Symposium on Human Factors in Computing Systems.New York, NY, USA: ACM, 2017. (IHC 2017), p. 33:1–33:10." (CASADEI; GRANOLLERS; ZAINA, 2017)

On Chapter 5 the virtual ethnography approach presented in the previous chapter was put into action in a big study that aimed to finally understand the community and to bring to the academia the results of the research informally developed by developers and designers.

During the ethnographic study, it was possible to identify the need for better preparation and definition of a protocol to guide the conduction of such research (Section 5.3 and Section 5.4).

Many lessons were learned from conducting a large scale study such as this one, as, for example, the enormous amount of that has to be analyzed and organized in order to extract useful information and the difficulty to extract such information from reports and narratives available in the 18 information sources selected (Section 5.5.2).

From the qualitative data analysis of documents collected in the ethnographic study using Grounded Theory (Chapter 6), many accessibility concerns were identified with the development and design of mobile interfaces, with special attention to the use of interaction design patterns. It was then possible to propose improvements and modifications in these patterns that should improve the accessibility of applications by better understanding the necessities of users who suffer with some disability and struggle with the use of mobile application.

Lastly, it was possible to comprehend the relationship between the interaction design patterns and other topics related to mobile design and development during the analysis of the data: how navigation is intrinsically related to several aspects of mobile applications such as pagination, menu; and gestures and the importance of the correct choice of icons and colors to represent states and information in any screen.

Finally, by observing the information collected in each category of the Grounded Theory, it was possible to present a guide to extend mobile interaction design patterns in

order to improve the accessibility and remove accessibility barriers that were previously created by the mistaken implementation of some of these patterns.

7.1 Contributions

Throughout the development of this project, it's possible to enumerate some important contributions that originated from the studies presented in this dissertation.

The bibliographic study also showed the deficit of academic works on interaction design patterns on mobile platforms. Through this discovery, it was possible to understand the need for more research in this topic and indicate to other researchers another area of research that needs special attention.

The approach for virtual ethnography on online communities presented on Chapter 4 is another strong contribution of this research as it might aid future researchers to be better prepared and have a more complete guide that shall answer some of questions that arise in this type of study. Also, it's an approach that can be used for any ethnography study on virtual communities, not being restricted to studies in the HCI or Software Engineering areas.

Finally, the most relevant and important contribution of this study is the identification of accessibility barriers related to common interaction design patterns and the suggestions to improve the implementation of such patterns and mitigate these barriers.

7.2 Limitations and Future Works

As limitations and future works for this research project we can list a few possible studies that will help to improve the research in the area and improve the overall accessibility of mobile applications:

- Extend the knowledge on accessibility problems of mobile interface design patterns;
- Propose recommendations for a better design for other design patterns patterns in order to improve their accessibility;
- Apply the approach for virtual ethnography in other contexts of Software Engineering;
- Propose solutions for mobile accessibility design patterns in terms of accessibility and validate such patterns with the development and usage of mobile applications by real users;
- Further research with other user groups with different types of disabilities (elderly and visually and hearing impaired users) on m-learning systems;

- Validate the results and recommendations for a better implementation of the interaction design patterns presented in this research with experiments with real users and functional mobile applications.

As the area of accessibility of mobile interaction design patterns has not yet been extensively studied by the scientific community and due to the broadness of the topic, it's possible to mention the above future works among other studies that would be of great importance to the research area.

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APPENDIX A – List of Documents selected in the Virtual Ethnography

#	Document Title	URL
1	#15 — Pagination, Accessibility and UI	https://goo.gl/ad8uYF
2	"It's Alive!"- Apps That Feed Back Accessibly	https://goo.gl/J8FvJi
3	108 million web users are color blind. Tips for designing keeping them in mind	https://goo.gl/xHbDkw
4	11 reasons why placeholders are problematic	https://goo.gl/fpzFtY
5	5 Simple Guidelines To Improve Your Website's Accessibility	https://goo.gl/9LeRgW
6	6 Principles Of Visual Accessibility Design	https://goo.gl/BNVRM4
7	6 Surprising Bad Practices That Hurt Dyslexic Users	https://goo.gl/x96BLa
8	7 Things Every Designer Needs to Know about Accessibility	https://goo.gl/xvGRPZ
9	8 Website Accessibility Best Practices to Improve UX	https://goo.gl/wxzzW3
10	A color wheel for the color-blind	https://goo.gl/Q2xHRZ
11	A Definitive Guide To The Android Carousel Design Pattern	https://goo.gl/7AwQAG
12	A designer's guide to colour and accessibility	https://goo.gl/AqCjzz
13	A Study of Trends in Mobile Design	https://goo.gl/YbJdA5
14	Accessibility - beyond the screen reader	https://goo.gl/MG2Nqn
15	Accessibility APIs- A Key To Web Accessibility	https://goo.gl/eGAxrS
16	Accessibility for mobile	https://goo.gl/XRJdC9
17	Accessibility for mobile apps. Just go for it.	https://goo.gl/cgKSd9
18	Accessibility- Improving The UX For Color-Blind Users	https://goo.gl/qDyd5m
19	Accessibility Is Not Enough	https://goo.gl/Jeiuwx
20	Accessible and Responsive Tables	https://goo.gl/VZ3Weq
21	Accessible data tables	https://goo.gl/2ew5sG
22	Accessible Interface Design	https://goo.gl/XmNYF3
23	Acessibilidade - experiências acessíveis em vários dispositivos	https://goo.gl/z8JdbK

24	Acessibilidade - muito além do design	https://goo.gl/56gnFi
25	Acessibilidade- o impacto das cores	https://goo.gl/x4JtvT
26	Algumas dicas de Acessibilidade	https://goo.gl/sFsKnD
27	Always use a label	https://goo.gl/2fejoW
28	Basic Patterns for Mobile Navigation	https://goo.gl/DGozio
29	Basic Patterns for Mobile Navigation - pt2	https://goo.gl/KpPBmz
30	Basic Patterns for Mobile Navigation 2	https://goo.gl/yQmsFV
31	Basic Patterns for Mobile Navigation- A Primer	https://goo.gl/qZmsCh
32	Best table pagination pattern for a mobile browser experience	https://goo.gl/HS3Lbo
33	Building accessible flash messages	https://goo.gl/ceZteP
34	Cards for layout in mobile apps	https://goo.gl/C18b4h
35	Considerations for mobile accessibility	https://goo.gl/wLEFft
36	Danger! Testing Accessibility with real people	https://goo.gl/Lmev72
37	Design Patterns - UX	https://goo.gl/ggX5W7
38	Designers, let's talk about accessibility	https://goo.gl/FVHKxm
39	Designing A Dementia-Friendly Website	https://goo.gl/a4bhqZ
40	Designing Accessible Mobile User Experiences	https://goo.gl/4TXzy6
41	Designing for Accessibility- The Ultimate in UX	https://goo.gl/HdCS7G
42	Designing for Everyone	https://goo.gl/czSqnd
43	Designing For The Elderly- Ways Older People Use Digital Technology Differently	https://goo.gl/b1WLpv
44	Designing inclusively	https://goo.gl/jLRWRm
45	Designing Perfect Text Field - Clarity, Accessibility and User Effort	https://goo.gl/pVk3dx
46	Developing for Android vs. iOS- Navigation Patterns	https://goo.gl/sgBNsd
47	Disabilities first design	https://goo.gl/XzkQaV
48	Diseñando productos digitales accesibles para móvil	https://goo.gl/z1DNxj
49	Do mobile devicescomputer tablets have a future in video games in a way that offers immersion and accessibility	https://goo.gl/UAo5ET
50	Ensure High Contrast for Text Over Images	https://goo.gl/Qiu2x5
51	Everything About Color Contrast And Why You Should Rethink It	https://goo.gl/1uEDk7
52	Float Label Pattern	https://goo.gl/Ta4z7B
53	Hamburger menu alternatives for mobile navigation	https://goo.gl/qE3dbM

54	Hamburger Menus and Hidden Navigation Hurt UX Metrics	https://goo.gl/zNAJya
55	How accessible are dropdown lists on mobile devices	https://goo.gl/J9t3Gw
56	How can graphic design be more accessible for people with disabilities	https://goo.gl/c5hhk5
57	How To Design Error States For Mobile Apps	https://goo.gl/UyrFEv
58	How to Design for Color Blindness	https://goo.gl/W2gSBQ
59	How To Design For Different Age Groups	https://goo.gl/3RdTtg
60	How to Design for Dyslexia	https://goo.gl/FQTkE7
61	How to make a menu discoverable with the right icon on e-commerce mobile	https://goo.gl/FY2zpN
62	How to Make Navigation (Even a Hamburger) Discoverable on Mobile	https://goo.gl/pYTqeZ
63	How To Plan for Visually Disabled Users on Computers and Mobile Devices- Color Blindness, Low Vision, and Blindness	https://goo.gl/9Xoxk4
64	In Plain Sight- Text, Contrast, and Accessibility	https://goo.gl/FdxEcy
65	Infinite Scrolling- Let's Get To The Bottom Of This	https://goo.gl/kPd5AG
66	Infinite Scrolling, Pagination Or "Load More" ButtonsUsability Findings In eCommerce	https://goo.gl/Gxg9yu
67	Is top navigation an accepted pattern for mobile devices	https://goo.gl/1P6nnE
68	It sounds stupid but how important are design patterns	https://goo.gl/zTTJpZ
69	La accesibilidad en entornos digitales	https://goo.gl/j9BRj9
70	Las personas con discapacidad y el acceso a la Web	https://goo.gl/TfnhL6
71	Lessons from building mobile-friendly, accessible data tables	https://goo.gl/W5eXoD
72	List Thumbnails on Mobile- When to Use Them and Where to Place Them	https://goo.gl/e1gskw
73	Looking for a Mobile device for an uncle with epilepsy.	https://goo.gl/bxkLjD
74	Low-Contrast Text Is Not the Answer	https://goo.gl/ZN5pv7
75	Misused mobile UX patterns	https://goo.gl/YLfH5o
76	Mobile And Accessibility- Why You Should Care And What You Can Do About It	https://goo.gl/Nx5GbR

77	Mobile Design Pattern- Inventory-Based Discrete Slider	https://goo.gl/91SpCG
78	Mobile First Is NOT Mobile Only	https://goo.gl/jZWMs6
79	mobile input feedback design pattern	https://goo.gl/cQEngf
80	Mobile Navigation For Smashing Magazine- A Case Study	https://goo.gl/h7HrmA
81	Mobile Navigation- Image Grids or Text Lists	https://goo.gl/66gq8V
82	Mobile Phones and the Importance of Accessibility.	https://goo.gl/6PGGvt
83	Mobile platform design guidelines vs consistenty in user experience across platforms	https://goo.gl/THnYdA
84	Mobile UI Design Patterns — Sign In	https://goo.gl/Bse534
85	Navigating the Mobile Application - 5 UX Design Patterns	https://goo.gl/4X8iBT
86	Notes On Client-Rendered Accessibility	https://goo.gl/DziGiQ
87	O impacto do menu hamburger nas métricas do seu produto	https://goo.gl/SuLWbx
88	Opciones de accesibilidad para dispositivos móviles	https://goo.gl/P5Xuqp
89	Placeholders in Form Fields Are Harmful	https://goo.gl/czso2T
90	Prototyping accessibility in web and mobile UI design	https://goo.gl/fnDbik
91	Responsive Navigation Patterns	https://goo.gl/6mfZWT
92	Rethinking Mobile Tutorials- Which Patterns Really Work	https://goo.gl/nbm4KY
93	Screen Readers on Touchscreen Devices	https://goo.gl/KezSUw
94	Seeking design patterns for indicating more content below the fold	https://goo.gl/FjQEYM
95	Smartphone UI Patterns	https://goo.gl/gh1hyz
96	Successful Mobile Applications - Using UI Design Patterns	https://goo.gl/uJi7n6
97	Supporting Mobile Navigation in Spite of a Hamburger Menu	https://goo.gl/sjV4o9
98	Taking Pattern Libraries To The Next Level	https://goo.gl/jhF1oY
99	The 4 Types of Creative Website Scrolling Patterns	https://goo.gl/EKSTsD
100	The Beginner's Guide to Accessible Mobile UI Design	https://goo.gl/psVxXE
101	The Burger Menu	https://goo.gl/SQt9zi
102	The cost of accessibility	https://goo.gl/j6dQYT
103	The Golden Rules Of Bottom Navigation Design	https://goo.gl/VrwJKJ

104	The hamburger menu doesn't work	https://goo.gl/zjb2ZU
105	The Hamburger Menu Doesn't Work - it's a beautiful, elegant solution that gets it all wrong, and it's time to move on	https://goo.gl/JaNiVP
106	The Most Creative Mobile Navigation Patterns	https://goo.gl/gc4JQW
107	The Most Creative Mobile Navigation Patterns 2	https://goo.gl/65KbXz
108	The Quest For Mobile Accessible Apps	https://goo.gl/HEB1Vs
109	The Thumb Zone- Designing For Mobile Users	https://goo.gl/uy1TQi
110	The Underestimated Power Of Color In Mobile App Design	https://goo.gl/ADzbdf
111	The UX of Password fields	https://goo.gl/qm6u4A
112	UIUX design and accessiblitly	https://goo.gl/MBrLRS
113	We need to talk about Accessibility on Chatbots	https://goo.gl/5B1cBo
114	Web Layout Best Practices -12 Timeless UI Patterns Analyzed	https://goo.gl/MGFVSp
115	What features do blindvisually-impaired look for in audio voice memo recorders on mobile	https://goo.gl/LhNCtt
116	What is the best UX pattern for large dropdowns in case of mobile web pages	https://goo.gl/tBfow6
117	What's holding back accessibility in 2016	https://goo.gl/CxiWME
118	What's so wrong about hamburger menus	https://goo.gl/aCDK1X
119	What's the best navigation UI pattern for nested resources on mobile	https://goo.gl/gopnbB
120	When to Choose the Dark Side in Mobile Design	https://goo.gl/bkz4r3
121	When to ignore 'Mobile-First'	https://goo.gl/p9xdqB
122	Why accessibility impacts UX web design	https://goo.gl/Ysvrs3
123	Why and How to Avoid Hamburger Menus	https://goo.gl/anH76n
124	Why mobile design means accessible design	https://goo.gl/rEHZFX
125	Why You Should Never Pair Green and Red on the Web	https://goo.gl/NbDaNC
126	Why Your Links Should Never Say "Click Here"	https://goo.gl/NfeiGy
127	Writing for all people- how to use alternative text well	https://goo.gl/9pfX3S

Table 3 – Title of documents used in the Virtual Ethnography study

APPENDIX B – Characterization Form

Formulário de Caracterização

*Obrigatório

1. **Login Moodle (primeira parte do e-mail, antes do @) ***

2. **Sexo ***
   Marcar apenas uma oval.
   - M
   - F

3. **Idade ***

4. **Escolaridade ***
   Marcar apenas uma oval.
   - Ensino Médio Completo
   - Ensino Superior Incompleto
   - Ensino Superior Completo
   - Pós graduação Incompleto
   - Pós graduação Completo

5. **Ocupação/Profissão ***

6. **Possui algum tipo de necessidades especiais? Se sim, Qual? ***

7. **Possui aparelho móvel (smartphone ou tablet)? ***
   Marcar apenas uma oval.
   - Sim
   - Não

8. **Há quanto tempo tem contato com smartphones/tablets?** *
Marcar apenas uma oval.

- ◯ Menos de 1 ano
- ◯ 1 ano
- ◯ 2 anos
- ◯ 3 anos
- ◯ 4 anos ou mais

9. **Qual a frequência de uso diária do smartphone/tablet?** *
Marcar apenas uma oval.

- ◯ Menos de 2 horas por dia
- ◯ Entre 2 e 5 horas por dia
- ◯ Entre 5 e 8 horas por dia
- ◯ Mais de 8 horas por dia
- ◯ Não uso smartphone/tablet diariamente

10. **Qual a frequência de acesso diário de Internet?** *
Marcar apenas uma oval.

- ◯ Menos de 2 horas por dia
- ◯ Entre 2 e 5 horas por dia
- ◯ Entre 5 e 8 horas por dia
- ◯ Mais de 8 horas por dia
- ◯ Não acesso a Internet diariamente

11. **Você utiliza o smartphone/tablet para acessar a Internet?** *
Marcar apenas uma oval.

- ◯ Sim
- ◯ Não

12. **Prefere o smartphone/tablet ou computador para acessar sites da Web?** *
Marcar apenas uma oval.

- ◯ Smartphone/Tablet
- ◯ Computador/Notebook

Exemplo de Botão Radio e Checkbox

13. **Assinale sua satisfação quanto a adaptação dos seguintes elementos web para smartphones/tablets:** *

Marcar apenas uma oval por linha.

	Parcialmente Insatisfeito	Satisfeito	Muito Satisfeito
Tabelas	◯	◯	◯
Formulários	◯	◯	◯
Tamanho de Imagens	◯	◯	◯
Tamanho da fonte de textos	◯	◯	◯
Links	◯	◯	◯
Ícones	◯	◯	◯
Botões	◯	◯	◯
Botão radio/Checkbox	◯	◯	◯
Inserção de texto	◯	◯	◯
Menus de sites	◯	◯	◯
Listas	◯	◯	◯
Caixa de pesquisa	◯	◯	◯
Navegação	◯	◯	◯

14. **Já encontrou algum obstáculo ou barreira* que tenha prejudicado encontrar informações em um site acessando pelo celular? Se sim, descreva a situação e o obstáculo ou barreira abaixo:** *

* Uma barreira é qualquer tipo de dificuldade que possa ter prejudicado ou até impedido a execução de alguma atividade.

_____

_____

_____

_____

_____

15. **Utiliza alguma plataforma de e-learning? Se sim, qual?** *

Marque todas que se aplicam.

- ☐ Moodle
- ☐ Outro: _____

16. **Com que frequência costuma acessar plataformas de e-learning pelo smartphone ou tablet?** *

Marcar apenas uma oval.

- ◯ Diariamente
- ◯ 2 ou 3 vezes na semana
- ◯ 1 vez na semana
- ◯ Nunca

APPENDIX C – Accompaniment Form

Formulário de Acompanhamento

Este questionário está dividido em 6 seções que correspondem a atividades que devem ser executadas no aplicativo Moodle Mobile. O objetivo é ter um feedback da sua experiência de uso do aplicativo quanto a alguns elementos da tela.

Cada seção terá algumas imagens com elementos indicados e enumerados. Nem sempre para a execução de uma operação você passará por todas as telas das imagens, mas é importante que responda em todas as situações onde utiliza um elemento ilustrado.

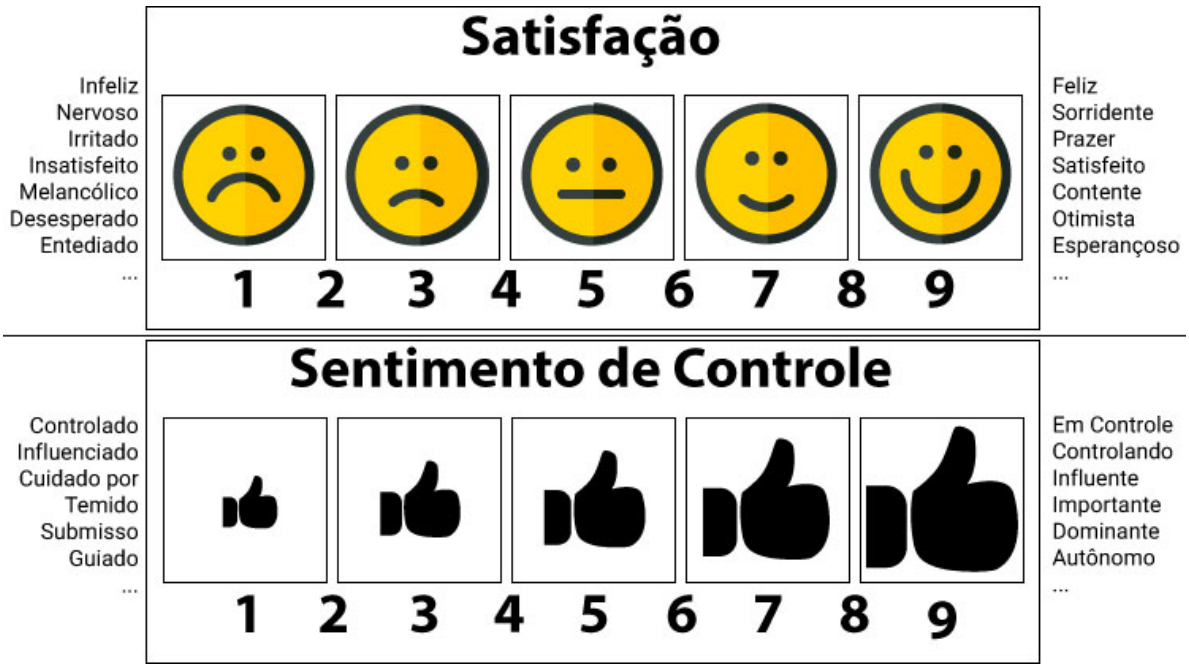
*Obrigatório

Satisfação e Sentimento de Controle

Abaixo, você encontra uma figura com alguns sentimentos mapeados para ícones.

O objetivo desta escala é mapear suas emoções quanto a Satisfação e Sentimento de Controle ao utilizar um elemento de interface por meio de imagens: smiley faces para Satisfação (de infeliz a feliz) e joinhas para Sentimento de Controle (de dominado a dominante).

Em cada uma das atividades, será requisitado que você aponte seu grau de satisfação e Sentimento de Controle, e você deve utilizar a escala definida nessa imagem para responder a tais questões.



Identificação

1. **Login Moodle (primeira parte do e-mail, antes do @)** *

Atividade 1: Consultar Eventos do Calendário

Nessa atividade, você deverá acessar a tela de Eventos do Calendário e acessar o detalhe do Evento "Experimento 26/04".

Algumas possíveis telas são reproduzidas, onde alguns elementos da interface estão destacados com

dos elementos/telas que utilizou somente (como existem várias formas de executar uma operação, podem existir telas e elementos que você não tenha utilizado para completar a atividade).

Possíveis telas

2. **Satisfação por elemento:**

   Com base na escala de Satisfação, você deve assinalar (somente os elementos que encontrou/utilizou) seu grau de Satisfação ao utilizar cada elemento de interface enumerado.
   Marcar apenas uma oval por linha.

	1	2	3	4	5	6	7	8	9
Elemento 1									
Elemento 2									
Elemento 3									
Elemento 4									
Elemento 5									
Elemento 6									
Elemento 7									
Elemento 8									
Elemento 9									
Elemento 10									
Elemento 11									
Elemento 12									

3. **Sentimento de Controle por elemento:**

   Com base na escala de Sentimento de Controle, você deve assinalar (somente os elementos que encontrou/utilizou) seu grau de Sentimento de Controle ao utilizar cada elemento de interface enumerado.
   Marcar apenas uma oval por linha.

	1	2	3	4	5	6	7	8	9
Elemento 1									
Elemento 2									
Elemento 3									
Elemento 4									
Elemento 5									
Elemento 6									
Elemento 7									
Elemento 8									
Elemento 9									
Elemento 10									
Elemento 11									
Elemento 12									

4. **Durante esta atividade você teve alguma dificuldade ou problema em utilizar ou entender algum elemento de interface? Se sim, cite o número do elemento e a dificuldade.** *

5. **Sobre a atividade em geral, responda:** *
Marcar apenas uma oval por linha.

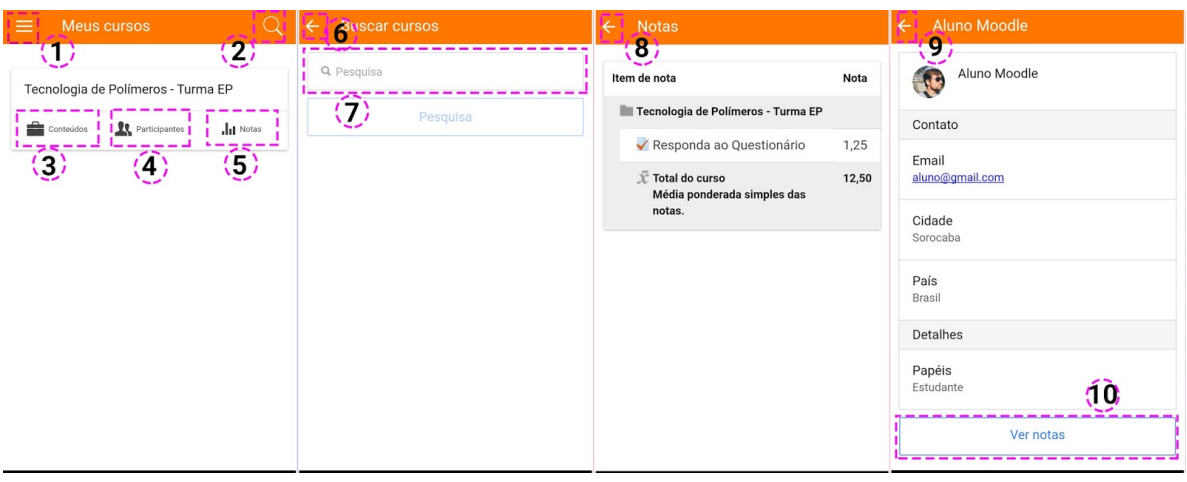
	Discordo Fortemente	Discordo	Discordo Parcialmente	Concordo Parcialmente	Concordo	Concordo Fortemente
Eu consegui cumprir a atividade	◯	◯	◯	◯	◯	◯
A quantidade de passos e telas na navegação para completar a atividade é adequada	◯	◯	◯	◯	◯	◯
A interação com a interface na execução da atividade foi fluida e não houveram problemas de localização e/ou direcionamento	◯	◯	◯	◯	◯	◯

Atividade 2: Verificar nota de Questionário

Nessa atividade, você deverá verificar a nota recebida na correção do questionário.

Algumas possíveis telas são reproduzidas, onde alguns elementos da interface estão destacados com retângulos pontilhados e enumerados. Você deve assinalar sua Satisfação e Sentimento de Controle dos elementos/telas que utilizou somente (como existem várias formas de executar uma operação, podem existir telas e elementos que você não tenha utilizado para completar a atividade).

Possíveis telas



6. **Satisfação por elemento:**

Com base na escala de Satisfação, você deve assinalar (somente os elementos que encontrou/utilizou) seu grau de Satisfação ao utilizar cada elemento de interface enumerado.
Marcar apenas uma oval por linha.

	1	2	3	4	5	6	7	8	9
Elemento 1	◯	◯	◯	◯	◯	◯	◯	◯	◯
Elemento 2	◯	◯	◯	◯	◯	◯	◯	◯	◯
Elemento 3	◯	◯	◯	◯	◯	◯	◯	◯	◯
Elemento 4	◯	◯	◯	◯	◯	◯	◯	◯	◯
Elemento 5	◯	◯	◯	◯	◯	◯	◯	◯	◯
Elemento 6	◯	◯	◯	◯	◯	◯	◯	◯	◯
Elemento 7	◯	◯	◯	◯	◯	◯	◯	◯	◯
Elemento 8	◯	◯	◯	◯	◯	◯	◯	◯	◯
Elemento 9	◯	◯	◯	◯	◯	◯	◯	◯	◯
Elemento 10	◯	◯	◯	◯	◯	◯	◯	◯	◯

7. **Sentimento de Controle por elemento:**

Com base na escala de Sentimento de Controle, você deve assinalar (somente os elementos que encontrou/utilizou) seu grau de Sentimento de Controle ao utilizar cada elemento de interface enumerado.
Marcar apenas uma oval por linha.

	1	2	3	4	5	6	7	8	9
Elemento 1	◯	◯	◯	◯	◯	◯	◯	◯	◯
Elemento 2	◯	◯	◯	◯	◯	◯	◯	◯	◯
Elemento 3	◯	◯	◯	◯	◯	◯	◯	◯	◯
Elemento 4	◯	◯	◯	◯	◯	◯	◯	◯	◯
Elemento 5	◯	◯	◯	◯	◯	◯	◯	◯	◯
Elemento 6	◯	◯	◯	◯	◯	◯	◯	◯	◯
Elemento 7	◯	◯	◯	◯	◯	◯	◯	◯	◯
Elemento 8	◯	◯	◯	◯	◯	◯	◯	◯	◯
Elemento 9	◯	◯	◯	◯	◯	◯	◯	◯	◯
Elemento 10	◯	◯	◯	◯	◯	◯	◯	◯	◯

8. **Durante esta atividade você teve alguma dificuldade ou problema em utilizar ou entender algum elemento de interface? Se sim, cite o número do elemento e a dificuldade.** *

_____

_____

_____

_____

_____

9. **Sobre a atividade em geral, responda:** *

Marcar apenas uma oval por linha.

	Discordo Fortemente	Discordo	Discordo Parcialmente	Concordo Parcialmente	Concordo	Concordo Fortemente
Eu consegui cumprir a atividade	◯	◯	◯	◯	◯	◯
A quantidade de passos e telas na navegação para completar a atividade é adequada	◯	◯	◯	◯	◯	◯
A interação com a interface na execução da atividade foi fluida e não houveram problemas de localização e/ou direcionamento	◯	◯	◯	◯	◯	◯

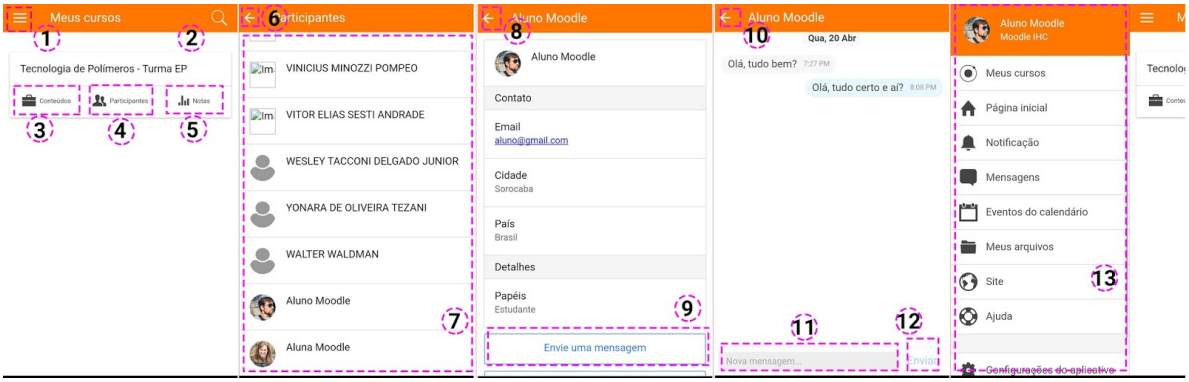
Ir para a pergunta 10.

Atividade 3: Enviar uma mensagem a um aluno

Nessa atividade, você deverá enviar uma mensagem qualquer ao participante "Aluno Moodle" ou "Aluna Moodle"

Algumas possíveis telas são reproduzidas, onde alguns elementos da interface estão destacados com retângulos pontilhados e enumerados. Você deve assinalar sua Satisfação e Sentimento de Controle dos elementos/telas que utilizou somente (como existem várias formas de executar uma operação, podem existir telas e elementos que você não tenha utilizado para completar a atividade).

Possíveis telas



10. **Satisfação por elemento:**

Com base na escala de Satisfação, você deve assinalar (somente os elementos que encontrou/utilizou) seu grau de Satisfação ao utilizar cada elemento de interface enumerado.
Marcar apenas uma oval por linha.

	1	2	3	4	5	6	7	8	9
Elemento 1	◯	◯	◯	◯	◯	◯	◯	◯	◯
Elemento 2	◯	◯	◯	◯	◯	◯	◯	◯	◯
Elemento 3	◯	◯	◯	◯	◯	◯	◯	◯	◯
Elemento 4	◯	◯	◯	◯	◯	◯	◯	◯	◯
Elemento 5	◯	◯	◯	◯	◯	◯	◯	◯	◯
Elemento 6	◯	◯	◯	◯	◯	◯	◯	◯	◯
Elemento 7	◯	◯	◯	◯	◯	◯	◯	◯	◯
Elemento 8	◯	◯	◯	◯	◯	◯	◯	◯	◯
Elemento 9	◯	◯	◯	◯	◯	◯	◯	◯	◯
Elemento 10	◯	◯	◯	◯	◯	◯	◯	◯	◯
Elemento 11	◯	◯	◯	◯	◯	◯	◯	◯	◯
Elemento 12	◯	◯	◯	◯	◯	◯	◯	◯	◯
Elemento 13	◯	◯	◯	◯	◯	◯	◯	◯	◯

11. **Sentimento de Controle por elemento:**

Com base na escala de Sentimento de Controle, você deve assinalar (somente os elementos que encontrou/utilizou) seu grau de Sentimento de Controle ao utilizar cada elemento de interface enumerado.
Marcar apenas uma oval por linha.

	1	2	3	4	5	6	7	8	9
Elemento 1	◯	◯	◯	◯	◯	◯	◯	◯	◯
Elemento 2	◯	◯	◯	◯	◯	◯	◯	◯	◯
Elemento 3	◯	◯	◯	◯	◯	◯	◯	◯	◯
Elemento 4	◯	◯	◯	◯	◯	◯	◯	◯	◯
Elemento 5	◯	◯	◯	◯	◯	◯	◯	◯	◯
Elemento 6	◯	◯	◯	◯	◯	◯	◯	◯	◯
Elemento 7	◯	◯	◯	◯	◯	◯	◯	◯	◯
Elemento 8	◯	◯	◯	◯	◯	◯	◯	◯	◯
Elemento 9	◯	◯	◯	◯	◯	◯	◯	◯	◯
Elemento 10	◯	◯	◯	◯	◯	◯	◯	◯	◯
Elemento 11	◯	◯	◯	◯	◯	◯	◯	◯	◯
Elemento 12	◯	◯	◯	◯	◯	◯	◯	◯	◯
Elemento 13	◯	◯	◯	◯	◯	◯	◯	◯	◯

12. **Durante esta atividade você teve alguma dificuldade ou problema em utilizar ou entender algum elemento de interface? Se sim, cite o número do elemento e a dificuldade.** *

_____

_____

_____

_____

_____

13. **Sobre a atividade em geral, responda:** *

Marcar apenas uma oval por linha.

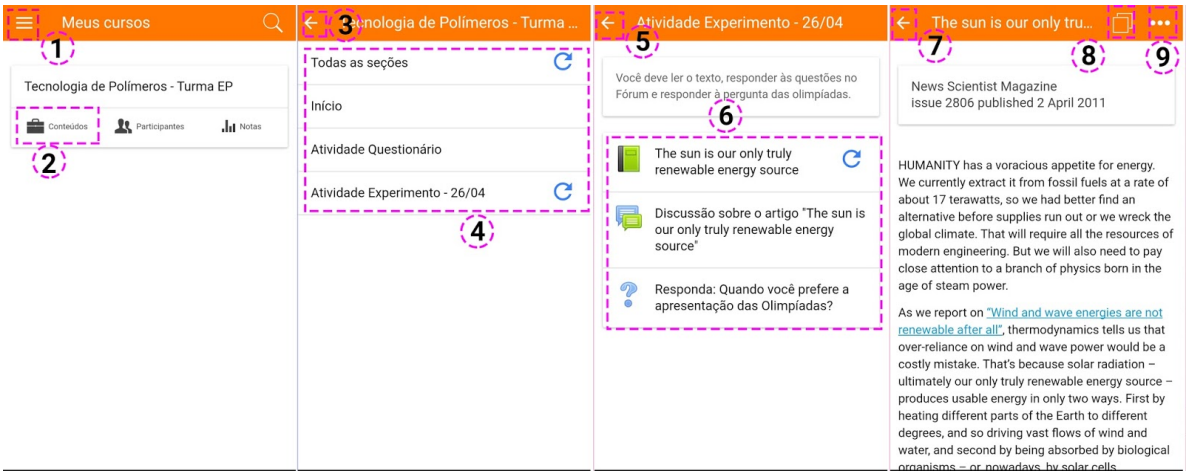
	Discordo Fortemente	Discordo	Discordo Parcialmente	Concordo Parcialmente	Concordo	Concordo Fortemente
Eu consegui cumprir a atividade	◯	◯	◯	◯	◯	◯
A quantidade de passos e telas na navegação para completar a atividade é adequada	◯	◯	◯	◯	◯	◯
A interação com a interface na execução da atividade foi fluida e não houveram problemas de localização e/ou direcionamento	◯	◯	◯	◯	◯	◯

Atividade 4: Ler um texto

Nessa atividade, você deverá ler rapidamente o texto "The sun is our only truly renewable energy source"

Algumas possíveis telas são reproduzidas, onde alguns elementos da interface estão destacados com retângulos pontilhados e enumerados. Você deve assinalar sua Satisfação e Sentimento de Controle dos elementos/telas que utilizou somente (como existem várias formas de executar uma operação, podem existir telas e elementos que você não tenha utilizado para completar a atividade).

Possíveis telas



14. **Satisfação por elemento:**

Com base na escala de Satisfação, você deve assinalar (somente os elementos que encontrou/utilizou) seu grau de Satisfação ao utilizar cada elemento de interface enumerado.
Marcar apenas uma oval por linha.

	1	2	3	4	5	6	7	8	9
Elemento 1	◯	◯	◯	◯	◯	◯	◯	◯	◯
Elemento 2	◯	◯	◯	◯	◯	◯	◯	◯	◯
Elemento 3	◯	◯	◯	◯	◯	◯	◯	◯	◯
Elemento 4	◯	◯	◯	◯	◯	◯	◯	◯	◯
Elemento 5	◯	◯	◯	◯	◯	◯	◯	◯	◯
Elemento 6	◯	◯	◯	◯	◯	◯	◯	◯	◯
Elemento 7	◯	◯	◯	◯	◯	◯	◯	◯	◯
Elemento 8	◯	◯	◯	◯	◯	◯	◯	◯	◯
Elemento 9	◯	◯	◯	◯	◯	◯	◯	◯	◯

15. **Sentimento de Controle por elemento:**

Com base na escala de Sentimento de Controle, você deve assinalar (somente os elementos que encontrou/utilizou) seu grau de Sentimento de Controle ao utilizar cada elemento de interface enumerado.
Marcar apenas uma oval por linha.

	1	2	3	4	5	6	7	8	9
Elemento 1	◯	◯	◯	◯	◯	◯	◯	◯	◯
Elemento 2	◯	◯	◯	◯	◯	◯	◯	◯	◯
Elemento 3	◯	◯	◯	◯	◯	◯	◯	◯	◯
Elemento 4	◯	◯	◯	◯	◯	◯	◯	◯	◯
Elemento 5	◯	◯	◯	◯	◯	◯	◯	◯	◯
Elemento 6	◯	◯	◯	◯	◯	◯	◯	◯	◯
Elemento 7	◯	◯	◯	◯	◯	◯	◯	◯	◯
Elemento 8	◯	◯	◯	◯	◯	◯	◯	◯	◯
Elemento 9	◯	◯	◯	◯	◯	◯	◯	◯	◯

16. **Durante esta atividade você teve alguma dificuldade ou problema em utilizar ou entender algum elemento de interface? Se sim, cite o número do elemento e a dificuldade.** *

_____

_____

_____

_____

_____

17. **Sobre a atividade em geral, responda:** *

Marcar apenas uma oval por linha.

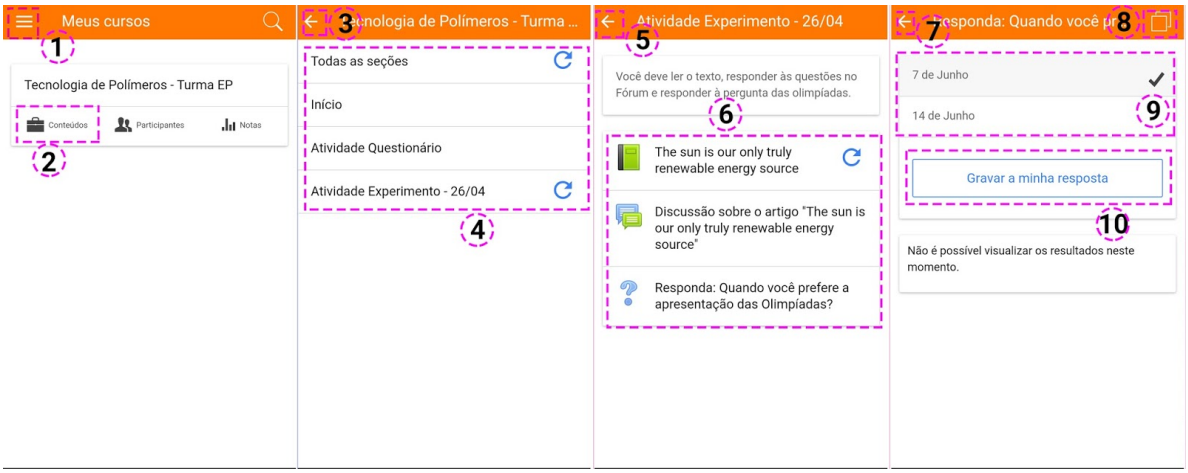
	Discordo Fortemente	Discordo	Discordo Parcialmente	Concordo Parcialmente	Concordo	Concordo Fortemente
Eu consegui cumprir a atividade	◯	◯	◯	◯	◯	◯
A quantidade de passos e telas na navegação para completar a atividade é adequada	◯	◯	◯	◯	◯	◯
A interação com a interface na execução da atividade foi fluida e não houveram problemas de localização e/ou direcionamento	◯	◯	◯	◯	◯	◯

Atividade 5: Responder a uma pergunta

Nessa atividade, você deverá responder à pergunta "Quando você prefere a apresentação das Olimpíadas?"

Algumas possíveis telas são reproduzidas, onde alguns elementos da interface estão destacados com retângulos pontilhados e enumerados. Você deve assinalar sua Satisfação e Sentimento de Controle dos elementos/telas que utilizou somente (como existem várias formas de executar uma operação, podem existir telas e elementos que você não tenha utilizado para completar a atividade).

Possíveis telas



18. **Satisfação por elemento:**

Com base na escala de Satisfação, você deve assinalar (somente os elementos que encontrou/utilizou) seu grau de Satisfação ao utilizar cada elemento de interface enumerado.
Marcar apenas uma oval por linha.

	1	2	3	4	5	6	7	8	9
Elemento 1	◯	◯	◯	◯	◯	◯	◯	◯	◯
Elemento 2	◯	◯	◯	◯	◯	◯	◯	◯	◯
Elemento 3	◯	◯	◯	◯	◯	◯	◯	◯	◯
Elemento 4	◯	◯	◯	◯	◯	◯	◯	◯	◯
Elemento 5	◯	◯	◯	◯	◯	◯	◯	◯	◯
Elemento 6	◯	◯	◯	◯	◯	◯	◯	◯	◯
Elemento 7	◯	◯	◯	◯	◯	◯	◯	◯	◯
Elemento 8	◯	◯	◯	◯	◯	◯	◯	◯	◯
Elemento 9	◯	◯	◯	◯	◯	◯	◯	◯	◯
Elemento 10	◯	◯	◯	◯	◯	◯	◯	◯	◯

19. **Sentimento de Controle por elemento:**

Com base na escala de Sentimento de Controle, você deve assinalar (somente os elementos que encontrou/utilizou) seu grau de Sentimento de Controle ao utilizar cada elemento de interface enumerado.
Marcar apenas uma oval por linha.

	1	2	3	4	5	6	7	8	9
Elemento 1	◯	◯	◯	◯	◯	◯	◯	◯	◯
Elemento 2	◯	◯	◯	◯	◯	◯	◯	◯	◯
Elemento 3	◯	◯	◯	◯	◯	◯	◯	◯	◯
Elemento 4	◯	◯	◯	◯	◯	◯	◯	◯	◯
Elemento 5	◯	◯	◯	◯	◯	◯	◯	◯	◯
Elemento 6	◯	◯	◯	◯	◯	◯	◯	◯	◯
Elemento 7	◯	◯	◯	◯	◯	◯	◯	◯	◯
Elemento 8	◯	◯	◯	◯	◯	◯	◯	◯	◯
Elemento 9	◯	◯	◯	◯	◯	◯	◯	◯	◯
Elemento 10	◯	◯	◯	◯	◯	◯	◯	◯	◯

20. **Durante esta atividade você teve alguma dificuldade ou problema em utilizar ou entender algum elemento de interface? Se sim, cite o número do elemento e a dificuldade.** *

_____

_____

_____

_____

_____

21. **Sobre a atividade em geral, responda:** *

Marcar apenas uma oval por linha.

	Discordo Fortemente	Discordo	Discordo Parcialmente	Concordo Parcialmente	Concordo	Concordo Fortemente
Eu consegui cumprir a atividade	◯	◯	◯	◯	◯	◯
A quantidade de passos e telas na navegação para completar a atividade é adequada	◯	◯	◯	◯	◯	◯
A interação com a interface na execução da atividade foi fluida e não houveram problemas de localização e/ou direcionamento	◯	◯	◯	◯	◯	◯

Considerações Finais

Está quase acabando :)
Nesta seção gostaria de ouvir sua opinião sobre mais alguns assuntos:

22. **Sobre o Moodle Mobile, responda:** *

Marcar apenas uma oval por linha.

	Discordo Fortemente	Discordo	Discordo Parcialmente	Concordo Parcialmente	Concordo	Concordo Fortemente
Eu continuaria utilizando o Moodle em dispositivos móveis	◯	◯	◯	◯	◯	◯
Eu estou satisfeito com a adaptação da plataforma Moodle em dispositivos móveis	◯	◯	◯	◯	◯	◯

23. **Você possui alguma sugestão ou reclamação sobre a execução da atividade?**

Muito Obrigado!

Agradecemos imensamente sua colaboração!

APPENDIX D – Observation Form

Formulário de Observação

Avaliador: _____ | Usuário: _____

1. **Em qual(is) atividades o aluno encontrou dificuldades?**

   _____

2. **O aluno entendeu como funciona o formulário SAM?**
   Marcar apenas uma oval.

	1	2	
Sim	◯	◯	Não

3. **O aluno realizou todas as Atividades e respondeu a todas as questões do quiz?**
   Marcar apenas uma oval.

	1	2	
Sim	◯	◯	Não

4. **O aluno teve dificuldade na utilização (touchscreen, botões etc) do dispositivo móvel (smartphone ou tablet)?**
   Marcar apenas uma oval.

	1	2	
Sim	◯	◯	Não

Observações Gerais

Caso tenha observado algo importante (alguma dificuldade ou peculiaridade), informe abaixo:

APPENDIX E – Form: Survey on Knowledge Bases of Mobile Interface Design Patterns

Survey on Knowledge Bases of Mobile Interface Design Patterns

Hello, my name is Vitor Casadei. I am a masters student at the Federal University of São Carlos in HCI (Human-Computer Interaction) and produced this survey with the objective of identifying online knowledge bases (websites, blogs, forums, feeds, etc.) from the community of developers and designers on the design and construction of Mobile interfaces.

If you are a Designer or Developer, please, contribute to this survey. There are fewer than 10 quick questions and your help will greatly contribute to the development of my research.

And you can rest easy, if you want to change or add something to your answer, you can at the end of the form.

If you want to know more about my work, contact me by e-mail (vitor.casadei@gmail.com) or visit my website (https://ux-leris.github.io/vitor_casadei/).

Thank you very much!

*Obrigatório

1. **Email (Optional)**
   This field is optional and will only be used to answer questions I may have about your answers.

2. **Are you a Designer or Developer?** *
   Marcar apenas uma oval.
   - ◯ Designer *Ir para a pergunta 3.*
   - ◯ Developer *Ir para a pergunta 5.*

Designer

Some questions about your work and experience

3. **What's your work experience as a Designer?** *
   Marcar apenas uma oval.
   - ◯ up to 1 year of experience
   - ◯ from 1 to 3 years of experience
   - ◯ from 3 to 5 years of experience
   - ◯ from 5 to 10 years of experience
   - ◯ more than 10 years of experience

4. **Check the platforms that you work or have already worked as a designer:** *
   You may select all options that apply
   Marque todas que se aplicam.

   - [ ] Web
   - [ ] Mobile (Android)
   - [ ] Mobile (iOS)
   - [ ] Outro: _____

Ir para a pergunta 7.

Developer

Some questions about your work and experience

5. **What's your work experience as a Developer?** *
   Marcar apenas uma oval.

   - ◯ up to 1 year of experience
   - ◯ from 1 to 3 years of experience
   - ◯ from 3 to 5 years of experience
   - ◯ from 5 to 10 years of experience
   - ◯ more than 10 years of experience

6. **Check the platforms that you work or have already worked as a developer:** *
   You may select all options that apply
   Marque todas que se aplicam.

   - [ ] Web
   - [ ] Mobile (Android)
   - [ ] Mobile (iOS)
   - [ ] Outro: _____

Ir para a pergunta 7.

UI/Interface Design Patterns

An Interface Design Pattern is a solution to a problem in designing an interface. It can be a way to implement or present an interface element or the whole screen.

Common examples of Interface Design Patterns are those defined by Google Material Design (https://material.google.com).

7. **Point your knowledge about Interface Design Patterns:** *
   Marcar apenas uma oval por linha.

	Don't know	know a little	know fairly	know a lot	am an Expert
I ...	◯	◯	◯	◯	◯

8. **If you have already used Interface Design Patterns in any project, check the alternative that corresponds to the size of the project in number of users:** *

Marcar apenas uma oval.

- ◯ I have never used
- ◯ from 1 to 10 users
- ◯ from 11 to 25 users
- ◯ from 26 to 50 users
- ◯ from 51 to 100 users
- ◯ more than 100 users

Ir para a pergunta 9.

Knowledge Bases

The purpose is to hear from you, a member of the community, about websites, blogs, forums or any other digital means by which you update yourself on subjects related to the design of mobile interfaces.

9. **Enter websites, blogs, forums, mailing lists, feeds, and other media that you know about and consult information on mobile interface design:** *

Insert the links along with the names of all the knowledge bases you know about the subject. It can be any link that you find relevant to the search for solutions for mobile interfaces. Add all the links you think are pertinent.