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DESIGNING CULTURALLY SENSITIVE ICONS FOR USER INTERFACES : AN APPROACH FOR THE INTERACTION DESIGN OF SMARTPHONES IN DEVELOPING COUNTRIES

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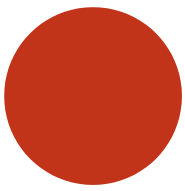

Designing Culturally Sensitive Icons for User Interfaces

An approach for the Interaction Design of smartphones in developing countries

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Abstract

The adhesion to smartphones in developing regions, mainly in the Sub-Saharan region, has been steadily growing. Developing countries are characterized by an array of culturally diverse users from different socio-economic and cultural backgrounds. Therefore, cultural diversity must be contemplated in order to ease the interaction process of the users with the system, but also to promote the usage of smartphones among novice users, illiterates and individuals from different cultural backgrounds. Moreover, solutions of Information and Communication Technologies aimed at supporting development in these regions are important, therefore making it essential to ease users' recognition of and interaction with graphical user interfaces.

This study aimed to assess the level of icon recognition from users from the Sub-Saharan region and attempted to improve it through culturally sensitive icons, defined as icons based upon the preferences of the cultural group. In addition, a repository for cultural material is conceived in order to assist professionals to promote user-centered design techniques for culturally different groups. Besides having the ability to save space in the screen, icons often do not require reading and are immediately recognized once the user is familiarized with their representation, thus constituting an important factor on mobile application usability.

The results demonstrate that culture has a substantial impact on icon recognition and interpretation, and professionals must become familiarized with the representations and actions that are deemed common by the target audience. Furthermore, the study reveals the advantages and disadvantages of this approach, mentions the limitations professionals encounter in the development of solutions for developing regions, and discusses future work in the area.

Keywords: ICT4D, Icon Design, User-Centered Design, Mobile, User Experience, Usability, Culture

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List of Graphs

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List of Acronyms

CRT Cathode Ray Tube

CSCW Computer-Supported Cooperative Work

CSS3 Cascading Style Sheets 3

DNA Deoxyribonucleic Acid

HTML5 HyperText Markup Language 5

HCI Human-Computer Interaction

ICT Information and Communications Technology

ICT4D Information and Communications Technology for Development

ISO International Organization for Standardization

ITEA International Technology Education Association

JSON JavaScript Object Notation

MS-DOS Microsoft Disk Operating System

OECD Organisation for Economic Co-Operation and Development

SQL Structured Query Language

SUS System Usability Scale

UDC Universal Decimal Classification

UNESCO United Nations Educational, Scientific and Cultural Organization

XML Extensible Markup Language

Chapter One
Introduction

1.Introduction

Culture is an intrinsic element of human life able to influence the knowledge of individuals, but it is hard to describe this complex context. Cultural diversity leads to different views and assumptions and these changes shape an individual (Chen, Mashhadi, Ang, & Harkrider, 1999). Culture can be seen as learned and shared behavior originating patterns in thinking, feeling and acting between individuals, and consequently, this element of human life is presented everywhere.

The implementation of culture in technological solutions has been a topic of discussion for some time. Despite cultural diversity being evident in our everyday actions, the plethora of cultural values, customs and traditions are often forgotten or unacknowledged when technological solutions are developed. On the other hand, this document advocates towards the recognition that cultural elements must be acknowledged in order to develop solutions with better usability and a greater user experience. A fair amount of researchers assure that culture must be recognized and implemented in technological solutions. For instance, Vanessa Evers and Donald Day (1997) indicate that user interfaces targeted at culturally different users must acknowledge and accommodate cultural differences. Furthermore, researchers have developed cultural models to cope with cultural differences. Unfortunately, users from different cultures still display difficulties in interacting with technological solutions, and these difficulties impact the adoption and sustainability of ICT solutions.

In the current years, cultural diversity is becoming more important than ever due to the growth of smartphones in developing regions. These regions not only present differences with regards to developed nations, but also within themselves. Developing regions also pose technological and environmental challenges, such as humidity and power outages. Most importantly, users from developing regions are more heterogeneous than in developed countries, and technological proficiency among users may vary. In addition, illiteracy is also more prevalent in these regions. Therefore, these problems must be acknowledged and dealt with it as a way to ease the interaction process of these users. Since a substantial amount of work has been performed in India, the Sub-Saharan region of Africa is the main geographical setting of this study.

Evaluating and redesigning every single element of a graphical user interface is simply not feasible due to time limitations and, consequently, icon design became the focus of the research. Icon design is an integral part of user interface design, and it is perhaps the most noticeable element in a user interface due to the heavy reliance it has on visual perception. The research documented in this dissertation assesses the recognition and interpretation of individuals from different cultural backgrounds, establishes preference levels regarding aesthetic elements constituent of an icon, and determines whether or not the icons of mobile operating systems need to be redesigned for these regions. In addition, the research presents a repository developed in order to assist professionals in future projects that address developing regions. Despite the research being a small milestone in the process of developing culturally sensitive user interfaces, it provides valuable insight regarding methods and approaches that professionals must follow when designing solutions for individuals of different cultures.

1.1. Research Questions and Objectives

In order to assure every objective of the dissertation was properly investigated, research questions were developed and answered in the fourth chapter of the document. The research questions are segmented by phases of research and these questions are the following:

Phase One: Explore the level of recognition of icons utilized in mobile operating system

RQ1: Do African individuals easily understand the icons used in mobile operating systems?

RQ2: Are African individuals without any contact with mobile technology and unable to read and write able to recognize the icons used in mobile operating systems?

RQ3: Is there an evident level of recognition associated to a specific icon?

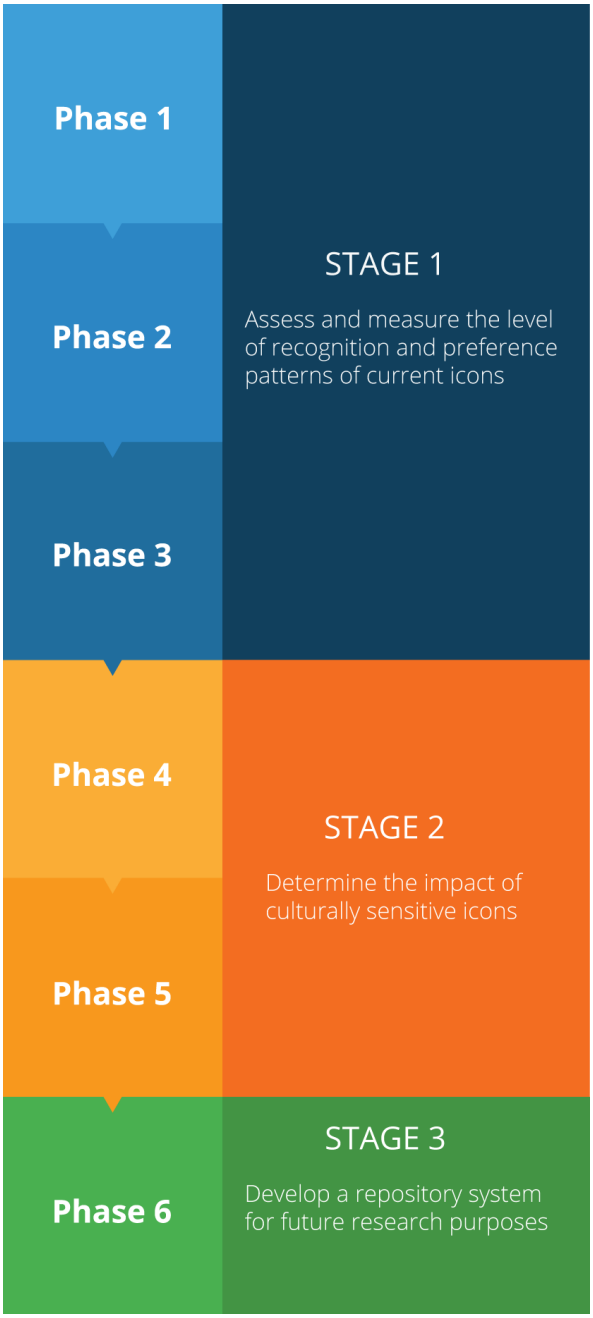


Figure 01. Research Approach of the study

Phase Two: Determine preference patterns of the users regarding the icons used in mobile operating systems

RQ4: Is there a preference level associated with a specific mobile operating system?
RQ5: Is there a correlation between culture based on nationality and the preferred operating system of the participants?

Phase Three: Establish preference levels of visual elements constituent of an icon

RQ6: Can the preference of the users pertaining to the elements constituents of an icon be correlated to the nationality of individuals?

Phase Four: Explore the recognition level of culturally sensitive icons

RQ7: Are African individuals more comfortable with culturally sensitive icons than with existing icons from mobile operating systems?
RQ8: Do African individuals recognize and interpret culturally sensitive icons more easily than existing icons from mobile operating systems?

Phase Five: Comparative analysis between culturally sensitive icons and icons from mobile operating systems

RQ9: Do the users prefer culturally sensitive icons or existing icons from mobile operating systems?
RQ10: Can the preference level between the two types of icons be associated with certain descriptive variables?

Phase Six: Develop a repository system for user-centered approaches

RQ11: Can a repository system assist in the creation of new culturally sensitive icons?
RQ12: Which elements should be considered as intrinsic in a repository system for user-centered approaches?

1.2. Contribution

The research conducted in this document was designed in order to gain insight about the impact of culture in the user experience and usability of graphical user interfaces. The study focuses on icon recognition and comprehension, but also addresses approaches to cope with misconceptions and misrepresentations of not only icons, but also other user interface elements. In other words, the research contributes for the development of user-centered design in developing regions.

The study is comprised by six phases, and each phase contributes to different aspects of the study. The first phase assesses the recognition level of icons utilized in mobile operating systems. The second one aims to establish preference patterns from the users regarding icons from mobile operating systems. The third phase establishes preference levels of elements constituents of an icon. The subsequent phase explores the recognition level of culturally sensitive icons, and the fifth phase is a comparative analysis between culturally sensitive icons and icons from mobile operating systems. The last phase is the development of a repository for future research purposes.

Regarding the content of the study, the research data are insightful but the methods implemented also contribute to the development and design of culturally sensitive icons. The methods established in this document contribute to the notion that culture has a substantial impact in recognition and comprehension of user interfaces, and these experiments assist in understanding which aspects of graphical user interfaces need to be remodeled in order to improve the user experience of culturally different individuals.

In addition, the research is supported by an extensive literature review, which provides context regarding the challenges and characteristics of developing ICT solutions for a large array of users in developing nations. The literature review not only explains the relevance of the interactions fields of study, but also provides an overview to visual perception and icon design. Moreover, the role of culture in interpretation is explained to detail, and the advantages of incorporating cultural values and other aspects in ICT4D solutions are described. In addition, an historical contextualization about the cultural approaches in Human-Computer Interaction is provided in the literature review.

1.3. Document Outline

The dissertation is structured in five chapters. The content of each chapter is summarized below.

Chapter One: Introduction

The first chapter describes the motivation and importance of the research and defines the research focus of the dissertation. The research questions and objectives are presented and the contributions of the study are listed.

Chapter Two: Literature Review

The second chapter describes previous research and bridges the conclusions from these studies with the focus of our study. The chapter is comprised by three sub-chapters, which are summarized below:

Interaction Principles and Methodologies

This sub-chapter briefly describes the interaction fields of study and, subsequently, specifies the advantages of the mobile environment. Afterwards, the role of conceptual models, metaphors, idioms, affordances, constraints and conventions in the interaction process are defined. In addition, the sub-chapter promotes the importance of usability and user experience, and demonstrates the interaction methodologies necessary to cope with cultural diversity.

Visual Perception and User Interface Design

The subsequent sub-chapter mentions the evolution of graphical user interfaces and refers special considerations professionals are required to have when designing for developing countries, namely the appropriate method to ease the interaction process of illiterate users with the system. Afterwards, the importance of visual perception in icon design is referred and the sub-chapter ends with a dissection of icon design.

The last sub-chapter defines culture, mentions patterns of culture and provides an overview of the influence that culture has on the interpretation of the users. Moreover, metamodels of culture and models of culture are discussed, and cultural influence in Human-Computer Interaction is examined. The sub-chapter also addresses the relationship of Information and Communication Technologies and cultural factors, and explains the culturalization approach.

Chapter Three: Methods

The third chapter of the dissertation explains the methods implemented during the experimental procedure. The chapter describes the research setting, reveals the data sample, and demonstrates the research approach. Afterwards, the research methods are described, followed by the research design and the research process of the study. Finally, the data collection methods and data analysis methods are explained to the reader.

Chapter Four: Findings and Results

The fourth chapter is responsible for noting and explaining the results of the experimental procedure. Each phase of the research is briefly summarized, the participants are characterized and the results are presented. In addition, the findings are discussed and conclusions pertaining to each phase are outlined.

Chapter Five: Conclusions

The last chapter of the dissertation aims to summarize the study mentioned in the previous chapters. The chapter also discusses the technical, cultural, time and distance limitations encountered throughout the study. Moreover, future work regarding the study is mentioned.

Chapter Two
Literature Review

2. Literature Review

2.1. Interaction Principles and Methodologies

2.1.1. Interaction Fields of Study

The study of interaction is essential in order to develop products that enhance interactivity between the user and the system. This section discusses two fields of study, Human-Computer Interaction and Interaction Design, and the relationship between them is explained. The role of Human-Computer Interaction is often unclear, nonetheless, the field has an important relationship with Interaction Design. As Lowgren (2001) affirms, the importance of Human-Computer Interaction increases as information technology becomes more pervasive in the life of people. While Human-Computer Interaction focuses on identifying and understanding usability problems in task-oriented computer systems, the field of Interaction Design is responsible for shaping interactive systems with particular emphasis on their use qualities (Lowgren 2001).

Human-Computer Interaction

Human-Computer Interaction does not have a standard definition, mostly due to its multidisciplinary approach, but the field can be described as a "discipline concerned with the design, evaluation and implementation of interactive computer systems for human use and with the study of major phenomena surrounding them" (Hewett et al. 1992, 5). Despite the discrepancy and lack of consensus regarding the field's definition, Human-Computer Interaction can be interpreted as design to produce a fit between the user, the machine and the required services in order to attain a particular level of performance in the quality and optimality of services (Karray et al. 2008). The field derives from several disciplines with particular emphasis on computer science, psychology, sociology and anthropology, and industrial design (Hewett et al. 1992). Karray et al. (2008) state that Human-Computer Interaction was based on the premise that most sophisticated machines are worthless unless humans can use them properly. Consequently, functionality and usability are the core foundations of Human-Computer Interaction (Karray et al. 2008).

Independently of the lack of consensus in defining Human-Computer Interaction, the field is characterized by three components: the human, the computer and the interaction process. These are fundamental components of an interactive system. The human user is the element that computer systems are designed to assist through a process of interaction. The human user is the central character of an interactive system and possesses limited capacity in information processing (Dix et al. 2004). The interaction between a person and the environment occurs through the delivery and collection of information through input and output channels. Dix et al. (2004) affirm that the input that humans acquire occurs through the senses and the output through the motor control of the effectors. The authors demonstrate the existence of several input and output channels, particularly the visual channel, the auditory channel, the haptic channel and movement (Dix et al. 2004). The visual channel is the primary source of information for the average person and Human-Computer Interaction researchers and practitioners are concerned with visual perception aspects, visual processing capabilities and limitations, and the reading process (Dix et al. 2004). Regarding visual perception, Human-Computer Interaction researchers and practitioners are concerned with aspects of brightness, size, depth, and color perception (Dix et al. 2004). The information from these channels is stored in the memory of users. (Dix et al. 2004) indicate the existence of three types of memory, namely sensory memory, short-term memory and long-term memory. Human-Computer Interaction is not only concerned in the perceptual and cognitive abilities of the human

user, but also with the influence of emotion on human capabilities (Dix et al. 2004). Emotions are fundamental components of human beings and the relationship between humans, computers and emotions has become increasingly more important in Human-computer Interaction. Scott Brave and Clifford Nass (2007) note that emotions are an integral part of Human-Computer Interaction and consequently, any interface that ignores the emotional state of the user or fails to manifest the appropriate emotional state, dramatically impacts the performance of the same and subsequently can be perceived as incompetent and socially inept. The use of multimodal interfaces provides a wider range of emotions compared to purely textual interfaces (Cassel, Sullivan, Prevost & Churchill, 2000 cited in Brave and Nass 2007).

The second component of an interactive system is the computer. Similar to the human user, the computer is composed by input and output devices for interactive use. Regarding input devices, Dix et al. (2004) mention the use of text entry devices (e.g. keyboard), pointing (e.g. touchpad) and 3D interaction devices. Ken Hinckley states input devices are responsible for sensing the physical properties of people, places, or things (Hinckley 2007). Hinckley identifies several modalities of interaction that enhance interfaces, such as speech and multimodal input, bimanual input, pen and gesture input, whole hand input, background sensing techniques and multitouch tables and screens (Hinckley 2007). On the other hand, Andrew D. Wilson discusses the use of sensors and other input methods for interaction based on recognition (Wilson 2007). Sensors convert physical signal into an electrical signal that can be manipulated on a computer in a symbolical manner and the author discusses the impact of sensors in interactive applications, such as occupancy and motion sensors, range sensors, positional sensors, gaze tracking and eye tracking systems, speech sensors, gestural sensors and brain-computer interfaces (Wilson 2007). Stephen Brewster defends that the combination of visual and auditory feedback in user interface forms a powerful interaction tool due to the fact that the visual system provides detailed information in a small area of focus, while the auditory system is responsible for providing general information from the environment (Brewster 2007).

The interaction process is the last component of Human-Computer Interaction. This component is responsible for the communication between the human user and the computer system. Dix et al. (2004) affirm that interaction takes place within a social and organizational context that affects the user and the system. Ergonomics is responsible for interpreting the physical characteristics of an interaction in Human-Computer Interaction and how these interactions influence the effectiveness of the same (Dix et al. 2004).

Human-Computer Interaction researchers and practitioners have to be concerned with the three components that characterized Human-Computer Interaction. Karray et al. state, “the complexity of the degree of the involvement of a human in interaction with a machine is sometimes invisible compared to the simplicity of the interaction method itself”(Karray et al. 2008, 139). The authors also demonstrate that user activity in Human-Computer Interaction is composed by three different levels, physical, cognitive and affective (Karray et al. 2008). The mechanics of the interaction between the user and the machine characterizes the physical aspect, while the understanding and interaction of the users with the system composed the cognitive aspect. At last, the affective aspect consists in creating a pleasurable experience to the user and incentivizes the user to continue using the machine by changing attitudes and emotions of the user (Karray et al. 2008).

Human-Computer Interaction lacks a unified theory but is characterized by strong principles aimed to the performance of users, computers and the tasks (Dix et al. 2004). The principles assist in the development of successful products and in order for a product to be successful, it needs to be useful, usable and used (Dix et al. 2004). In other words, a system must accomplish what is required in an easy and natural way in order to incentivize people to use it. Dix et al. (2004) state

that the principles that Human-Computer Interaction is based on have the objective to create beautiful and/or novel interfaces that "are artistically pleasing and capable of fulfilling the tasks required" (Dix et al. 2004, 6). In order to obtain a coexistence of art and science into a successful whole, practitioners need to be inspired and learn from past examples, both good and bad. Therefore, Human-Computer Interaction is not only about the functionality and usability of a system, but also how and why a system operates and works.

Interaction Design

Human-Computer Interaction is mostly concerned with usability issues and subsequently, interactive systems are often aimed to working effectively from an engineering perspective, and the users for which the system is designed for are disregarded at times. Human-Computer Interaction and Interaction Design are two fields concerned with designing systems in order to match the user's goals, but each field presents a different focus and methodology. The objective of interaction designers is to develop easy, effective and enjoyable interactive products from a user's perspective (Preece, Rogers, and Sharp 2002). Therefore, Terry Winograd describes Interaction Design as the "design of spaces for human communication and interaction" (Winograd 1997 cited in Preece, Rogers, and Sharp 2002, 6). Meanwhile, Preece, Rogers and Sharp (2002) identify Interaction Design as the "design of interactive products that support people in their everyday and working lives" (Preece, Rogers, and Sharp 2002, 6). On the other hand, Moggridge and Atkinson (2007) provide a narrow definition of Interaction Design, which is interpreted as "the design of the subjective and qualitative aspects of everything that is both digital and interactive, creating designs that are useful, desirable and accessible" (Moggridge and Atkinson 2007, 659), as well as a broader definition, which is "the design of everything that is both digital and interactive" (Moggridge and Atkinson 2007, 660).

Interaction Design can also be described as the design of product and system behavior (Cooper et al. 2014). Victor Papanek characterizes Design as the "conscious and intuitive purpose to impose meaningful order" (Cooper et al. 2014, 3) and Interaction Design aims to avoid the consequences of poor product behavior. Cooper and his colleagues (2014) describe that the user's needs and desires are often ignored in digital products and products that lack appropriate design blame the users for making mistakes, assume that the users are technological literate, make the navigation and comprehension of the system difficult for unnecessary reasons and most importantly, require humans to do the heavy lifting. In order to avoid these consequences, one of the central concerns of Interaction Design is to develop usable interactive products that provide a good user experience through effectiveness and ease of learning (Preece, Rogers, and Sharp 2002). Digital Products tend to fail due to four particular reasons, which are misplaced properties on product management and development teams, ignorance about the real users, conflicts of interest and the lack of a design process (Cooper et al. 2014).

Relationship between Human-Computer Interaction and Interaction Design

As previously mentioned, Human-Computer Interaction focuses on identifying and understanding usability problems in task-oriented computer systems, while the field of Interaction Design is responsible for shaping interactive systems with particular emphasis on their use qualities (Lowgren 2001). Interaction Design emerged due to the increasing importance of designing spaces for human communication and interaction focused on people, rather than machinery (Winograd, 1997 cited in Lowgren 2001). In other words, interaction design is more concerned with the users and their interactive behaviors. Lowgren (2001) states the traditional quality criterion for Human-Computer Interaction has been the usability aspects, such as task efficiency and the absence of usability issues, and since usability is strongly associated with

user interface, Human- Computer Interaction is concerned with mediating the transactions occurring between the user and the system. On the other hand, Interaction Design focuses on use qualities, which comprise the whole system and the whole use situation (Lowgren 2001). Therefore, Interaction Design entails structural, functional, emotional, aesthetically and ethical aspects of the use context and these particular aspects cannot be simplified in a general way (Lowgren 2001).

2.1.2. The Mobile Environment

Mobile devices are optimal for the purposes of this dissertation due to being personal and portable devices. The definition of mobile varies according to perspective, but from a fundamental perspective, the notion of mobile does not refer to the application or the device, but rather to the user (Ballard 2007). Mobile devices can range from personal data assistants, game players, book readers and so forth, but the epitome of this category are mobile phones (Ballard 2007). Hoober and Berkman (2011) note that the evolution of mobile devices can be divided in four eras: voice, paging and text, pervasive network connectivity and general computing devices. Current mobile devices are small, portable, wireless connected, interactive and contextually aware (Hoober and Berkman 2011).

Mobile Devices

Brian Fling (2009) separates the history of mobile devices into five eras: the Brick Era, the Candy Bar Era, the Feature Phone Era, the Smartphone Era and the Touch Era. Fling (2009) notes “the devices of tomorrow will be able to leverage location, movement, and the collective knowledge of mankind, to provide people’s lives with greater meaning” (Fling 2009, 12), which is something occurring in modern times.

In *Mobile First*, Luke Wroblewski (2012) notes that products and systems must be designed primarily for mobile devices. Mobile devices are varied in quantity, but smartphones are the focus of this dissertation due to their explosive growth in recent years. Smartphones present a fast adoption rate and the devices have become more and more affordable over time (Wroblewski 2012).

A significant difference between desktop and mobile interfaces is the interaction methods. Dan Saffer (2008) states the era of interactive gestures began recently and the majority of gestural interfaces can be categorized as touchscreen or free form. Mobile interfaces are touch oriented and therefore, mobile devices present several particularities. Touchscreen gestural interfaces require the direct touch of the user with the device. Consequently, smartphones revolve around direct manipulation. The term *direct manipulation* was coined by Ben Shneiderman in 1983, and describes the “ability to manipulate digital objects in a screen without the use of command-line commands” (2008, 24). The use of gestural interfaces is advantageous due to being less cumbersome, more flexible, increases practicality in certain environments, as well as providing natural interactions with digital objects in a physical form (Saffer 2008). Nonetheless, gestural interfaces display some negative aspects compared to other interfaces. For instance, the users of mobile devices are more prone to mistakes due to human constraints. Josh Clark (2010) indicates the human finger is unreliable when it comes to precision on touchscreen interactions. Moreover, if users are distracted or in a rush, they tend to miss buttons, tap the wrong targets or even tap a bottom icon when they intend to scroll the screen. Therefore, interfaces for mobile devices have to be simple, easy and effortless (Clark 2010).

Mobile Human-Computer Interaction

Human-Computer Interaction aimed for mobile devices presents several distinct factors that must be taken into account by practitioners and researchers. Mobile devices are an intrinsic aspect of modern society and as a consequence, designing for mobile devices poses multiple challenges from an interaction point of view, namely in user interface design (Huang 2009). Human-Computer Interaction is about creating easy and efficient interactions between the users and the system, but current mobile devices share a common problem: mobile devices attempt to provide access to powerful computing resources and services for users through the use of small interfaces (Dunlop and Brewster 2002). These interfaces have several limitations, including small visual displays, poor audio interaction facilities and limited input techniques (Dunlop and Brewster 2002). The need to operate with limited battery charge and the necessity to design considering position awareness and context sensitivity along with the concern of design for intermittent and expensive network access form several apprehensions unique to mobile Human-Computer Interaction (Huang 2009, Dunlop and Brewster 2002).

In *Essential Mobile Interaction Design: Perfecting Interface Design in Mobile Apps*, Cameron Banga and Josh Weinhold (2014) highlight certain interactions that are possible with a smartphone. They note that prior to the release of the iPhone, mobile phones were seen as second-class computing systems. The conceptual development of these interactions was not an easy task as a result of mobile constraints. Nonetheless, mobile devices today present improved hardware components and cloud-hosting solutions solved the storage limitations associated with mobile devices (Banga and Weinhold 2014). They explain a couple of interaction processes that are associated to smartphones, namely location identification with Global Positioning System receivers and cell-tower triangulation, and the use of a phone's gyroscope to "determine the device's orientation or create augmented reality applications using a device's magnetic compass" (Banga and Weinhold 2014, 43). These interactions correlate with the idea that mobile interaction design should always minimize the users' workload required to interact with the system. Furthermore, new technologies such as near-field communication and infrared sensors are developing new interaction methods for mobile devices.

Mark Dunlop and Stephen Brewster (2002) note the presence of five main challenges regarding Human-Computer Interaction for mobile devices. Designing for mobility is a particular issue for mobile devices, not only due to the constant movement of the users when interacting with the devices, but also the need to work in smaller devices (Dunlop and Brewster 2002). Huang (2009) states that portability and ergonomic factors are major challenges when designing for mobility along with power facility in a mobile device. The need to develop interactions for a widespread population including users with no formal training is another challenge evidenced in mobile Human-Computer Interaction (Dunlop and Brewster 2002).

The small screen size of mobile devices due to portability reasons, the poor sound output quality along with restricted voice recognition and the keyboard's size limitation are examples of the limited input and output facilities in mobile devices (Dunlop and Brewster 2002). Huang (2009) supports the authors by displaying other input and output limitations. He discusses the three main input facilities in the market, which are the keyboard, the stylus with touch screen and the scroll wheel. The keyboard is responsible for allowing the user to perform a task or navigate through the menu functionalities and the challenge with this input facility derives from the space limitation for key installation (Huang 2009). The stylus and touch screen present the user with the option of hit the screen to perform a task but the small screen size displays problems with touch input (Huang 2009). On the other hand, the scroll wheel can be used for menu navigation as well as scrolled and pushed for task performance (Huang 2009). In modern

times, the dominant form of input is the touch screen. With regards to the output facilities, Huang (2009) affirms the small screen size is the main output facility and the audio output facility is often used in multimodal interfaces due to its capability to deliver information to the user.

The awareness of the surrounding environment by mobile devices through the use of sensors and networks present challenges from a context information point of view (Dunlop and Brewster 2002). The authors also discuss the concern of designing for users multitasking. Multitasking and support for task interruption between desktop design and mobile design is substantially different due to the number of opportunities and the frequency of interruptions given the different environments (Dunlop and Brewster 2002).

Besides discussing hardware challenges in mobile interaction, Kuo-Ying Huang (2009) presents software challenges evidenced in mobile devices. The implementation of hierarchical menus, navigation and browsing characteristics and the use of images and icons are the software challenges that the author discusses (Huang 2009). Hierarchical menus are relevant because it allows users to select a menu item in a structured manner with the objective to fulfill the user's desire (Huang 2009). Navigation and browsing characteristics attempt to ease information organization in an effective form but the small screen size of mobile devices presents a challenge (Huang 2009). Lastly, images and icons are important types of data and information visualization in desktop com¬puters (Huang 2009). Mobile devices present several restrictions regarding the use of images and icons due to size and application purposes (Huang 2009).

Mobile Design Principles

The design of systems and products for mobile phones is a complex and detailed task and as a consequence, the experience and conclusions of other researchers and practitioners resulted in the creation of principles of Mobile Design, that are subjective, temporary and constantly changing over time. Hoober and Berkman (2011) mention certain Mobile Design principles, which are the following:

Respect user-entered data

When possible, data should always be preserved. Planning for crisis and real-world behaviors, as well as contexts must be considered.

Realize that mobiles are personal

Mobile devices are assumed as belonging to only one individual. The prevention of misuse of information can be executed through reasonable and transparent precautions. Even though Hoober and Berkman (2011) claim that mobile devices are personal, this principle cannot be taken into consideration in the Sub-Saharan region and other developing regions because mobile devices tend to be shared by several people in these geographical areas.

Ensure that lives take precedence

The contextualization of mobile devices has to be respected and the devices are used to enhance people's lives, rather than consuming it.

Realize that mobiles must work in all contexts

Designers must properly think about the context in which the devices will be used on.

Use your sensors and use your smarts

Implement actions for the user based on sensors and user data whenever it is possible.

Realize that the user usually takes precedence

The user should never be interrupted once a task is initiated and when an operation is can¬celled, the user must never be guided to another page because all the information will be lost.

Ensure consistency

The users have expectations about the system and therefore, to ensure consistency, avoid changing the paradigm.8

Respect information

Presentation and visualization are essential for design and can be used to clarify information, but information must never be omitted just to save space.

Other mobile design principles are existent. For instance, Ballard (2007) discusses the correlation between the carry principle and mobile devices. The carry principle refers to the user carrying the device all the time and implications regarding form, features, capabilities, user interface and proliferation are seen in the device (Ballard 2007). On the other hand, the carry principle also has an effect on the users and they present limitation in user availability, sustained focus and social behavior (Ballard 2007).

2.1.3. Understanding the user

Human-Computer Interaction and Interaction Design are concerned with the constant interactions occurring between the human user and the computer system, but understanding users is a complicated and intricate task. Human users differ according to their cultural values and therefore, a substantial understanding of the user and the appropriate communication channel must be carefully selected as a form to increase the usability and experience of the user with the product.

Conceptual models

Prior to mentioning the fundamental value that conceptual models have in user interface design, the notions of implementation models and represented models must be identified as a form to understand the different models present in the development of interactive products. Implementation models, or system models, refer to the representation of how a system functions and describe the details pertaining to the way how it is implemented in code (Cooper et al. 2014). Represented models, or the designer's models, refer to the existent disconnection between what is implemented and what is provided as an explanation (Cooper et al. 2014). The authors state, "the closer the represented model comes to the user's mental model, the easier he will find the application to use and understand" (Cooper et al. 2014, 18). The opposite is not beneficial to the user because the closer the represented model is to the implementation model, the harder it is for the user to understand and use the application (Cooper et al. 2014). From a design and developmental point of view, the represented model is the appropriate representation that professionals must implement but when working with interaction behaviors, the users are the priority and as a consequence, the role of conceptual models must be discussed.

Conceptual models are fundamental to assist the users in guiding their actions and interpret the system's behavior (Staggers and Norcio 1993). Conceptual Models, sometimes referred to as mental models, are broadly defined as "high-level descriptions of how a system is organized and operates" (Johnson and Henderson 2002, 26). In a more specific manner, conceptual models are described as a "description of the proposed system in terms of a set of integrated ideas and

concepts about what it should do, behave and look like, that will be understandable by the users in the manner intended" (Preece, Rogers, and Sharp 2002, 40). According to Donald Norman (1999), the most important and difficult part of design is the formulation of appropriate conceptual models and the assurance that every other aspect is consistent with it.

There are substantial differences between the conceptual model of a user and the implementation model (Cooper et al. 2014). Implementation models reflect technological values and the model represents the method in which software operates (Cooper et al. 2014). On the other hand, mental models reflect the perspective of the user (Cooper et al. 2014). Mental models are concerned with the form how users perceive the tasks they need to perform and how computers might operate (Cooper et al. 2014).

Staggers and Norcio (1993) affirm that no individual knows exactly how mental models are created and one existing notion is the idea that analogies or metaphors act as instruments of thoughts that assist in the structure of unfamiliar domains. Conceptual models have the objective to specify and describe metaphors, analogies, concepts exposed to the user, relationships between concepts and mappings between concepts (Johnson and Henderson 2002). Jeff Johnson and Austin Henderson (2002) claim that a conceptual model must be simple and focused on the tasks. The less is more philosophy is prevalent in conceptual models and the model must be as direct as possible.

Preece, Rogers and Sharp (2002) affirm the development of a conceptual model involves the vision of the product, based on the established requirements and the needs of the user. The same authors state the existence of different conceptual models and these can be categorized as conceptual models based on activities and conceptual models based on objects (Preece, Rogers, and Sharp 2002). Conceptual models based on activities are often not mutually exclusive and the most common types are instructing, conversing, manipulating and navigation, and exploring and browsing. Conceptual models based on objects tend to be more specific than the previous ones and these are focused on a particular object with the intent of being used in a specific context (Preece, Rogers, and Sharp 2002). Analogies based on aspects pertaining to the physical world are often applied (Preece, Rogers, and Sharp 2002).

Conceptual models are necessary tools to assist the user in interaction behaviors but several problems and consequences are detected. Staggers and Norcio (1993) explain that mental models are simple, inaccurate and incomplete and people present several limitations regarding the ability to 'run' their conceptual models. The authors also state that conceptual models do not present specific boundaries, are unstable due to individuals constantly forgetting the details of the system, unscientific and parsimonious (Staggers and Norcio 1993).

Additionally, Johnson and Henderson (2002) mention a couple of issues with the correct representation and definition of conceptual models. There is a misconception that the conceptual model of an interactive system is the user interface. The purpose of the conceptual model is to describe what individuals can do with the system and what concepts they should understand in order to use the system in question (Johnson and Henderson 2002) and as the authors state, "it refers only to task-domain objects, attributes and actions" (Johnson and Henderson 2002, 28). Other incorrect argument is the idea that a conceptual model is the mental model of the user. The proper definition and boundaries of conceptual models are an important problem that must be properly investigated. From an objective perspective, the mental model of the user is not accessible to the designers and professionals should not waste time attempting to determine the users' mental models (Johnson and Henderson 2002). The last misrepresentation about conceptual models provided by Johnson and Henderson (2002) is the fact that conceptual models are not implementation architecture.

Metaphors

Other method to ease user understanding and enhance the familiarity with the system comes from interface metaphors. Metaphors are fundamental in conceptual design and depend on real world connections users establish between the visual cues in and interface and its function (Cooper et al. 2014). Metaphors support the understanding of one concept in terms of another as a method to enrich the mental imagery of the user with meaningful attributes (Hey and Agogino 2007). One fundamental characteristic of metaphors is the fact that they are existent everywhere but they are difficult to notice. Metaphors are an integral part of language and thought, and as Thomas Erickson (1995) notes, "metaphors invisibly permeate our everyday speech, so do they occur throughout the interfaces we use and design" (Erickson 1995, 66). The objective of interface metaphors is to create instinctive and intuitive interfaces that accelerate the learning process of the user. Metaphors are culturally biased but if implemented correctly, they can be powerful tool for communication purposes (Shen, Woolley, and Prior 2006).

From an Interaction Design perspective, interface metaphors "can range from tiny icons on toolbar buttons to the entire screen of some applications" (Cooper et al. 2014, 301). Therefore, interface metaphors are visual elements used to represent functionalities according to the user's perspective. Metaphors are essential elements to deliver interfaces that are easy to learn and use. John Carroll, Robert Mack and Wendy Kellogg indicate that the utilization of metaphors seeks to increase the relationship and the familiarity of actions, procedures and concepts (Carroll, Mack, and Kellogg 1988). As Cooper and his colleagues (2014) note "metaphorical inter-faces are an efficient way to take advantage of the awesome power of the human mind to make inferences"(Cooper et al. 2014, 302).

Nonetheless, metaphors in user interface design present significant problems. Carroll, Mack and Kellogg (1988) advise towards the haphazard implementation of interface metaphors. Global metaphors present the most significant problem towards supporting the use of interface metaphors due to its relationship with artifacts from the Mechanical Age (Cooper et al. 2014). A global metaphor is a "single, overarching metaphor that provides a framework for all the other metaphors in the system" (Cooper et al. 2014, 303) and the notion that lower-level metaphors present consist-ent cognitive benefits is erroneous (Cooper et al. 2014). Other substantial limitation is the fact that metaphors are quite difficult, and often impossible, to create when it comes to processes, relationships, services and transformations (Cooper et al. 2014). Scalability is another problem with the use of metaphors (Cooper et al. 2014). Additionally, metaphors present two severe limitations. The first consists in the notion that metaphors are helpful for first-time users but they do not benefit intermediate users (Cooper et al. 2014). The second limitation is the fact that metaphors rely on associations perceived by the designer and the user and cultural differences have a significant role in this process. Cultural misunderstandings result in failed metaphors (Cooper et al. 2014). To conclude, metaphors are helpful to assist first time users and may be utilized for physical objects, but their extensive use is not indicated. Cooper and his colleagues (2014) affirm that an interface must never be bended in order to fit a metaphor.

Idioms

Unlike metaphors, idioms do not rely on associative connections (Cooper et al. 2014). In Designing Interfaces, Tidwell defines interface idioms as " recognizable types or styles of interfaces, each with its own vocabulary of objects, actions and visuals" (2010, xvi). Idiomatic design is based on "how we learn and use idioms"(Cooper et al. 2014, 308) such as figures of speech. Idiomatic interfaces are fundamental due to focusing on the learning of behavioral idioms and simple, non-metaphorical visual idioms as a form to accomplish the user's goals (Cooper et al. 2014). Graphical

user interfaces are composed by several visual idioms, which are easy to learn. Idioms consist in the combination and structure of compounds through the use of domain knowledge towards the problems and good idioms must only need to be learned once (Cooper et al. 2014).

Affordances, constraints and conventions

Donald Norman (2002) defines affordances as "the perceived and actual properties of the thing, primarily those fundamental properties that determine just how the thing could possibly be used" (Norman 2002, 9). The term was previously coined by J.J. Gibson to describe actionable properties between the world and the actor, and to Gibson, affordances were visible, known or desirable relationships (Norman 1999). Affordances are essential for Design due to its focus on material features relevant for behavior (Gaver 1996). Norman (1999) explains the differences between physical affordances and perceived affordances. In graphical interfaces, the physical affordances should not be a concern and the perceived affordances must be the primary point of attention due to being the only type of affordances that the designer can control (Norman 1999). Affordances are often misinterpreted and misused. Norman (1999) notes that designers often believe they added affordance to the system when the truth is that they only provided visual feedback that advertises affordances.

Constraints and conventions also need to be mentioned in order to obtain a coherent user understanding. Donald Norman (1999) identifies three kinds of behavioral constraints, namely physical, logical and cultural. Physical constraints are related to real affordances and the epitome of physical constraints is the impossibility to move the cursor outside the screen (Norman 1999). Logical constraints are characterized by the use of reasoning to determine alternatives and they are valuable when guiding behavior (Norman 1999). An example of logical constraints is when the users know when they have finished a task (Norman 1999). Cultural constraints are conventions evidenced by a particular cultural group (Norman 1999). For instance, turning screws clockwise to tighten and counterclockwise to loosen is a cultural constraint (Norman 2002). Donald Norman (1999) affirms that logical and cultural constraints are powerful tools that designer must utilize. Conventions are constraints that prohibit certain activities and encourage others, and they are im-portant tools for designers (Norman 1999). Conventions are not arbitrary, require practice, present a slow rate of adoption, take a long time to disappear and are constantly evolving (Norman 1999). Norman (2002) notes that many cultural constraints rely on cultural conventions. To finalize, affordances and perceived affordances are two different things and affordances should not be confused with conventions (Norman 1999).

2.1.4. Usability and User Experience

Designing interactions between user's and a system is a complex task. Besides creating interactive systems that support the user's needs and understand the way users interact with the products, designers also need to think about effectiveness and ease of use. As a consequence, usability and user experience goals must be reflected upon and properly determined. Usability and user experience are correlated despite presenting differences in the method through which they are operationalized. Usability goals consider specific usability criteria, such as efficiency, and user experience goals are worried with the quality of the user experience, including the aesthetic way of a product (Preece, Rogers, and Sharp 2002).

Usability

The most appropriate definition regarding usability comes from the International Organization for Standardization (ISO). ISO 9241-11 (Guidance on Usability) defines usability as the "the extent to which a product can be used by specific users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use" (Jokela et al. 2003). Effectiveness refers to the "accuracy and completeness with which specific users achieve specified goals in particular environments" (Dix et al. 2004, 277), efficiency is defined as "the resources expended in relation to the accuracy and completeness of goals achieved" (Dix et al. 2004, 277). At last, satisfaction is described as "the comfort and acceptability of the work system to its user and other people affected by its use" (Dix et al. 2004, 277). At the same time, Jokela and his colleagues state that the definition provided by Nielsen is the best-known definition of usability (Jokela et al. 2003). Nielsen notes that usability is a quality attribute for assessing how easy user interfaces are for the users to use and the term is defined by five components: learnability, efficiency, memorability, errors and satisfaction (Nielsen 2012).

Usability presents several benefits for interactive systems and Nielsen even affirms that usability is a necessary condition for survival on the Web (Nielsen 2012). A system's usability can be improved through user testing and the most important usability problems can typically be detected when five users are tested (Nielsen 2012). User testing, or usability testing, is a collection of techniques aimed to measure characteristics of a user's interaction with a product (Cooper et al. 2014).

At the same time, usability is associated with particular misconceptions such as the expense of the process, the time it takes to perform user testing, the belief that creative processes are destroyed by usability and the egregious thought that customer feedback can replace user testing (Nielsen 2003). Jakob Nielsen (2003) disproves these misconceptions. Nielsen claims that usability projects can be cheap and, on average, 10% of the design budget must be used on usability (Nielsen 2003). Regarding the time usability involves, Nielsen notes that several case studies prove that usability can be integrated with Agile[1] methodologies and user testing can resolve arguments pertaining to features that the users need (Nielsen 2003). The argument for Nielsen when people discuss that usability destroys the creative process consists in stating that design is problem solving under several constraints, and usability is just another constraint (Nielsen 2003). Additionally, customer feedback is not a great method to decide whether a user interface causes problems or not, because listening to customers employs the wrong method of data collection (Nielsen 2003).

Jakob Nielsen is responsible for popularizing heuristic evaluation for usability purposes in user interface design. Heuristics are broad rules of thumb and not usability guidelines (Nielsen 1995a). The usability specialist mentions ten principles for interaction design, whose purpose is to improve the usability of a particular system and they are the following (Nielsen 1995a):

Visibility of system status

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

1 Agile methodologies, such as XP and SCRUM, are development methodologies consisting in small teams de¬fining the requirements for the iteration, developing the code, defining and running integrated test scripts, and let the users verify the results. Agile development provides opportunities to assess the direction throughout the development lifecycle, through the use of regular cadences of work, known as sprints. From an agile point of view, every aspect of development is continuously revisited and re-evaluated.

Match between system and the real world

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

User control and freedom

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

Consistency and standards

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

Error prevention

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

Recognition rather than recall

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

Flexibility and efficiency of use

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

Aesthetic and minimalist design

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

Help users recognize, diagnose and recover from errors

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

Help and documentation

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

User experience

Jesse James Garrett describes user experience as "the experience the product creates for the people who use it in the real world" (Garrett 2010, 6). He notes that user experience design is concerned about the aspects of the system that directly face the user. User experience design deals with contextual questions and is dictated by the behavioral and psychological habits of the users (Garrett 2010). A positive user experience results in the users becoming more susceptible to use a product. The consideration of user experience is fundamental when designing for mobile

devices. Moreover, user experience has to consider the constraints of the mobile users, as well as the constraints of the mobile devices (Subramanya and Byung 2007).

In *Elements of User Experience*, Jesse James Garrett (2010) breaks user experience through five planes as a way to ensure that no aspect of the user's experience with the website occurs without a conscious and explicit intent. Even though Garrett implements the five planes with particular attention to websites, the planes are fundamental to explain how the interaction between the user and the system occur and which elements are involved in the interaction processes.

Garrett (2010) divides the user experience components into five planes: surface plane, skeleton plane, structure plane, scope plane and the strategy plane. The strategy plane is the most abstract plane and focuses on the product objectives and the needs of the user. This plane is responsible for determining how the site will be strategized. The scope plane is concerned about the functional specifications and the content requirements. In other words, the scope plane defines the most appropriate method to fit the various features and functions that form the product. The structure plane is influenced by Interaction Design and Information Architecture principles and it is responsible for arranging the navigational elements of the system. The skeleton plane is focused on the refinement of the structure and aspects derived from Interface Design, Navigation Design, and Information Design are identified. Lastly, the surface plane is the most concrete plane of the five and is influenced by sensory design. At last, the surface plane pays attention to content, functionality and aesthetic aspects that users will notice first in the system. It is important to mention that the lines between the planes are blurred and the planes must work together in order to accomplish a positive user experience (Garrett 2010).

Cooper and his colleagues (2014) state that digital products have to consider three levels of experience. The first level consists in the rapid and effortless transition from beginner to intermediate user. Beginners are sensitive and easily demoralized, but most importantly, designers must realize that no one wants to remain a beginner (Cooper et al. 2014). The authors support that products utilized in a transient or distracted manner, as well as systems focused on individuals with disabilities, must be optimized for beginners rather than intermediates (Cooper et al. 2014). Novice users need to rapidly grasp the concepts of the product or else they will abandon it and therefore, designers have to ensure that the products functions in harmony with the mental models of the user (Cooper et al. 2014). The second level of experience mentioned by the authors is the avoidance of obstacles relating to intermediate users that want to become experts. Experts are important members of the product and their influence is substantial for prospective customers. Experts are permanent learners of the product and they appreciate higher information density in comparison to the other users (Cooper et al. 2014). The last level of experience mentioned by the authors refers to the intermediate users, which makes the larger percentage of users but are typically ignored (Cooper et al. 2014). Perpetual intermediate users need fast access to common materials, know how to use reference materials, recognize the existence of advanced features and are eager to learn (Cooper et al. 2014).

2.1.5. Interaction Methodologies

There are several Human-Computer Interaction methodologies, but only a certain number pursue a user-centered philosophy, namely User-Centered Design and Culture-Centered Design. Since users are the core concern for designing effective interactive systems, user involvement needs to occur in the development process (Preece, Rogers, and Sharp 2002). Besides user involvement being a fundamental method to understand the user's needs and goals, it is also important for expectation management and ownership purposes (Preece, Rogers, and Sharp 2002). Expectation

management focuses on the certification that the users' views and expectations about the product are realistic (Preece, Rogers, and Sharp 2002). This process is important due to ensuring that the users do not encounter any surprises when the product is released and for the most part, it is preferable to exceed the users' expectations rather than disappointing them (Preece, Rogers, and Sharp 2002). The concept of ownership, which refers to the user involvement and the subsequent feeling that they have contributed to the development of a product, is also important for user involvement (Preece, Rogers, and Sharp 2002). The sense of ownership contributes for the users to become more receptive towards the product (Preece, Rogers, and Sharp 2002). Nonetheless, the degree of user involvement still remains a matter of debate due to studies indicating that a great amount of user involvement may lead to problems (Preece, Rogers, and Sharp 2002).

An overview of the most important methodologies and techniques regarding user-centered philosophy is depicted in page 44. Even though the methodologies and techniques do not belong to the same categories, these are important concepts to grasp.

Table 01. Interaction Methodologies and Techniques

User-Centered Design	Culture-Centered Design	Participant Observation	Ethnography	Participatory Design	Design Patterns
User Centered Design is a methodology concerned with user involvement but differs from Participatory Design in the degree of user involvement. Donald Norman (2002) describes **User-Centered design** as a "philosophy based on the needs and interests of the user, with an emphasis on making products us-able and understandable" (Norman 2002, 188). **User-centered Design** emphasizes the users and their goals as the driving forces for the development of the product (Preece, Rogers, and Sharp 2002). **User-Centered Design** involves the users since the initial stage of development and the identification of user requirements is a crucial phase (Costabile 2001). Early user involvement has the potential to prevent major mistakes and the user-centered design approach presents benefits related to user satisfaction and system functionality (Costabile 2001). This approach is concerned with the use of the natural properties of people and the world (Norman 2002). Costabile (2001) refers that **User-Centered Design** is composed by three basic principles, which are the following: (1) analyze users and task (2) design and implement the system iteratively through prototypes of increasing complexity (3) evaluate design choices and prototypes with users.	The perception and behavior of a user is influenced by previous social and cultural experiences and backgrounds and therefore, the value of culture is must be recognized in order to create successful user interfaces (Shen, Woolley, and Prior 2006). A better understanding of an individual sensorial perceptions and cultural values results in a new paradigm of quality where products make the user experience more meaningful and the true needs of the user are met (Li, Sun, and Zhang 2007). Cultural perspective is fundamental in order to create systems appropriate for a user. **Culture-Centered Design** is a culturally oriented system concentrated in the user and his/her specific cultural conditions (Shen, Woolley, and Prior 2006). The approach acknowledges the user's cultural context as a method to enhance comprehensibility and transparency of the interface (Shen, Woolley, and Prior 2006). The **Culture-Centered Design** approach aims to complement other design methodologies, rather than oppose or criticize them. Cultural appropriateness, relevance, semiotics, functionality and usability are aspects analyzed through iterations in the **Culture-Centered Design** approach (Shen, Woolley, and Prior 2006).	**Participant Observation** is a technique for naturalistic observation. Naturalistic observation comes from the fact that explaining a task is very difficult to explain to humans and consequently, observation of users in their environment performing tasks may ease the comprehension of certain user behaviors (Preece, Rogers, and Sharp 2002). **Participant Observation** is characterized as the process whereby evaluators observe users *in loco* as a way to learn about what they do, how they do it and why they do it (Preece, Rogers, and Sharp 2002). Participant observers must be integrated in the group and participate in the group's social conventions including their beliefs, dress codes and use of languages (Preece, Rogers, and Sharp 2002). Fetterman states "participant observation combines participation in the lives of the people under study with the maintenance of a professional distance that allows adequate observation and record-ing of data" (Fetterman 1998 cited in Preece, Rogers, and Sharp 2002, 364).	**Ethnography** is technique derived from Anthropology with the objective to comprehend cultural phenomena in their natural environment. **Ethnography** became immersed in design due to the need to gain understanding about the everyday realities of people working within diverse settings (Blomberg and Burrell 2009). The authors also note that the explosion of the Internet accelerated the adoption of information technologies and as a consequence, the cultural divergence between users has increased substantially (Blomberg and Burrell 2009). Christina Wasson (2000) notes that **ethnography** has been appealing to design because it provides a new dimension of the user. **Ethnography** in design is not particularly a technique for data collection but rather a way to document the experiences that users encounter (Preece, Rogers, and Sharp 2002). According to Bloomberg and Burrell (2007), **ethnography** occurs in a first-hand nature in natural settings and the approach must follow a holistic and descriptive essence. The **ethnography** approach is concerned with intricate details about people and how they interact within their environment. On the other hand, design is interested in rationalization and abstraction, and therefore, the goals of ethnogra-phy and design are very distinct (Preece, Rogers, and Sharp 2002).	**Participatory Design** was developed with the intent to allow users to become equal partners in the design team. The idea emerged in Scandinavia in the late 1960s and early 1970s. The concept of Participatory Design is important for Kensing and Blomberg (1998) because it "will help ensure a better fit between technology and the ways people (want to) perform their work " (Kensing and Blomberg 1998, 168). The politics of design, the nature of participation, and methods, tools and techniques for carrying out design projects are the main issues discussed in literature about **Participatory Design** (Kensing and Blomberg 1998). This methodology has several supporters but Cooper and his colleagues (2014) state that **Participatory Design** creates significant problems relating to the conceptualization of the design. In comparison to Participatory Design, the authors claim that the creation of personas allows "designers to separate critical behaviors and needs that are common across a broad set of users from the idiosyncratic behaviors that are particular to a given user" (Cooper et al. 2014, 94).	**Design Patterns** are proven solutions to particular problems and these are helpful to reduce time and effort regarding common problems and solutions in user interface design. Furthermore, design patterns improve the quality of design solutions, ease the communication between designers and developers and instruct designers (Cooper et al. 2014). Van Welie, Van Der Veer, and Eliëns (2001) state a pattern has to "capture proven design knowledge and is described in terms of a problem, context and solution" (Van Welie, Van Der Veer, and Eliëns 2001, 2). Jenifer Tidwell affirms patterns have the objective to make things more understandable and beautiful, as well as making tools more usable and useful (Tidwell 2010). The purpose of patterns is to describe the problem in a detailed manner, construe the rationale for the solution, determine how to apply the solution and identify certain trade-offs in applying the solution (Duyne, Landay, and Hong 2002). Patterns are prescriptive, constructive, and must consist of a proven solution approved by designers. Additionally, they are concrete and need to present validity across different platforms and systems.

2.1.6. Conclusion

A basis about interaction principles, methods and processes is essential for creating products that enhance the communication and understanding between the user and the computer system. A strong grasp about the interactions fields of study and the mobile environment is beneficial in order to properly understand the interaction processes, methods and principles available. In addition, understanding the user through conceptual models, metaphors, idioms, affordances, constraints and conventions is a necessity in order to deliver solutions easy to interact.

Usability and User Experience also have a significant role in the adoption of devices and once the interaction problems are properly resolved, the usability and user experience associated with the product or system will improve substantially. Finally, researchers must determine which interaction methodologies are appropriate to certain environments. For instance, the implementation of design patterns allows designers to solve problems in an easy and structured manner, but design patterns do not give enough attention to the user's values, ideals and thoughts. On the other hand, the utilization of a user-centered approach is indicated due to giving the proper importance to the user. The users' knowledge is often unknown by designers and themselves and therefore, their participation in the design process is necessary.

2.2. Visual Perception and User Interface Design

2.2.1. User Interface Design

Designing good and usable interfaces is not an easy task and the users' expectations and needs are increasingly more demanding. As a result, Galitz (2002) states the user interface is the most important part of a computer system due to being the interpretation of the system to most users, and the best interface is unnoticeable and permits the user to focus their attention into the information and tasks. User interface design is a subset of Human-Computer Interaction. Wilbert Galitz (2002) defines user interface as "the part of a computer and its software that people can see, hear, touch, talk to, or otherwise understand or direct" (Galitz 2002, 4). Therefore, an interface is composed by input and output components. The earlier is responsible for communicating the user's needs to the computer and the latter is accountable for conveying information to the user (Galitz 2002).

Graphical User Interfaces

The first person associated with the conceptualization of graphical user interfaces was Vannevar Bush. In 1945, Bush wrote an article describing *Memex*, a tool that combined technologies and whose goal was to store data in an accessible and linkable manner (Martinez 2011). Ivan Sutherland, the creator of Sketchpad, is another key individual associated with the evolution of graphical user interfaces. Sketchpad was a communication system between the user and the system that allowed the creation of line drawings with a light pen on a CRT screen (Martinez 2011). Another prominent figure regarding graphical user interfaces is Douglas Engelbart. During the 1950s, Engelbart explored the ways that a machine can enhance the "human's ability to exploit information and turn it into knowledge" (Martinez 2011, 120). Douglas Engelbart and his colleagues at the Augmentation Research Center at Stanford University are also responsible for developing and working on many Human-Computer Interaction ideas, including the mouse (Martinez 2011). The evolution of user interfaces eventually lead to the creation of the first graphical user interfaces in the 1970s at Xerox's Palo Alto Research Center. This graphical user interface was the Xerox Star, which proved to be a commercial failure (Martinez 2011).

Prior to the introduction of graphical user interfaces, command line interfaces were the prominent type of user interfaces. Command line interfaces are characterized by the presentation of a black screen and a prompt to the user (Martinez 2011). These interface type assumes the user understand the required language to communicate with the system in order to accomplish tasks (Martinez 2011). The epitome of a command line interface is the MS-DOS.

In graphical user interfaces, the user interacts with objects, which are visible to the user and are used to perform tasks denominated actions (Galitz 2002). Graphical user interfaces support the graphical capabilities of computers to provide an easier method of communication to the user through the use of windows, icons, menus, buttons, drop-down lists, dialog boxes and more. Furthermore, Wendy Martinez (2011) enumerates four principles for developing successful graphical user interfaces, and these are the following:

1. "Focus on the users and their tasks, not the technology" (Martinez 2011, 123);
2. "Consider function first, presentation later" (Martinez 2011, 123);
3. "Conform to the user's view of the task, and do not make it more complicated" (Martinez 2011, 124);
4. "Promote learning and deliver information, not just data" (Martinez 2011, 124).

Graphical user interfaces are responsible for revolutionizing the user interfaces of technological systems. The ability to replace text with icons that represent objects and actions, as well as the capacity to manipulate the appearance or disappearance of information are some of the revolutions caused by the implementation of graphical elements (Galitz 2002). Most importantly, Galitz (2002) states the graphical presentation of information is responsible for providing better information processing capabilities compared to other presentation methods due to the ability to reduce memory load, perceptual and mental information recoding and reorganization, and enabling faster information transfer between humans and computers.

Graphical user interfaces display distinctive features and Galitz (2002) enumerates them as the sophisticated visual presentation, pick-and-click interaction, a restricted set of interface options, visualization, object orientation, extensive use of an individual's recognition memory, and a concurrent performance of functions.

2.2.2. Designing for Illiterate Users

Due to social and cultural characteristics, including the prominence of oral-based cultures and high illiteracy rates in remote areas of developing countries, the interfaces developed for these regions also need to consider literacy issues. Literacy remains a problem in developing nations and interface design needs to discover feasible solutions to ease the usability of these users. Literacy is also a problem because the users can range from a spectrum between literate and illiterate. Researchers and practitioners have been studying solutions to ease the usability and improve the experience of these inexperienced users. A detailed overview of this research is displayed in Appendix B.

In order to develop and design interfaces aimed for low-literacy users, researchers and practitioners have explored the concept of multimodal interfaces. Multimodal interfaces rely on the use of several human communication channels for output and input purposes (Dix et al. 2004). Sharon Oviatt and Philip Cohen (2000) state that multimodal interfaces are preferable because this type of interface expands the accessibility for a greater range of users and usage contexts. Multimodal interfaces also improve the performance stability and robustness of recognition-based systems (Oviatt and Cohen 2000).

The emergence of mobile devices in rural areas and developing regions has served as a tool to mediate and study the correlation of literacy with user interface design. Compared to the computer, the non-traditional users demonstrate a greater level of acceptance to mobile devices as an ICT option and the utilization of mobile devices might be the instrument to bridge the digital divide between users (Lalji and Good 2008). Consequently, Lalji and Good (2008) note that mobile communication have been found to contribute significantly to the improvement of quality of life and enhanced income in these regions.

Zereh Lalji and Judith Good (2008) state that user interface design necessitates to give attention to a number of considerations such as characteristics of the user population, context, purpose, conditions under which the technology will be used, product expectations and the nature of its influence on the user population. Illiterate populations in developing nations have different life experiences, expectations, difficulties, needs and coping mechanisms in comparison to the elites in the same area and therefore, illiteracy and its consequences need to be properly analyzed (Lalji and Good 2008). The replication of western interfaces and its elements, such as symbols and features, without a proper and structured analysis could result in useless and unusable interfaces

in developing regions (Lalji and Good 2008).

Illiterate and Semi-literate Users

Literacy has an intrinsic relationship with interface design. Literacy is the ability to understand and employ printed information in daily activities in order to achieve one's goals and to develop one's knowledge and potential (Darcovich 2000). The Organisation for Economic Co-Operation and Development (OECD) identifies three domains of literacy skills: prose literacy, document literacy and quantitative literacy. Prose literacy corresponds to the knowledge and skills needed to comprehend information in texts such as editorials and instructions manuals (Darcovich 2000). Document literacy is the knowledge and skills required to find and use information displayed in several formats such as job applications, payroll forms and maps (Darcovich 2000). Quantitative literacy is the knowledge and skills used in arithmetic operations to numbers embedded in printed materials such as balancing a chequebook (Darcovich 2000).

Illiteracy is antagonistic to literacy and is characterized as the inability to read and write. While the number of illiterate individuals has dropped in the past decade, the UNESCO Institute for Statistics states that 781 million adults lack basic reading and writing skills. It is also important to note that 64% of these illiterate adults are women. The youth illiterate population is also a concern and 126 million young individuals are not able to read or write. The female share pertaining to the youth illiterate population is 61.9%. Illiteracy is a problem in the field of Human Computer Interaction, particularly when an interface is targeted for developing regions. The ICT adoption and inte¬gration in developing countries is greatly influenced by illiteracy as well. According to the UNESCO Institute for Statistics, the lowest literacy rates are in Sub-Saharan Africa, South Asia and West Asia. Nonetheless, the institute warns about the masking of disparities at a country level by providing the example between Niger, which presents a 15% literacy rate, and Equatorial Guinea, which displays a literacy rate of 95%. The institute of statistics also states that 24% of the global illiterate population lives in sub-Saharan Africa and by 2015, two thirds of adults and three-quarters of young individuals are expected to be able to read and write.

Technological Literacy is another concern in developing countries due to the adoption and implement of ICTs. The International Technology Education Association (ITEA) defines technological literacy as the ability to use, manage, assess and understand technology (International Technology Education Association & Technology for All Americans Project, 2000). The authors state that a technologically literate person understands what technology is, how it is created, how it shapes society and how it is shaped by society (International Technology Education Association & Technology for All Americans Project, 2000).

The technological differences between developing and developed regions are evident and these differences must be properly implemented depending on the environment, functional literacy and technological literacy. Designing interfaces aimed for developing countries can be a complex task and as a consequence, the deployment of interfaces has not proven successful in developing regions because of the mismatch between the technology and the environment it is located (Sherwani, Ali, et al. 2007). A large number of interfaces are created in developed regions with the mission of being used in developing regions. On that account, the realities between environments differ from region and differences in cost, power and usage are evident (Gavaza 2012). Takayedzwa Gavaza (2012) notes that ICT initiatives use Graphical User Interfaces as the primary interface and many of these interfaces were designed for literate users that are technologically proficient and speakers of a language with a written form. This is not the case in developing regions, where many users are not functionally literate and are speakers of a language without a written form (Gavaza 2012).

The number of illiterate users in developing regions is a concern in Human-Computer Interaction because Graphical User Interfaces are largely dependent on literacy since they contain textual components and the user is required to recognize applications and filenames. Despite the importance of textual components, illiterate users simply visualize text in the User Interface as visual noise (Friscira, Knoche, and Huang 2012). Subsequently, Jan Chipchase (2005) recommends illiterates users should not be distinguished from the other users in order to avoid stigmatization. Alternatives to textual components have been suggested such as speech recognition and speech analysis, graphics and animation. Leah Findlater, Ravin Balakrishnan and Kentaro Toyama (2009) propose that the existence of a text-based interface with audio annotations is a viable solution for illiterate and semi-literate users.

User Interfaces for Semi-literate and Illiterate Users

A number of studies and research has been conducted with the objective to assist illiterate and semi-literate users through the use of different interfaces in order to access information on computers. Jan Chipchase (2005) notes there are many ways to learn how to use a device or complete a task. Chipchase (2005) affirms since mobile phone interface includes both numbers and letters, a degree of literacy is required in order to utilize many of the features of the phone.

Designing user interfaces for illiterate and semi-literate users focuses on broad elements, the use of graphical icons, minimal use of text, voice annotation, ease of navigation and use of numbers for illiterate individuals who can recognize numerals (Medhi, Prasad, and Toyama 2007). Designing user interfaces for illiterate and semi-literate users should be treated differently and interfaces with minimal or no text that use one or more graphical, audio and numerical components have proven to be helpful for users with low levels of literacy (Findlater, Balakrishnan, and Toyama 2009).

A significant number of user interfaces have emerged in order to assist illiterate and semi-literate users. Kodagoda and Wong (2008) explore the implementation of touch interfaces and discover relevant differences between high literacy users and low-literacy users. Gavaza (2012) affirms that touch interfaces can assist low literacy users because the ability to locate elements in a screen with a pointer has proven to be an intricate task for novice users and notes that pointing with a finger rather than a mouse is more intuitive for low-literacy users.

The design of user interfaces aimed at illiterate and semi-literate users needs a different approach compared to interfaces designed for literate and technological proficient individuals. Different types of representations can be utilized for representative purposes. Indrani Medhi, Archana Prasad and Kentaro Toyama (2007) examine which representation type is ideal for the illiterate audience to comprehend. The authors note the importance of culturally appropriate representations and the type of representation holds significant value. Illiterate users appear to prefer voice annotation because it helps in the speed of comprehension and bimodal audio and video representation appears to confuse this type of users (Medhi, Prasad, and Toyama 2007). Additionally, richer information is not related to a better understanding and the value of dynamic imagery compared to static imagery in user interface guided for illiterate user is influenced by various factors (Medhi, Prasad, and Toyama 2007). Toyama, Sagar, and Medhi (2009) also discuss the graphic representation of action activities such as wash, clean, cook and dry. For instance, the icon associated with cleaning a room can be represented with a dripping sponge (Toyama, Sagar, and Medhi 2009). Therefore, icons in interfaces needs to ease the interpretation of the illiterate user through the representation of an action that can be recognized by these users rather than a representation that the developers of the interface assume the illiterate users will understand.

A substantial number of alternatives aimed to assist illiterate users have been explored and conceived by researchers. An overview of the most important considerations researchers must have when designing for illiterate users is depicted in page 51. These considerations derive from several researchers and are comprised into six sections, namely textless interaction, voice feedback, integration of a consistent help feature, selection options, voice annotation and speech feedback, and integration of video with audio support.

Table 02. User Interfaces for Semi-literate and Illiterate Users

Textless Interaction	Voice Feedback	Integration of a consistent help feature	Selection Options	Voice Annotation and Speech Feedback	Integration of Video with Audio Support
Three implementations of text markers are mentioned: Introduce text on a gradual manner Present test once the user becomesfamiliarized with text Allow the user to decide the amount of text displayed (Toyama, Sagar, and Medhi 2009) Support the usage of numerals (Medhi, Sagar, and Toyama 2006).	When a user passes or hovers a cursor through a control, the associated voice speaks the name of the control along with a brief description or fuller description on how to use the control (Toyama, Sagar, and Medhi 2009). Prasad et al. (2008) also elaborate on the benefits of prerecording human speech segments as an interaction method with the user. Other alternatives proposed by Toyama, Sagar and Medhi subsist in playing other information about the system and/or control, or the information is related to the amount of time the cursor hovers over the control (Toyama, Sagar, and Medhi 2009).	Mehdi, Sagar and Toyama (2006) claim that the use of help features on all screens provides autonomy to the users. Prasad et al. (2008) state that easily accessible auditory assists the users. Implementation of on-screen character could help users associate audio to a visual representation (Prasad et al. 2008). Research indicates that help must be preferably provided at three levels, namely at application- level, screen-page level and control-level help features (Toyama, Sagar, and Medhi 2009). Toyama, Sagar, and Medhi (2009) also discuss the benefits of a help feature for novice users. The existence of an introductory video where human actors act the intent and use the application appears to lower the barrier of comfort and the understanding for novice users (Toyama, Sagar, and Medhi 2009).	Toyama, Sagar, and Medhi (2009) indicate an example consisting of an icon increasing in size when the user points or clicks over it. This change in size also suggests to the user that the icon is an interactive device and the user should pay attention to it (Toyama, Sagar, and Medhi 2009). Other example for selection options consists in a clickless mode of interaction where selectable graphical controls have the option of being selected once the user hovers over for a particular amount of time (Toyama, Sagar, and Medhi 2009). Another example provided by the authors consists in employing a voice associated to the control. The voice will inform the user that the control will be selected without further input from the user (Toyama, Sagar, and Medhi 2009).	Findlater, Balakrishnan, and Toyama (2009) indicate that audio support in textual interfaces assists the users on their reading skill acquisitions and over time, illiterate users start to associate audio with words. The constant daily exposure to text develops substantial incidental learning opportunities to the user (Findlater, Balakrishnan, and Toyama 2009) Plauché et al. (2006) note that speech-driven interfaces are the key for countries such as India, where the illiteracy rate is particularly high. More importantly, the authors state that traditional speech technologies developed for and by literate individuals in developed nations cannot be properly integrated in nations with low literacy rates (Plaucheé et al. 2006). Brewer et al. (2006) demonstrate that dialectical variation, multilingualism, cross-cultural barriers and a lack of linguistic resources have a negative impact in the success of interfaces. Brewer et al. (2006) affirm that traditional techniques of recruiting, recording and user testing need to be implement-ed in order to develop and design better interfaces for developing regions.	Prasad et al. (2008) discuss the implementation of video with audio support and the authors determine that despite the challenges illiterate users had using the system, the presence of an onscreen audio assistant aided the user and consequently, the existence of a human expert attendant is only necessary in the initial demonstration. Prasad et al. (2008) also explore the notion of asynchronous communication among illiterate users and discover if this type of communication is viable among these users.

Information Systems for Low-literacy Users

Over the past years, research with the objective of assisting illiterate users in developing regions has been prevalent and several information systems and services have been explored. This section aims to list and discuss some of the most prominent information systems.

An overview regarding information systems for literate users can be seen in pages 53 and 54. The figure points out the investigation and fieldwork performed by several researchers and separates the content into thirteen sections associated to a particular research paper.

Table 03. Information Systems for Low-literacy Users (1 of 2)

	Goetze and Strohotte (2001)	Deo et al. (2004)	Medhi, Pitti and Toyama (2005)	Medhi, Gautama and Toyama (2009)	Plauché and Prabaker (2006)	Plauché et al. (2006)
Premise of the Study	Marcel Goetze and Thomas Strothotte conducted one of the earliest studies with illiterate users.	Deo et al. (2004) studied the problems that illiteracy originates in accessing information.	Indrani Medhi, Bharati Pitti and Kentaro Toyama (2005) discuss the development and design of Kelesa Konnection, a text-free application that allows employers to look for domestic help, and domestic helpers look for employers. Computers pose an accessibility problem to illiterate users and the researchers conducted an ethnographic design approach in order to understand what the users desired (Medhi, Pitti, and Toyama 2005).	Medhi, Gautama, and Toyama (2009) investigate the usability of different payment services in several nations, namely India, Kenya, the Philippines and South Africa.		The Tamil Market study from Plauché and Prabaker (2006) was further investigated and Plauché et al. (2006) explored the gathering of linguistic resources needed to power a spoken dialog system.
Process	The researchers developed a set of principles aimed for building a web browser for illiterate people with the integration of interactive graphical reading aids (Goetze and Strothotte 2001).	The authors explore the development of a digital library interface suitable for illiterate users (Deo et al. 2004).	The researchers provide principles for text-free user interface that were achieved through ethnographic design and usability studies in Bangalore, India (Medhi, Pitti, and Toyama 2005).	The study explores the idea of delivering financial services to individuals living in remote areas via mobile phone (Medhi, Gautama, and Toyama 2009). As the authors state, the mobile phone market has penetrated into some of the world's most improvised areas and the study conducted by Medhi, Gautama and Toyama has prove to be important for the socio-economical development of these regions (Medhi, Gautama, and Toyama 2009).	The enhancement of interfaces with voice started to thrive and Madelaine Plauché and Madhu Prabaker (2006) began a pilot study for Tamil Market, a speech-driven agricultral query system for community centers in rural India.	This speech recognition study was conducted in Tamil Nadu, India and allows illiterate users to access information by voice.
Outcomes	The principles consist in targeting functionally illiterate users and the authors state that text has to explained rather than replaced (Goetze and Strothotte 2001).	Deo et al. (2004) affirm the feasibility in constructing a digital library aimed for illiterate users and they discover that the replacement of text with short audio clips can enhance the accessibility for illiterate users.	This research lead to other investigations regarding user interfaces for low-literacy users by the same researchers (Medhi, Prasad, and Toyama 2007, Medhi, Sagar, and Toyama 2006, Medhi, Gautama, and Toyama 2009).	The results of the study indicate that non-text designs are strongly preferred over text-based designs and the spoken-dialog system requires less assistance and speed to complete (Medhi, Gautama, and Toyama 2009).	Plauché and Prabaker (2006) state that speech-based user interfaces are cheaper than display-based user interfaces and more accessible than text-based user interfaces. The study demonstrated the potential of speech-based user interfaces in developing regions (Plauché and Prabaker 2006).	The importance of the study relates to addressing problems of multilingualism, literacy and linguistic variation in a single village (Plauché et al. 2006).

Table 04. Information Systems for Low-literacy Users (2 of 2)

Sherwani, Ali et al. (2007)	Sherwani, Yu et al. (2007)	Prasad et al. (2008)	Cuendet et al. (2013)	Bhamidipaty and Deepak (2007)	Friscira, Knoche and Huang (2012)	Dew et al. (2013)
While Plauché's research is focused on agricultural systems, **Sherwani, Ali, et al. (2007)** investigate the implementation of speech-based user interfaces in order to access to information pertaining to health.		**Prasad et al. (2008)** explore the sustainability of video mail conceived for illiterate users. The authors also investigated the capability that these users have regarding asynchronous communication.	**Cuendet et al. (2013)** also experimented with the accessibility of video content for low literate and novice users. The researchers present VideoKheti, a mobile agricultural system that uses speech, graphics and touch interaction for farmers in India **(Cuendet et al. 2013)**. The objective of the system is to locate and visualize agricultural videos on a mobile device through a multimodal interface **(Cuendet et al. 2013)**. According to the researchers, multimodal interfaces have shown to increase efficiency, as well as improve handling and reliability **(Cuendet et al. 2013)**.		**Elsa Friscira, Hendrik Knoche and Jeffrey Huang (2012)** state that a large number of illiterate people cannot access asynchronous communication through text messages.	**Dew et al. (2013)** claim mobile technology is a tool to overcome cost and infrastructure barriers to increase social and economical development. The researchers state that illiterate users discover workarounds for the default interface and core functions, including memorizing patterns, but the accessibility of mobile devices is obstructed by the heavy use of text **(Dew et al. 2013)**. As a consequence, **Dew et al. (2013)** discuss Karaoke, an assistive alternative interface for illiterate mobile device users and the objective of this interface is to helps users to learn to read rather than cope with illiteracy. The interface is aimed to accompany the user's written and technical literacy development through an approach consisting in the ease of access and the support of learning aspirations of the user.
The researchers explore the literacy level along with the reading and comprehension skills in Urdu of community health workers in Pakistan **(Sherwani, Ali, et al. 2007)**. The experiment determines the existence of a significant gap in the health knowledge of these workers and the HealthLine prototype aims to assist these workers **(Sherwani, Ali, et al. 2007)**. The research conducted by Jahanzeb Sherwani and other researchers was further investigated with community workers in Pakistan.	Sherwani was also involved in the development of VoicePedia, a dialog system that enabled voice-based access to unstructured information on websites **(Sherwani, Yu, et al. 2007)**.	The use of an audio assistant for the video mail system was developed but the users demonstrated difficulty in following multiple linear audio instructions and audio instructions that relied on color associations were misleading to the users **(Prasad et al. 2008)**. On the other hand, congratulatory messages in the auditory format appeared to produce encouragement and excitement **(Prasad et al. 2008)**.		The interest in the basic usage of a mobile phone has increased in developing countries and consequently, novice and semi-literate users present difficulties interacting with these devices. **Bhamidipaty and Deepak (2007)** explore the usability of an address book for these users along with the enhancement of a symbol-based design.	The researchers discuss EasyTexting, an application that allows illiterate users to receive audio text messages and compose text messages with the assistance of touch-initiated text-to-speech support **(Friscira, Knoche, and Huang 2012)**.	
Sherwani, Ali, et al. (2007) perform a series of experiments and establish that speech-interfaces outperform touch-tone interfaces, and literacy has a significant impact in the task success of the users.	The results from the study suggest that keyword entry is faster by speech but search navigation and page navigation were slower **(Sherwani, Yu, et al. 2007)**. Nevertheless, users involved in the study preferred the graphical user interface based on speech recognition and synthesis issues **(Sherwani, Yu, et al. 2007)**.	At last, the prototype exhibits that linear progressions are not conceptually understood by low-literacy users **(Prasad et al. 2008)**. Nonetheless, the results indicated that a personal asynchronous communication system aimed for illiterate users can be viable **(Prasad et al, 2008)**.	The results indicate that the educational level of the users has a significant impact in the system usability and consequently, low-literate users demonstrated more difficulty compared to the educated individuals **(Cuendet et al. 2013)**.	The study determined that accessing the address book is a difficult task for semi-literate users, and these users have a small set of contacts frequently used, while the rest of the contacts are rarely used **(Bhamidipaty and Deepak 2007)**.	The results determined that illiterate users struggled with managing their contacts and dealing with text messages **(Friscira, Knoche, and Huang 2012)**. To cope with text messages, the users often asked their relative to read the message or the user would call the sender of the message **(Friscira, Knoche, and Huang 2012)**.	This accessibility barrier presented with the heavy use of text can be replaced by multimedia content such as audio and visual media support **(Dew et al. 2013)**.

Conclusions

Users differ on a literacy level and the ICT adoption in developing regions needs to consider the spectrum that literacy ranges. In these regions in particular, the literacy rates and the digital divide present an incremental disparity and therefore, researchers and practitioners have dedicated a significant amount of time to the literacy issue.

Researchers and practitioners have investigated the correlation of literacy with interface design and multimodal interfaces appeared to be the most feasible type of interfaces for this context. The development of textless interaction interfaces and the integration of speech recognition, video, voice annotation are some of the methods utilized to ease accessibility to low-literacy users in developing regions. Multimodal interfaces are interfaces that assist the users in learning to use interactive systems and increase the technological literacy of these regions. The popularity of mobile devices in these areas is another important factor. Mobile devices are better accepted by the users compared to computer systems and consequently, recent studies have been focused in user interfaces for smartphones.

A significant number of systems have been developed to analyze the most successful method to increase technological literacy and diminish the accessibility barriers to low-literacy users. The development of prototypes and the subsequent user testing has generated some interesting results about low-literacy users, such as their difference in response due to psychological, cultural or religious aspects (Medhi, Sagar, and Toyama 2006). The importance of voice feedback and the consistent “help” feature have also demonstrated to be valuable elements to low-literacy users (Medhi, Sagar, and Toyama 2006). A large number of the systems were developed and designed for ICT purposes ranging from agricultural, financial and socio-economical development.

Despite the large amount of results and conclusions gathered from the studies, there is still a significant amount of information to learn about these users and their interaction behaviors. The importance of literacy in user interface design targeted for developing regions is still significant and the disparity between the type of users along with their associated behaviors and actions need to be further investigated.

2.2.3. The Role of Visual Perception in Icon Design

Perceptive, cognitive and psychological aspects pertaining to the user have a significant influence in icon design (McDougall and Curry 2004). Prior to discussing icon design, a few concepts have to be explained, namely visual perception, gestalt theory and semiotics. Perception is necessary in order to create icons that the users are able to understand, perceive and interpret their meaning. Gestalt theory is important due to the categorization of perceptual phenomena and semiotics is responsible for delivering appropriate visual imagery to the user.

Visual Perception

Perception is an important human characteristic on interface design and visual perception is key to icon design. Wilbert Galitz (2002) defines perception as “our awareness and understanding of the elements and objects of our environment through the physical sensation of our various senses, including sight, sound, smell and so forth” (Galitz 2002, 65). Perception is molded by experience and it is composed by certain perceptual characteristics, including: (1) proximity; (2) similarity; (3) pattern matching; (4) succinctness; (5) closure; (6) unity; (7) continuity; (8) balance;

(9) expectancies; (10) context; (11) and signals versus noise (Galitz 2002). The main goal in screen design consists in the use of our perceptual characteristics in order to make the screen of a system structured in obvious form.

The affordance theory from perception theorist J. J. Gibson is closely related to visual perception. J.J. Gibson argued that humans perceive in order to operate in a particular environment and therefore, perception is designed for action (Ware 2013). The direct and immediate perceivable possibilities for actions are denominated affordances (Ware 2013). Gibson's affordance theory encourages visual perception as the result of the resemblance regarding the decision making process.

In *Information Visualization*, Colin Ware proposes a model of human visual perception denominated the Model of Perpetual Processing. The model is composed by three stages. The first stage is characterized by Ware as the parallel processing to extract low-level properties of the visual scene. During the first stage, visual information is processed by neurons in the eye along with the primary visual cortex at the back of the brain (Ware 2013). Furthermore, Ware (2013) identifies five important characteristics of this stage, which are: (1) rapid parallel processing; (2) pattern extraction, namely as features, orientation, color, texture and movement; (3) transitory nature of information; (4) bottom-up, data-driven model of processing; (5) and basis for understanding the visual saliency of elements in displays.

The second stage, also called 2-1/2-D sketch or proto-object flux, is associated with pattern processing (Ware 2013). During this stage, rapid processes are responsible for dividing the visual field into regions and simple patterns. The findings of these patterns are extremely malleable and this stage is influenced by the amount of information gathered in stage one. Similar to the first stage, Colin Ware discusses the main characteristics of this particular stage, which are: (1) the presence of a slower serial processing; (2) a top-down attention; (3) a small number of patterns become constrained; (4) and different pathways regarding object recognition and visually guided hand motion are detected.

The third stage is about the visual working memory of the user. Sequences of visual queries are solved through visual search strategies as a way to utilize external visualization (Ware 2013). The objects previously processed are built from the "available patterns that may provide answers to the visual query and from information stored in long-term memory related to the task" (Ware 2013, 22). Furthermore, Colin Ware (2013) explains the role of attention in every single stage of the model of perpetual perception. Attention is described as "a multifaceted pervasive set of processes involving the entire visual system" (Ware 2013, 22).

Gestalt

Gestalt theory is an essential aspect of visual perception and it was the first serious attempt to understand pattern perception (Ware 2013). In 1912, a group of psychologists mainly consisting of Max Westheimer, Kurt Kofka and Wolfgang Kohler attempted to document a clear description of particular basic perceptual phenomena (Ware 2013). Consequently, a set of gestalt laws of pattern perception was developed and today, gestalt theory is one of the foundations for instructional screen design (Chang, Dooley, and Tuovinen 2002).

The Gestalt theory is built under the premise that knowledge and insight can be reused for problem solving (Dix et al. 2004). Dempsey Chang, Laurence Dooley and Juhani Tuovinen (2002) identify the eleven laws of gestalt theory for computer screen design, which are: (1) Law of Balance/ Symmetry; (2) Law of Continuation; (3) Law of Closure; (4) Law of Figure-ground; (5) Law of Focal Point; (6) Law of Isomorphic Correspondence; (7) Law of *Prägnanz* (Good Form); (8) Law of Prox-

imity; (9) Law of Similarity; (10) Law of Simplicity; (11) Law of Unity/Harmony. An example of each principle is given in Figures 02 to 12.

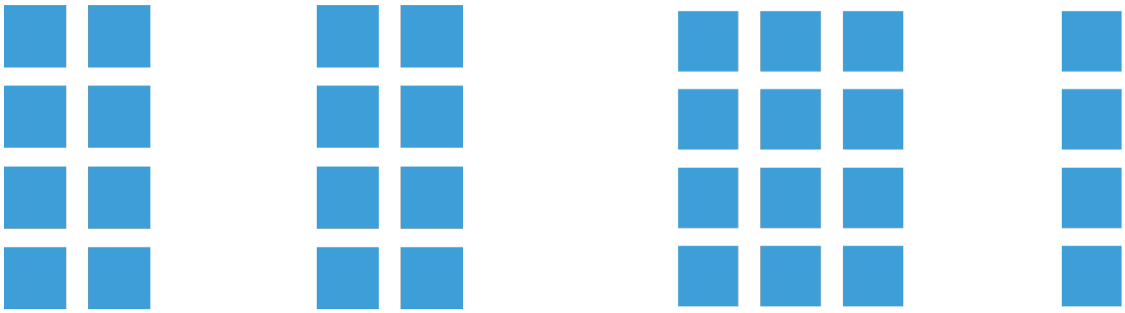


Figure 02. Law of Balance

Figure 03. Law of Continuation

Figure 04. Law of Closure

Figure 05. Law of Figure-ground

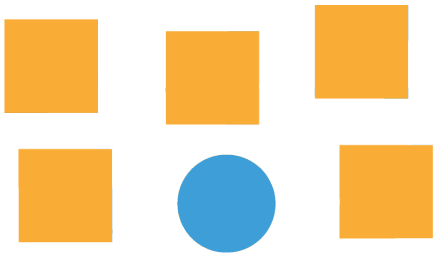


Figure 06. Law of Focal Point

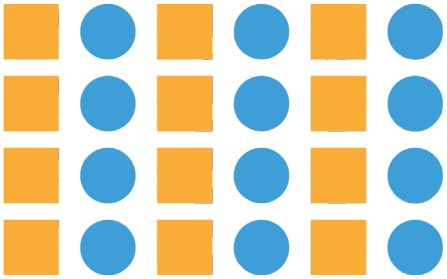


Figure 07. Law of Similarity

Figure 08. Law of Isomorphic Correspondence

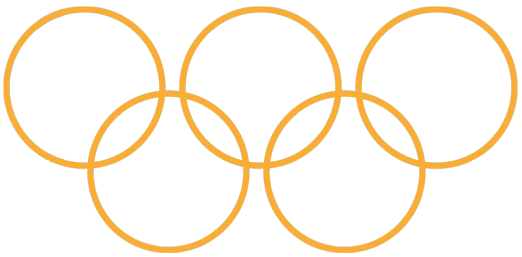


Figure 09. Law of Prägnanz

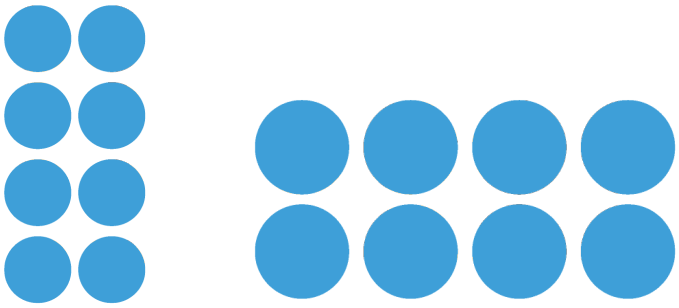


Figure 10. Law of Proximity

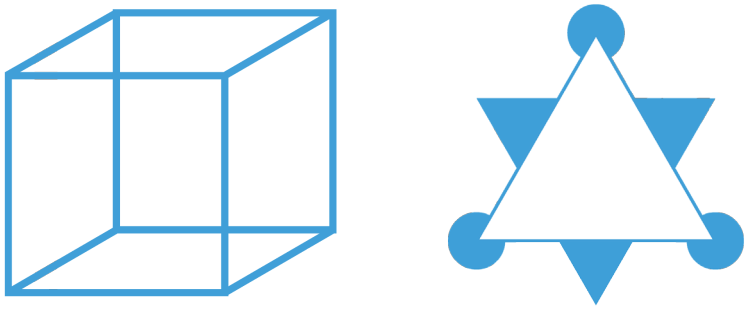


Figure 11. Law of Simplicity

Figure 12. Law of Unity/Harmony

Semiotics

Representation is the basis to all communication and in icon design, communication has an important role in conveying ideas in a form that users can properly interpret (Mullet and Sano 1995). A broad definition of semiotics is the study of symbols and how they convey meaning (Ware 2013). In *Designing Visual Interfaces*, Mihai Nadin defines semiotics as the "general theory and practice of signs (whose scope includes) everything that is interpreted by human beings as a sign, and defines the circumstances under which interpreting something as a sign allows for its better understanding, or for an improved use of it" (Mihai Nadin, 1989 cited in Mullet and Sano 1995, 171). Therefore, graphical user interfaces are sign systems, in which the interactions occur between the user and the computer system through the use of signs (Mullet and Sano 1995).

2.2.4. Icon Design

User interface design is composed by several aspects, namely menu design, icon design and screen layout. Consequently, designing user interfaces is a complex, detailed and intricate task, and due to time limitations, icon design is the primary concern of the study. Nonetheless, the design of a good icon takes a fair amount of time.

In *Human-Computer Interaction*, Alan Dix et al. describe icons as "small pictures used to represent a closed window". Furthermore, Aaron Marcus (2003) provides a much more intricate definition of icons. Icons are self-evident, "natural" or "realistic" signs for a particular group of interpreters. Icons differ from symbols and signs. Marcus notes signs are "perceivable (or conceivable) objects that convey 'meaning'"(Marcus 2003, 38) and symbols are "signs that are usually meaningful by convention and they are often abstract, like the letters of this sentence or a national flag" (Marcus 2003, 38).

Dix et al. (2004) indicate icons can range from realistic representations to being highly stylized or even arbitrary symbols. Arbitrary symbols tend to difficult the user interpretation (Dix et al. 2004). Colin Ware (2013) discusses the use and the differences between iconic images, words and abstract symbols. Ware (2013) advocates the best visual representation depends on a few factors, namely the purpose of the visualization, the number and density of the data points and the availability of "canonical images" (Ware 2013, 320).

Prior to the use of icons in computer systems, interfaces relied on text (Blattner, Sumikawa, and Greenberg 1989). The versatility of icons influenced their use in computer systems since the early 1970s. Icons rose to popularity in computer systems due to the Apple Macintosh and in the

1980s, icons became an essential part of the graphical user interfaces and associated with the desktop metaphor (Marcus 2003). Over time, several windowing environments adopted variations of icons (Marcus 2003).

Despite their prominence in graphical user interfaces, icons and their associated imagery remain the most obvious and least understood aspect of this type of interfaces (Mullet and Sano 1995). Preece, Rogers and Sharp (2002) indicate designers should always consider existing traditions or standards, and not contradict or oppose them. Additionally, Kevin Mullet and Darrell Sano (1995) state iconic representations are influenced by a number of principles, denominated immediacy, generality, cohesiveness, characterization and communicability. Immediacy relates to the effortless and involuntary perception of visual representations. Generality defines "the ability of the individual sign to represent these higher-level groupings" (Mullet and Sano 1995, 179). Cohesiveness refers to the degree to which the various icons fit together with a common style or theme.

Characterization is responsible to "calling to mind one or more essential characteristics of the sign object" (Mullet and Sano 1995, 185). At last, communicability is dependent on the context shared between the sender and the receiver of a representation. The communicability of a representation is affected by other images in the ensemble, along with the physical, conceptual and cultural environment in which the representation appears.

The use of icons is ideal when the product presents language, cultural and literate barriers. William Horton notes good icon design reduces translation, simplifies learning behaviors, improves intelligibility of text and provides products with an "international look". Icons function as representational tools to expose ideas in a graphical manner. Furthermore, Horton (1996) indicates icons have the ability to communicate complex meanings, but the viewer must be exposed to a collection of symbols. Each symbol provided by the designer must evoke the correct thought to the viewer in order to evoke the desired meaning (Horton 1996).

Perceptive and Cognitive issues have a significant impact on icon interpretation and their perceived meaning. Siné McDougall and Martin Curry (2004) denote icon interpretation does not occur in an isolated environment but rather in a complex context. The relationship between perception and interpretation is closer than researchers previously thought (McDougall and Curry 2004). The authors also discuss the role of cognitive icon characteristics such as concreteness, semantic distance, and familiarity and user experience. Concreteness refers to the degree a pictorial resemblance bears to its real world counterpart (McDougall and Curry 2004). Semantic distance is concerned with the "closeness between the icon and the function it is intended to represent" (McDougall and Curry 2004, 75). Familiarity and user experience pertains to the familiarity with the objects in the icon and the experience level the user has with an icon (McDougall and Curry 2004). Lastly, McDougall and Curry (2004) describe particular guidelines for design, which are the following:

1. The employment of visual metaphors based on real world experiences must be carefully planned;

2. The relationship of the icon and its function displays a greater impact on user performance that the pictorial content;

3. The cognitive characteristics responsible for determining icon usability change in terms of importance once the experience of the user grows;

4. A proper understanding of the skills needed for icon comprehension is important;

5. The user preferences and aesthetic values in icon design have to be considered.

Ravindran S. Goonetilleke and his colleagues (2001) state icons tend to be localized as a result of their geographical region and artistic nature, and they advise this localization might occur due to “a lack of governing principles for icon design” (Goonetilleke et al. 2001, 758). Nonetheless, cultural factors have a significant impact in icon design and subsequently, in user interface design. For instance, Kim and Lee (2005) provide evidence affirming that cultural differences are found in icon recognition according to the level of abstraction. Pappachan and Ziefle (2008) support the idea that culture is an influencing force in the comprehension of specific icons. The authors note icons are optimal for intercultural use and they can be considered language free.

Moreover, the use of icons provides many advantages to the users. William Horton (1996) enumerates certain advantages: (1) the visual and spatial representations of concepts; (2) the ability to save space on the screen; (3) the capacity to speed search is enabled; (4) immediate recognition; (5) provide better recall; (6) users do not have to read; (7) help in globalizing an interface; (8) and help the users work smarter. Despite the numerous advantages, the use of icons presents one major limitation, which is the fact that many objects and operations do not present a familiar or obvious representation in the pictorial form (Blattner, Sumikawa, and Greenberg 1989). Consequently, the design of a good icon is a difficult and intricate task.

In addition, Appendix C provides a brief overview regarding Icon Design studies, papers and articles.

2.2.5. Conclusion

User interface design is the form of communication between the user and system. Graphical user interfaces, one of the many types of interfaces, thrive on visual representations and it is used in mobile devices. When designing solutions for developing regions, researchers must consider the characteristics of the user in those regions and it is not uncommon to encounter substantial differences between users, including the prominence of oral-based cultures and high illiteracy rates. For instance, a significant number of researchers have studied the relationship between illiterate and semi-literate users with technological devices.

Since the diversity of the users is higher in developing regions, the role of visual perception is important and a strong grasp on this subject along with Gestalt theory and semiotics is necessary in order to deliver viable and understandable solutions to the users. In other words, an exhaustive analysis about visual perception is essential to deliver optimal icon design that eases the understanding of the user and their communication with the system. Icons are advantageous elements in graphical user interfaces for developing regions due to their conspicuous nature but also due to other reasons including the ability to save space on the screen and the capacity to speed search.

2.3. Cultural influence and Cultural Interpretation

Culture is an intrinsic element of human life and it is such a complex concept that cannot be simply described. Chen et al. (1999) note that all the knowledge an individual possesses is embedded within a historical, cultural and social framework. The diversity among individuals generates different views and assumptions, and as a consequence, culture holds important value in shaping an individual. It is assumed that societies do not possess culture but the truth is that societies are cultures (Chen et al. 1999). Hofstede (2010) reinforces this thought by claiming that particular assumptions underlie certain cultures. Therefore, the influence of culture and the different interpretations that these cultures present should be considered as a concern in the design of interfaces.

Vanessa Evers and Donald Day (1997) indicate that culture is a discernible variable in interface acceptance and interfaces targeted for culturally different users must acknowledge and accommodate cultural differences. The need to accommodate for the users cultural differences leads to the development of cultural models. Fitzgerald (2004) affirms that cultural dimension models seek to measure cultures through the use of cultural variables and factors.

Moreover, the adoption of ICT in developing regions has to consider cultural differences due to the fact that many systems are optimized to the cognitive abilities of western individuals and a considerable number of people in these areas do not present the same cognitive abilities. Erumban and De Jong (2006) note that national culture influences the adoption and penetration of ICT within a country. Consequently, cultural influence is an important concept in the development and design of ICT.

Over the years, culture has been increasingly more important for researchers and practitioners. The use of cultural models has helped in the cross-cultural design of interfaces. Additionally, interfaces are considering cultural differences, and the influence of culture has been investigated. A detailed overview pertained to research based on culture influence and interpretation can be found in Appendix A.

2.3.1. Culture

Cultural interpretation and implementation in the area of Human Computer Interaction has been a topic of debate for quite some time. The literature about Human Computer Interaction presents an equal amount of favorable and critical arguments regarding the accommodation of culture into a user interface design (Ford 2005). Besides the issues with the acceptance of cultural factors in user interface design, the individuals that support the implementation do not agree with the proper way to implement it (Ford 2005). Gabrielle Ford states that the difficulty in accommodating culture in user interface design is due to the fact that "the theoretical foundation for cultural influences on interface design is confused and not yet at the level which would allow designers to predict where culture will have influence on products, or how these differences can be addressed" (Dunckley and Smith 2000, 3 cited in Ford 2005).

The concept of culture is so complex that it cannot be simply described and therefore needs to be interpreted. Consequently, there are several interpretations to the concept of culture and no specific definition of culture has been defined. For instance, culture is defined in the dictionary as "the integrate pattern of human knowledge, belief and behavior that depends upon the capacity for learning and transmitting knowledge to succeeding generations" (Merriam-Webster 2015a). Bodker and Pederson describe culture as a conceptualized "system of meaning that underlies routine and

behavior in everyday working life" (Bodker and Pederson 1991, 22 cited in Ford 2005). Meanwhile, Borgman claims that culture "includes race and ethnicity as well as other variables and is manifested in customary behaviors, assumptions and values, patterns of thinking and communication style" (Borgman 1986, 49 cited in Ford 2005). On the other hand, LeVine views culture "as a organized collection of rules focusing on the ways in which members of a population should communicate, think, and interact with one another and their environments" (LeVine cited in Ford 2005).

Edward Hall affirms "culture is communication, communication is culture" (Hall 1959, 186 cited in Ford 2005) and "culture is a technical term used by anthropologists to refer to a system for creating, sending, storing, and processing information developed by human beings, which differentiates them from other life forms" (Hall 1990, 183 cited in Rincon 2013). On the contrary, Geert Hofstede and his colleagues compare culture to the way that computers are programmed and he considers culture to be the "collective programming of the mind that distinguishes the members of one group or category of people from anothers" (Hofstede, Hofstede, and Minkov 2010, 5). Nancy Hoft (1996) provides a different approach to culture, which she defines as "learned behavior consisting of thoughts, feelings and actions"(Hoft 1996, 41). Santiago Ruano Rincon (2013) defends Hoft's definition and supports the idea that culture is learned and shared. Meanwhile, for the purpose of this dissertation, culture will be a conjoint definition of Hofstede's view and Hoft's view. Therefore, culture is described as a learned and shared behavior that originates patterns in thinking, feeling and acting between individuals.

As mentioned before, the complexity of culture leads to the generation of ambiguous definitions and a consensus regarding the true concept of culture cannot be found. To further support the ambiguity of the subject, Alvin Yeo (1996) affirms that cultures are "not mutually exclusive. A person may belong to a number of cultures (e.g. a Muslim who plays soccer would belong to an Islamic culture and a soccer-playing culture). Given that a person belongs to certain cultures, we would be able to predict with high accuracy certain things that the person knows. In the case of the Muslim soccer player, we would expect the person to know where Mecca is and what a soccer ball looks like. This knowledge of a particular culture cannot be assumed" (Yeo 1996, 5).

2.3.2. Patterns of Culture

A pattern is defined in the dictionary as a reliable sample of traits, acts, tendencies, or other observable characteristics of a person, group or institution (Merriam-Webster 2015c). Therefore, a cultural pattern can be defined as a reliable sample of learned and shared behavior that originates a set of thinking, feeling and acting characteristics between individuals. Marcus and Gould (2000) affirm, "cultures, even within some countries, are very different" (Marcus and Gould 2000, 34) and consequently, patterns of culture should not be set according to national, regional, linguistic or any other type of boundaries.

Patterns of Culture

In *Patterns of Culture*, Ruth Benedict (1934) mentions, "culture, like an individual, is a more or less consistent pattern of thought and action. Within each culture there come into being characteristic purposes not necessarily shared by other types of society " (Benedict 1934, 46). Furthermore, Benedict (1934) states "the whole, as a modern science is insisting in many fields, is not merely the sum of all its parts, but the result of a unique arrangement and interrelation of the parts that has brought about a new entity"(Benedict 1934, 47). She additionally affirms, "cultures, likewise, are more than the sum of their traits. We may know all about the distribution of a tribe's form of

marriage, ritual dances and puberty initiations, and yet understand nothing of the culture as a whole which has used these elements to its own purpose" (Benedict 1934, 47).

On the other hand, Clifford Geertz (1973) claims in *The Interpretation of Cultures* that "culture patterns – religious, philosophical, aesthetic, scientific, ideological – are "programs"; they provide a template or blueprint for the organization of social and psychological processes, much as a genetic systems provide such a template for the organization of organic processes " (Geertz 1973, 217). As Clifford Geertz previously claims in his book " whatever their other differences, both so-called cognitive and so-called expressive symbols or symbol-systems have, then, at least one thing in common: they are extrinsic sources of information in terms of which human life can be patterned – extra personal mechanism for the perception, understanding, judgment and manipulation of the world "(Geertz 1973, 217). In order to further support his position, Geertz mentions that "it is through culture patterns, ordered clusters of significant symbols, that man makes sense of events through which he lives. The study of culture, the accumulated totality of such patterns, is thus the study of the machinery individuals and groups of individuals employ to orient themselves in a world otherwise opaque" (Geertz 1973, 363). Geertz also states "peoples everywhere have developed symbolic structures in terms of which persons are perceived not badly as such, as mere unadorned members of the human race, but as representatives of certain distinct categories of persons, specific sorts of individuals" (Geertz 1973, 363).

The individual and patterns of culture

When patterns of culture are mentioned, the coexistence between the individual and the pattern of culture needs to be examined. Individuals should be considered from the point of view of their ability to function adequately in their society and the adequate functioning defines the normality values of a society leading to the assumption that all the deviations from this norm are defined as abnormal (Benedict 1934). Ruth Benedict (1934) supports the idea that "there is no proper antagonism between the role of society and that of the individual" (Benedict 1934, 251). She affirms "no anthropologist with a background of experience of other cultures has ever believed that individuals were automatons, mechanically carrying out the decrees of their civilization" (Benedict 1934, 253). In other words, Benedict states that individuals belonging to a particular culture are not homogeneous nor are they strict abiders of the implemented cultural guidelines. The relationship between the individual and culture can be described as one of mutual reinforcement in which "most people are shaped to the form of their culture because of the enormous malleability of their original endowment" (Benedict 1934, 254). Benedict (1934) also claims "individuals are plastic to the molding force of the society into which they are born" (Benedict 1934, 254) and therefore, the molding will differentiate among individuals.

2.3.3. The Influence of Culture and Cultural Interpretation

Cultural influence and cultural interpretation are correlated with perception. Perception is a term that has been wrongly employed and it has been implemented in a misleading way in terms regarding the visual concept of a particular social group. Edward Smith and Stephen Kosslyn (2007) state that sensation and perception provide the raw material for cognition. Smith and Kosslyn (2007) define perception as the processing of information from the senses. On the other hand, Melgarejo (1994) describes perception as a bio cultural phenomenon that depends on sensorial and physical stimuli as well as the selection and organization of these sensorial and physical stimuli. Smith and Kosslyn (2007) also note that perception is not only a simple registration of sensory stimuli

and sophisticated complex processes are immediately activated leading to the production of the brain's interpretation of the external world. The subsequent interpretation is guided by the result of the analysis of incoming stimuli and existing knowledge guides (Smith, Kosslyn, and Barsalou 2007). The selection and organization of the sensory stimuli are guided to satisfy the individual and collective needs of human beings (Melgarejo 1994). On the other hand, the sensorial experiments are acquired and interpreted according to the behaviors learned from childhood, which includes culture (Melgarejo 1994). Edward Smith and Stephen Kosslyn (2007) claim that William Shakespeare understood that sensory stimuli are often ambiguous and open to multiple interpretations. These characteristics support the idea that culture influences perception and as a consequence, different individuals perceive things differently. Hence, culture influences the perception of an individual, which is necessary for interpreting information.

Perception and the influence of culture have been linked in research and academic studies. Prior to these, psychologists and philosopher assumed that the processes of cognition and perception were fixed and universal to all individuals. These assumptions appear to be nothing more than fallacies due to the fact that recent studies provide substantial evidence that cognitive and perceptual processes are influenced by the participation of an individual in cultural practices. The social and physical environments surrounding an individual also influence these perpetual processes (Nisbett and Miyamoto 2005). Yee-Yin Choong and Gavriel Salvendy (1998) state that cultures not only differ in language, orthography, symbols, images and numbers formats but also in their appearance, perception, cognition and style of thinking. Consequently, individuals from a particular culture may contain distinct cultural assumptions, values, customs and they might visualize the world in a different manner (Choong and Salvendy 1998). Denise Park and Angela Gutchess (2002) also affirm that behavioral studies suggest differences across cultures in cognitive processes including attention to context, stereotypes about aging and metamemory judgements.

Culture is responsible for influencing an individual's behavior and the neuro-anatomical changes in an individual's brain is partly associated with the influence of culture. For this reason, an individual's ability to perceive and interpret information is correlated with the influence of culture (Reinecke and Gajos 2011). Life experiences impact the organization and function of the brain, and recent work on behavior explore the idea that culture-specific experiences are responsible for shaping cognition in a number of precise ways (Gutchess et al. 2006).

Katharina Reinecke and Krzysztof Gajos (2011) declare that behavioral and neurological findings display that how an individual perceives information is influenced by the cultural factors that defined the individual's background. The statements from Reinecke and Gajos are supported by the work of Richard Nisbett and Takahiko Masuda (2003), which explores the relationship between culture and point of view. Nisbett and Masuda (2003) compare how East Asians and Westerners perceive and think about the world, and the authors discuss cognitive, attention and perception differences. The cognitive differences mentioned by Nisbett and Masuda (2003) are causal attribution and prediction, logic versus dialectics principles, categorization based on rules versus family resemblance, and categorization based on shared taxonomic label versus relationships. On the other hand, attentional and perceptual differences mentioned by the authors differentiate in detection of covariation, difficulty in separating an object from its surroundings, attention to the field, change blindness, environmental "affordances", aesthetic differences between the East and the West, change versus stability and perception of everyday life events. Nisbett and Masuda (2003) state "the environments influence perception and the resulting perceptual preferences prompt people to produce different environments" (Nisbett and Masuda 2003, 11170). Gutchess et al. (2006) support Nisbett and Masuda statements and the authors state that the difference in behavior regarding attention biases and judgments suggests that systematic cultural differences in neural process to complex scenes should occur between Westerners and Easterns.

Furthermore, Richard Nisbett and Yuri Miyamoto (2005) affirm that perceptual differences are influenced by culture, and while Westerners engage in context-independent and analytical perceptual processes, Asians present a more context-dependent and holistic perceptual process. The authors analyze several aspects regarding cultural differences in attention and perception and one of these differences is the relationship versus rules and categories. They affirm that culture has an influence in the late stages of perception, particularly in perceptual categorization. Nisbett and Miyamoto (2005) also mention that cultural differences in the way an individual perceives similarities is not only found at a conceptual level, but also with more purely perceptual stimuli. Moreover, researchers claim that perceptual categorization differences appear to be linked to differences across cultures in patterns of attention (Nisbett and Miyamoto 2005) and cultural differences in eye movements have been discovered (Chua, Boland, and Nisbett 2005).

Additionally, Nisbett and Miyamoto (2005) explore mechanisms underlying cultural differences and the evidence suggests that perceptual differences among Asians and Westerners may be connected to the differences in social structure and social practices. The authors discuss chronic effects of culture on perception, temporary effects of culture on perception and cultural affordances. Regarding the chronic effects of culture in perception, Nisbett and Miyamoto claim that socialization processes such as child rearing practices lead to the acquisition of a certain attentional pattern through participation. They also examine the temporary effects of culture on perception and they display several studies that show a direct link between temporary social orientation and analytic versus holistic perception. Nisbett and Masuda (2003) define analytic perception as a perception that focus the attention on a salient object and consequently, the properties of the object are assessed and the object is assigned to a category in order to determine the rules that governed its behavior. On the other hand, holistic perception attends to the field in which the salient object is located and the relationship among objects and the events in the field is noticed. At last, the cultural affordances refer to particular cultural practices and environments that occur on a daily basis and they imply the use of certain attentional patterns. Nisbett and Miyamoto exhibit “the perceptual environment prompts culturally specific patterns of attention” (Nisbett and Miyamoto 2005, 471) and the ‘default’ patterns of a given culture are generated due to practices and environments on a daily basis.

Reinecke and Gajos support Nisbett and Miyamoto’s work by stating the “perception processing changes according to what our environment (i.e. cultural exposure) teaches us to focus our visual attention on”(2011, 2). To further support the idea that culture influences the perceptual and cognitive processes of an individual, Rune Pettersson (1982) discusses the existing cultural differences in the perception of image and color in pictures. Pettersson (1982) claims that human perception in the visual field and the manner in which humans interpret the content of an image is greatly influenced by the familiarity of an image within a society and whether the proper interpretation of the image has a survival value within this culture. Rune Pettersson (1982) also notes the existence of major differences in perception, naming and usage of colors in different cultures. Moreover, Lindsey and Brown (2004) demonstrate that an individual visual perception is influenced by language and if language impacts thought, it also influences color perceptions.

As discussed above, several studies confirm that perceptual and cognitive processes are influenced by culture and culture plays a role in the interpretation of information. Subsequently, perception influences the form how a user interacts with a particular interface. Park and Gutchess (2002) determine that the environment or the experiences of an individual mold cognition and neural organization. Perception also displays a relevant role in the user’s attention, the organization of objects, the arrangement of components, the level of information density, color sensitivities, navigational capabilities and the hierarchy aspects in interface design (Reinecke and Gajos 2011).

Cultural diversity derives from the influence that culture displays on an individual's perceptual and cognitive processes and how these processes alter the methods that individuals use to interpret data.

2.3.4. Metamodels of Culture

Metamodels can be described as an intricate definition of rules created as a means to establish models in a particular area of study. As previously mentioned, culture is such a complex concept that one definition is not enough to describe it and therefore the concept of culture can only be interpreted. The complexity of the subject derives from the fact that culture is interpreted and a multi layer organization aids individuals to better understand this concept.

According to Gabrielle Ford (2005), metamodels of culture can be characterized as a high-level view of the intersecting philosophies regarding the concept of culture and they are defined with different layers of culture. Nancy Hoft (1996) states that metamodels of culture serve as a backdrop for models of culture due to the fact that they offer a perspective about the contextual depth of a cultural group.

Nancy Hoft (1996) mentions four metamodels of culture found in the literature, namely the Iceberg model, the Pyramid Model, the Onion Model and the Objective culture, and subjective culture. An overview of these four metamodels of culture is depicted in page 70.

The Iceberg Model

The Iceberg Model is a popular metamodel due to the fact that it provides a useful metaphor for describing cultural layers. This metamodel is divided in three metaphorical layers of culture, which are surface, unspoken rules and unconscious rules (Hoft, 1996).

The surface layer hosts the visible, obvious and easy to research cultural characteristics such as number, currency, time and date formats, language, font direction and character sets (Ford, 2005). The unspoken rules layer encompasses the somewhat obscured cultural characteristics such as business etiquette and protocol. Generally speaking, in order to understand the unspoken rules layer, one needs to identify the contextual situation (Hoft, 1996). The unconscious rules layer is for cultural characteristics that are out of conscious awareness and are difficult to study. This layer gathers cultural characteristics such as nonverbal communication, sense of time and physical distances and the rate and intensity of speech (Hoft, 1996).

The Pyramid Model

The Pyramid Model was introduced by Geert Hofstede and establishes three cultural layers, which are Personality, Culture and Human Nature. These layers attempt to show the origin of culture and why culture is unique in human mental programming (Hoft, 1996).

The Personality layer is specified to an individual and this layer is learned and inherited while the Culture layer is learned and not inherited. The Culture layer is specific to a group or a category of people. The Human Nature layer encompasses everything that is common to all human beings. It is universal and it is inherited because it is passed down through generations via DNA. Contrary to the previous ones, the Human Nature layer is not learned.

The Onion Model

Introduced by Fons Trompenaars, the Onion Model consists of three layers, which are the outer

layer, the middle layer and the core. The outer layer consists of explicit products and artifacts of culture. Trompenaars suggests that the outer layer encloses the first things we encounter on a cultural level. This layer identifies symbols of a deeper level of culture such as language, food, buildings, monuments, agriculture, fashions and art. Prejudices start on this symbolic and observable level (Trompenaars & Hampden-Turner, 1998).

The middle layer defines norms and values. Norms are the mutual sense of right and wrong that are shared among a group of people while values determine the definition of "good and bad" between groups of people. Norms can develop on a formal level as written laws and on an informal level as social control. On the other hand, values are related to the ideals shared by a group of people (Trompenaars & Hampden-Turner, 1998).

The core of culture is implicit and consists of the basic assumptions of human existence. The core layer determines how people adapt to their environments given their available resources (Trompenaars & Hampden-Turner, 1998).

The Objective Culture and Subjective Culture Model

Developed by Edward C. Stewart and Milton J. Bennet, the Objective Culture and Subjective Culture Model identifies two layers of culture, the objective culture and the subjective culture.

The Objective Culture is defined as "the institutions and artifacts of a culture, such as its economic system, social customs, political structures and processes, arts, crafts and literature" (Hoft, 1996, p. 43). Objective culture is visible, easy to examine and tangible and it is represented in terms of text orientation, color and language, date and number formats (Hoft, 1996).

In *Cultures and Organizations: Software of the Mind,* Hofstede and his colleagues (2010) classified the characteristics mentioned above into levels of culture and these include: (1) a national level according to one's country; (2) a regional and/or ethnic and/or religious and/or linguistic affiliation level, as most nations are composed of culturally different regions and/or ethnic and /or religious and/or language groups; (3) a gender level, according to whether a person was born as a girl or as a boy; (4) a generation level, which separates grandparents from parents from children; (5) a social class level, associated with educational opportunities and with a person's occupation or profession;

For those who are employed, an organizational or corporate level according to the way employees have been socialized by their work organization (Ford, 2005)

The Objective Culture layer correlates to the outer layer of the Onion Model and the surface layer of the Iceberg Model (Ford, 2005).

The other layer present in this model is Subjective Culture, which is denominated as "the psychological features of a culture, including assumptions, values, and patterns of thinking" (Hoft, 1996, p. 43). Subjective culture is characterized as difficult to examine because it operates outside of the conscious awareness. Values, assumptions and patterns of thinking are some of the cultural characteristics that belong to the subjective culture layer. Since subjective culture operates outside of conscious awareness, it is difficult to examine it. Ford exemplifies this difficulty by providing examples from Geert Hofstede, David Victor and Fons Trompenaars. Hofstede describes how people accept or reject uncertainty, Hofstede and Victor demonstrate the similarities and differences in power and authority and Trompenaars shows the amount of emotions that people express when dealing with others (Ford, 2005).

Subjective culture is similar to the middle and core layers of the Onion Model, the unspoken rules and unconscious rules layers of the Iceberg Model and all the layers in the Pyramid Model (Ford, 2005). Objective culture is an abstract layer due to the fact that objective culture is the externalization of subjective culture. On the other hand, subjective culture is real and concrete. However, it is ironic because objective culture tends to be seen as more real and concrete than subjective culture (Hoft, 1996).

Table 05. Metamodels of Culture

The Iceberg Model	The Pyramid Model	The Onion Model	The Objective Culture and Subjective Culture Model
The **Iceberg Model** is a popular metamodel due to the fact that it provides a useful metaphor for describing cultural layers. This metamodel is divided in three metaphorical layers of culture, which are **Surface**, **Unspoken Rules** and **Unconscious Rules** (Hoft 1996). The **Surface layer** hosts the visible, obvious and easy to research cultural characteristics such as number, currency, time and date formats, language, font direction and character sets (Ford 2005). The **Unspoken Rules layer** encompasses the somewhat obscured cultural characteristics such as business etiquette and protocol. Generally speaking, in order to understand the unspoken rules layer, one needs to identify the contextual situation (Hoft 1996). The **Unconscious Rules layer** is for cultural characteristics that are out of conscious awareness and are difficult to study. This layer gathers cultural characteristics such as nonverbal communication, sense of time and physical distances and the rate and intensity of speech (Hoft 1996).	The **Pyramid Model** was introduced by Geert Hofstede and establishes three cultural layers, which are **Personality**, **Culture** and **Human Nature**. These layers attempt to show the origin of culture and why culture is unique in human mental programming (Hoft 1996). The **Personality layer** is specified to an individual and this layer is learned and inherited while the Culture layer is learned and not inherited. The **Culture layer** is specific to a group or a category of people. The **Human Nature layer** encompasses everything that is common to all human beings. It is universal and it is inherited because it is passed down through generations via DNA. Contrary to the previous ones, the Human Nature layer is not learned.	Introduced by Fons Trompenaars, the **Onion Model** consists of three layers, which are the **Outer layer**, **the Middle layer** and the **Core**. The **Outer layer** consists of explicit products and artifacts of culture. Trompenaars suggests that the outer layer encloses the first things we encounter on a cultural level. This layer identifies symbols of a deeper level of culture such as language, food, buildings, monuments, agriculture, fashions and art. Prejudices start on this symbolic and observable level (Trompenaars and Hampden-Turner 1998). The **Middle layer** defines norms and values. Norms are the mutual sense of right and wrong that are shared among a group of people while values determine the definition of "good and bad" between groups of people. Norms can develop on a formal level as written laws and on an informal level as social control. On the other hand, values are related to the ideals shared by a group of people (Trompenaars and Hampden-Turner 1998). The **Core** of culture is implicit and consists of the basic assumptions of human existence. The core layer determines how people adapt to their environments given their available resources (Trompenaars and Hampden-Turner 1998).	Developed by Edward C. Stewart and Milton J. Bennet, the **Objective Culture and Subjective Culture Model** identifies two layers of culture: the **Objective Culture** and the **Subjective Culture**. The **Objective Culture** is defined as "the institutions and artifacts of a culture, such as its economic system, social customs, political structures and processes, arts, crafts and literature" (Hoft 1996, 43). Objective culture is visible, easy to examine and tangible and it is represented in terms of text orientation, color and language, date and number formats (Hoft 1996). The other layer present in this model is **Subjective Culture**, which is denominated as "the psychological features of a culture, including assumptions, values, and patterns of thinking" (Hoft 1996, 43). Subjective culture is characterized as difficult to examine because it operates outside of the conscious awareness. Values, assumptions and patterns of thinking are some of the cultural characteristics that belong to the subjective culture layer. Since subjective culture operates outside of conscious awareness, it is difficult to examine it. Objective culture is an abstract layer due to the fact that objective culture is the externalization of subjective culture. On the other hand, subjective culture is real and concrete. However, it is ironic because objective culture tends to be seen as more real and concrete than subjective culture (Hoft 1996).

2.3.5. Cultural Models

The metamodels of culture previously mentioned act as the basis for the development of models of culture, which provide a more detailed view of culture (Ford 2005). A model is defined in the dictionary as a set of ideas and numbers that describe the past, present, or future state of something such as an economy or a business (Merriam-Webster 2015b). A cultural model compares the similarities and differences of two or more cultures through the identification of international variables that examine below the surface and focus on the unconscious level of culture. International variables can be defined as categories that organize cultural data. They can range from objective, easy to research cultural differences such as economical contexts or text directionality in the writing system, to subjective information like value and behavioral systems (Hoft 1996).

Authored individuals have written extensively about the subject and consequently, created the documented cultural models. Therefore, the models created originate from extensive research through questionnaires, surveys, interviews, focus groups and years of experience and observation (Hoft 1996). An overview of five cultural models can be seen in page 72.

Table 06. Cultural Models

Kluckhohn and Strodtbeck	Geert Hofstede	Fons Trompenaars	Edward Hall	David Victor
Kluckhohn and Strodtbeck formulated five orientations, namely **Human Nature Orientation**, **Man Nature Orientation**, **Time Orientation**, **Activity Orientation** and **Relational Orientation** **Human Nature Orientation** can be depicted as : Good Good-and-Evil Evil The **Man Nature Orientation** is divided into three categories: Subjugation to Nature Harmony with Nature Mastery over Nature The **Time Orientation** deals with the value each culture assigns to "Past", "Present" and "Future" Kluckhohn and Strodtbeck separate the **Activity Orientation** as: Being Being-in-Becoming Doing The **Relation Orientation** can be classified between: Lineal Collateral Individualistic	Geert Hofstede identified five cultural dimensions entitled: **Power Distance** **Uncertainty Avoidance** **Masculinity/Femininity** **Individualism/Collectivism** **Time Orientation** All the five cultural dimensions relate to subjective culture and are dichotomies, meaning there are two opposing sides to every cultural dimension (Ford 2005). **Power Distance** is responsible for measuring how subordinates respond to power and authority. In other words, this dimension determines to which extent less powerful members in a society expect and accept the power distribution with a culture. The Power Distance is classified either as a high power distance or low power distance. **Uncertainty Avoidance** refers to the way people cope with uncertainty and risk. The dimension classifies nations as high uncertainty avoidance and low uncertainty avoidance (Ford 2005). **Masculinity/Femininity** refers to gender roles in the society and not physical characteristics. **Individualism/ Collectivism** describes the relationship between the individual and the predominant society in a culture (Rincon 2013). **Time Orientation** refers to people concerns regarding the past, present and future and the two sides are short-term orientation and long-term orientation (Ford 2005).	The model developed by Trompenaars defines culture as the way in which groups of people solve problems and the problems are divided into three headings, which identify seven dimensions of culture (Hoft 1996). The model created by Fons Trompenaars presents the following structure: 1. Problems that arise from our relationships with other people: **Universalism versus Particularism** **Individualism versus Collectivism** **Neutral versus Emotional** **Specific versus Diffuse** **Achievement versus Ascription** 2. Problems that come from the passage of time **Attitudes to time** 3. Problems that relate to the environment **Attitudes to the environment**	Hall distinguished cultures based on the way they communicated along a dimension from 'high-context' to 'low-context' (Ford 2005). Hall believes culture is a program for behavior and he claims that an effective cross-cultural communication "has more to do with releasing the right response than with sending the 'right' messages" (Hoft 1996, 50). Edward Hall presents six variables, which are the following: **Speed of Messages** **Context** **Space** **Time** **Information Flow** **Action Chains** **Speed of Messages** refers to the message velocity continuum, or in other words, the speed it takes for one person to decode and act on messages **Context** is concerned with the amount of information that is in a given communication as a function of the context in which it occurs. Hall defines two kinds of contesting denominated high context and low context (Ford 2005). Hall classifies **Space** in four cultural traits: territoriality, personal space, multisensory space and unconscious reactions to spatial differences. **Time** is divided in two types: polychronic time and monochronic time. **Information Flow** refers to the measurement of how long it takes for a message to travel and release the required response from the intended recipient. An **Action Chain** is defined as a sequence of events that lead to the accomplishment of a goal and they are central to technical communication.	David Victor developed the LESCANT model with the intention to create a framework that would formulate the correct questions in an international business environment. The model's name is an acronym for **Language**, **Environment and Technology**, **Social Organization**, **Contexting**, **Authority Conception**, **Nonverbal Behavior** and **Temporal Conception** (Rincon 2013). **Language** includes the degrees of fluency, accents and regional dialects and how these factors influence business communications (Ford 2005). The **Environment and Technology** variable is concerned with larger issues of how geography, population, physical space and perceptions of technology influence business communication (Ford 2005). **Social Organization** encompasses the cultural effects of kinship and family structure, educational systems and ties, class systems and economic stratification, gender roles, individualism versus collectivism, religion, occupational institutions, political and judicial system, mobility and geographic attachment and recreational institutions (Rincon 2013). David Victor proposes two categories for **Contexting**, a high-context and a low-context category. **Authority Conception** is concerned with the differences and similarities in power, authority and leadership. **Non-verbal behavior** includes active behavior such as movement, sound, eye and touching, and passive behavior such as the use of colors, symbols and smells (Ford 2005). **Temporal Conception** consists of polychronic and monochronic time in terms of scheduling (Ford 2005).

Criticism against the use of cultural models

According to Fitzgerald (2004), cultural models and their interest arose from the need to create a model for cross-cultural software development but the use of cultural models has been criticized due to discomfort with stereotypes along with the inconclusive results from studies that apply cultural models to Human Computer Interaction (Ford, Kotzè, and Marcus 2005). Geert Hofstede (2010) defines stereotypes as "conventional notions that are usually associated uncritically with a person on the basis of his or her background" (Hofstede, Hofstede, and Minkov 2010, 39). Therefore, the use of cultural models is considered inadequate due to the generalizations that they form and the fact that not every single individual fits into the "cultural mean" due to individual differences. As Jainaba Jagne and colleagues (2006) state "designers ought to be careful though to not stereotype their markets by using existing cultural models" (Jagne and Smith-Atakan 2006, 5). The same authors suggest that the indicated approach consists in engaging with the cultures directly in order to get a better understanding of the indigenous people (Jagne and Smith-Atakan 2006).

Out of the five cultural models mentioned above, Hofstede's cultural model has been the most criticized by the Human Computer-Interaction community. It has been labeled too stereotypical (Bourges-Waldegg and Scrivener 1998), rigid (Nocera and Hall cited in Jagne and Smith-Atakan 2006) and previous studies using the model resulted in conflicting and inconclusive findings. Regarding the stereotypical aspect, Bourges-Waldegg and Scrivener (1998) state that the use of cultural models is inadequate for dealing with localization because cultural models are generalizations and therefore, insensitive to the context they are applied on. The authors also affirm that cultural models are responsible for reinforcing stereotypical views (Bourges-Waldegg and Scrivener 1998). In relation to the rigidity aspect, Nocera and Hall affirm that designers who implement cultural models are looking for quick solutions to be able to "deliver systems in the quickest and most cost-efficient way"(Jagne and Smith-Atakan 2006, 4).

The main criticism regarding the use of cultural models is the statement that they are responsible for stereotyping users. Despite Hofstede's cultural model identifying a dominant cultural profile for each country, not everyone shares the same profile (Ford, Kotzè, and Marcus 2005). Cultural boundaries are not limited to national boundaries (Duncker 2002) and countries are often comprised by several cultures and ethnicities (Ford, Kotzè, and Marcus 2005), which can be exemplified by most countries in Sub-Saharan Africa. Therefore, assuming that a select sample of users will have the same cultural profile based on their country of residence is a fallacy, even one that Geert Hofstede warns against (Ford, Kotzè, and Marcus 2005). Ford, Kotzè and Marcus (2005) also note that the problem in the stereotyping and the inconclusive results may result from the lack of assessing cultural profiles of the test subject and consequently, the model is being stereotyped rather than doing the stereotyping (Ford, Kotzè, and Marcus 2005). Regardless of the criticisms against cultural models, a vast number of researchers still implement them or create new ones based on these five cultural models (Marcus and Gould 2000, Ford and Kotzé 2005, Khaslavsky 1998, Honold 1999, Evers and Day 1997).

2.3.6. Influence of Culture in Human-Computer Interaction

Culture is an impactful concept that influences not only the interaction among individuals but also the interaction between an individual and the computer. Communication between the user and the computer system is as important as the communication among individuals, and the cultural patterns observed among users can be implemented in an interactive system. Julie Khaslavsky

states, “given the impact that culture has on people’s behavior, truly intuitive international software should reflect the cultural orientation of its users and not just be a translation of an American interface” (Khaslavsky 1998, 365).

As mentioned before, culture is a learned and shared behavior and people learn patterns of thinking and acting from living within a particular social environment normally characterized by national culture (Massey et al. 2001). Therefore, culture is responsible for partially pre-determining the communication preferences and behaviors of an individual and the communication style displays the form how individuals interpret and send verbal and nonverbal messages (Massey et al. 2001). Consequently, it is plausible to assume that the communication style represents the overall patterns and values of a culture. Due to the fact that culture is shared among a group of people, culture influences predictions that individuals generate when communicating (Massey et al. 2001). These predictions are based on experiments from previous events along with future expectations (Massey et al. 2001).

The user interface is the channel that enables the interaction and communication between the user and the system and for this reason the interface should facilitate the communication between the two elements by using communication styles familiar to the user (Ford 2005). Therefore, global interfaces need to accommodate a vast and diversity array of communication styles in order to support the cultural diversity among users (Ford 2005).

The United Nations Educational, Scientific and Cultural Organization (UNESCO) characterizes cultural diversity as groups of people that worked and lived together leading to the development of distinctive cultures. The originated cultural distinction expands choices, nurtures a variety of skills, human values and worldviews, and provides wisdom from the past to inform the future. Cultural diversity is becoming increasingly more relevant in Human-Computer Interaction, and due to the process of globalization, the optimal use of a system is correlated with the adaptability of the same within several cultures. Consequently, cultural diversity is an important aspect to considering in global interfaces. Marcus and Gould state “in a multicultural world, it is necessary to cooperate to achieve practical goals without requiring everyone to think, act and believe identically” (Marcus and Gould 2000, 43). Therefore, cultural diversity needs to be accepted rather than rejected because it provides new solutions to old problems.

Cultural diversity presents different levels of impact when discussing traditional software ap¬plications and websites. The concern with cultural diversity has been particularly prominent in websites due to the presence of a global audience. Traditional user interfaces and web interfaces should ensure the information is conveyed in a cognitively efficient way and the interface should facilitate the use of learning and use of the system (Chau et al. 2002). However, designing usable websites presents additional issues that are not standard to traditional user interfaces (Ford 2005).

Jakob Nielsen (1997) provides an insightful analysis regarding the differences between Web Design and Graphical User Interface Design. Nielsen affirms that there are similarities in design for the web and for graphical user interface, and he supports this statement by claiming that both are interactive systems and software designs. Furthermore, the author states that when designing for the web the designer “has to give up full control and share responsibility for the user interface with users and their client hardware/software”. Nielsen identifies three differences, denominated device diversity, navigational control and part of a whole, relating to control and shared responsibility. Device diversity relates to setting aside all assumptions about the system when designing for web interface. In traditional user interface design, the designer is familiar with the system and every pixel on the screen will look exactly the same on the user’s screen. Systems that adopt web interfaces are substantially different compared to traditional user interfaces due to the diversity of

the devices available. On the other hand, the navigational control refers to the level of control that can be designed into the interface (Ford 2005). In a traditional graphic user interface, the designer can control where the user can go when while in the web, the user is responsible for controlling the navigation through the pages. Therefore, web designers need to accommodate and support user-controlled navigation. The last difference pertains to part of a whole and this characteristic refers to how users perceive different applications to be different and consequently, the expected differences in conceptual models, layouts and features (Ford 2005). While traditional graphical user interfaces are advised to follow the vendor's guidelines, the web allows the users to move between sites at a frantic pace and the borders between different designs are very fluid.

The influence of culture and the impact of cultural diversity in Human Computer Interaction are also correlated with cross-cultural usability. Regarding cross-cultural usability, traditional software and web-based interfaces are approached differently and the primary difference between the two types of interfaces is the fact that websites are constantly addressing different cultural groups at the same time (Chau et al. 2002). As Gabrielle Ford (2005) affirms users differ across multiple factors, including regional, linguistic and country boundaries, and consequently the user expectations of websites are based on their local cultural perspectives. Therefore, it can be determined that cultural characteristics present an intrinsically oriented nature regarding the usability of a product. Wendy Barber and Albert Badre (1998) claim that a user's reaction is more predictable and understandable when the cultural perspective of the user is taken into account. The previous statement is supported with the concept of culturability which is a term used to emphasize the importance of the relationship between culture and usability in web design (Barber and Badre 1998). Culturability is better defined as designing the interface to accommodate cultural preferences and biases in order to improve the usability of the interface and consequently, the overall product (Ford 2005).

There are many arguments favoring the influence of culture in Human Computer Interaction, but at the same time, there is a large number of arguments against the influence and importance of culture in the field. The main argument against the influence of culture in Human Computer Interaction derives from cultural convergence theory. Lawrence Kincaid and his colleagues (Kincaid et al. 1983) claim the convergence model of communication states mutual understanding is the primary function of the communication processes. The cultural convergence theory supports the idea that cultures display a tendency to become more similar (Kincaid et al. 1983, Lee 2007) and these similarities occur because technology changes cultural patterns and ideologies. Diane Norton (2002) reached the conclusion that little evidence is shown regarding the customization of user interfaces in South Africa and she states, " while the users are from different traditional cultures, they have a common country, and organizational culture, as well as similar work processes and goals to be achieved" (Norton 2002, 535). Norton also suggests that users across traditional cultural groups understand the existence of a computer/technology culture that uses a language, symbols, values, and protocols for behavior. Regarding Norton's conclusions, Gabrielle Ford (2005) states that the existence of sub-cultures refutes the need to accommodate objective and subjective cultural differences.

2.3.7. ICT and Cultural Factors

The context of the study is strongly influenced by Information and Communication Technologies, in particular ICT4D. Richard Heeks (2008) defines ICT4D as the application of information and communication technologies for international development. Considering the serious problems in the world such as climate change, disease epidemics and resource depletion, Heeks claims the poor of the world are the most affected group and these five billion individuals comprise the core audience for Information and Communication Technologies for development (Heeks 2008).

ICT4D is not a recent trend and evidence states the first digital computer was installed in Kolkata, India in 1956. During the 1990's, the general availability of the Internet and the Millennium Development Goals (MDGs) supported the creation of ICT4D 1.0 (Heeks 2008). The emergence of ICT4D 2.0 occurred due to technology-as-invention approach that ICT4D 1.0 implemented. On the other hand, ICT4D 2.0 uses the technology-in-use invention, which leads to less emphasis on what might be used and more emphasis on what is actually used (Heeks 2008). The technology-in-use also promotes more emphasis on application and business model innovation as well as assessing and scaling existing applications (Heeks 2008).

The cultural diversity existent between these five billion individuals is substantially large and therefore, cultural factors need to be considered in ICT. The integration and transferring of technology differ between countries, and the cultural and social factors are the primary enablers for the adoption of information and communication technologies (Hill et al. 2008). Erumban and De Jong (2006) note that some nations are receptive to changes while others welcome it, and this divergence can be traced to economic and non-economic factors. The non-economic factors include socio-cultural ambience, perceived values, institutions and political atmosphere. These factors along with economic factors have an impact on the adoption of ICT and the perception of individuals within a nation (Erumban and De Jong 2006). Abdulkafi Albirini (2006) explores the relationship between cultural perceptions and the adoption of ICT in the educational system of Syria. Albirini (2006) states one of the reasons for the disappointing results pertaining to ICT adoption in an educational environment is due to the inattention of the decision-makers to the cultural conditions of the end users. The cultural setting of a society demonstrates an important role in the adoption of ICT in a particular country (Erumban and De Jong 2006). Albirini (2006) advises that force fitting a culture to the technology can create an unfavorable climate to the acceptance and adoption of ICT. Westerners attempt to implement technology transfer but many times, they are challenged by their own ideas, beliefs, and values about how the technology should be implemented in developing countries and subsequently, the adoption of these technologies result in failure (Hill et al. 2008). As noted before, culture influences behavior and it may enhance or create barriers to the adoption and use of ICT (Erumban and De Jong 2006). The adoption and use of ICT for development is dependent of cultural and social factors that ease the adoption process or create barriers to prevent the integration of these technologies. Therefore, the technology transfer needs to consider the culture of the end users in order for the use of ICT to thrive in developing countries.

The adoption of ICT in developing regions presents several technological, environmental and cultural challenges. Brewer et al. (2006) discuss the challenges regarding developing regions and state that cultural issues present the greatest challenges. Technological issues may vary from one region to another but they are easier to solve compared to cultural issues (Brewer et al. 2006). Equipment failures are common because the specifications of the equipment are not prepared for the environment of the developing region. Humidity, the lack of a widespread climate control, and the presence of dirt and dust cause the machines to become unreliable and impractical (Brewer et al. 2006). Consequently, Brewer et al. (2006) advise for equipment to be robust to water and ultraviolet exposure. Power problems, in particular power outages, software infection and reinstallation, and remote management are other technological challenges present in these regions. Regarding environmental challenges, the authors indicate two sets of challenges, namely logistical issues, such as transportation, customs and shipping and local production, and risks of personal safety, such as safety in urban slums and natural disasters (Brewer et al. 2006).

The cultural issues vary widely between regions and can range from staff problems, tampering, theft, corruption and illiteracy (Brewer et al. 2006). Developing regions display a shortage of IT personnel, and the ones available are relatively inexperienced or lack confidence (Brewer et al.

2006). Furthermore, tampering and theft of equipment, as well as corruption, are prevalent issues in developing nations. At last, illiteracy issues in developing regions are a significant problem because this disables the user from accessing to technology (Brewer et al. 2006). Brewer et al. (2006) note that illiteracy also presents problems regarding recruiting, recording and user testing.

2.3.8. The Culturalization Approach

Cultural diversity has been increasingly relevant to the Human Computer Interaction community. Despite the controversial issues surrounding the theme, the exposure of technological systems for individuals in the developing regions lead to the culturalization process in order to achieve optimal usage. Consequently, culturalization is one of the methods developed for interface designers and Human Computer Interaction practitioners to cope with cultural diversity. Paula Bourges-Waldegg and Stephen Scrivener (1998) define culturalization as the internationalization-localization process that determines culturally determined usability problems in the design of interfaces.

Culturalization is the preparation of a product for a copious amount of cultures and Patricia Russo and Stephen Boor (1993) claim that the method to prepare a product for another cultures involves two steps: internationalization and localization. The internationalization process refers to the isolation of culturally specific elements of a product and occurs in the country where the product is originally developed (Russo and Boor 1993). The internationalization process usually focuses on elements related to text, numbers and dates such as character sets. On the other hand, the localization process consists in infusing a particular cultural context into an internationalized product (Russo and Boor 1993). This process is often limited to translating the text, date and number formats, which is insufficient in order to create interfaces that are culturally fluent (Russo and Boor 1993). Patricia Young (2008) supports this idea by stating that internationalization consists of a generic design approach while localization is about the inclusion of culture-specific design specifications and therefore, this approach consists in a specialized design.

Despite the scant guidance that the culturalization approach provides to interface designers and Human Computer Interaction practitioners, the approach's primary focus is the translation of cultural aspects (Russo and Boor 1993). Consequently, the culturalization approach is heavily based on the objective cultural aspects and the subjective cultural aspects such as values, ethics, and morals of the users need to be considered (Russo and Boor 1993).

The culturalization approach has been labeled as inadequate and according to several researchers, subjective culture has to be implemented in order to make the user more accepting and comfortable with the interface (Ford 2005). Paula Bourges-Waldegg and Stephen Scrivener (1998) list some general problems and situations that can be encountered when the culturalization approach is utilized. The first concern presented by the researchers is the fact that culturalization is not appropriate for designing systems intended to support communication and interaction between culturally diverse individuals such as Internet applications and Computer-Supported Cooperative Work (CSCW) (Bourges-Waldegg and Scrivener 1998). Therefore, it is important to differentiate the notion of designing interfaces aimed exclusively for a particular culture and designing interfaces that are shared by users of different culture. Paula Bourges-Waldegg and Scrivener (1998) also note that the culturalization approach may not be practical due to the variety of languages existent in the world. Furthermore, the culturalization approach heavily relies in the identification of culturally homogenous 'locales' and consequently, the notion of locality is another concern due to the fact that location is a " traditional physical, bounded-space sense" (Bourges-Waldegg and Scrivener 1998, 289), and in the case of systems like the Internet, the notion of location cannot

be properly understood.

The use of the culturalization approach presents additional problems. For instance, Landsdale and Ormerod found several drawbacks with the guidelines, rules, standards and general advices that the culturalization approach utilizes (Bourges-Waldegg and Scrivener 1998). They state that these resources cannot guarantee well-designed systems but they can lead to systems that are poorly designed (Bourges-Waldegg and Scrivener 1998). These resources are also generalizations that can be insensitive depending on the context of use and lastly, the long term utility of the same resources is questionable (Bourges-Waldegg and Scrivener 1998).

Another problem presented by the use of culturalization approach is the fact that identifying and describing the target culture is difficult to achieve. Bourges-Waldegg and Scrivener (1998) state that "cultures are not ontologically objective and they are continuously interacting and developing" (Bourges-Waldegg and Scrivener 1998, 289) which may originate inappropriate designs. The establishment of boundaries pertaining to culturalization also remains an issue and therefore, some differences between members of a targeted user group and similarities between excluded users groups must be ignored (Bourges-Waldegg and Scrivener 1998). Another issue with culturalization refers to bilingualism and multilingualism due to the fact that culturalization seems to equate one nation with one specific language, which is not the case in several nations. As Cristal affirms, "multi-lingualism is the natural way of life for hundreds of millions all over the world" (Cristal 1993 cited in Bourges-Waldegg and Scrivener 1998, 289) and therefore the association between one nation and one language is wrongfully established and needs to be resolved.

Another issue associated with culturalization is the idea of promoting culturalization as a means of opposing the "cultural homogenization" or "Americanization" of the world. Bourges-Waldegg and Scrivener (1998) note that culturalization rather than opposing to cultural homogenization is contributing to this ideology because "it is precisely by adapting products to 'locales' that many American cultural values have penetrated a wide range of different cultures" (Bourges-Waldegg and Scrivener 1998, 290). Therefore, it is discernible that most of these issues can be resolved once subjective culture is factored in in the process. Gabrielle Ford and Paula Kotzè (2005) state that, despite subjective culture being difficult to examine, it represents what is real and concrete through the psychological features of a culture, including assumptions, values and patterns of thinking.

Subjective cultural issues reflect the values, ethics and morals of the target users but these tend to be hidden from an individual consciousness and are difficult to discover and interpret. The information discussed above clearly determines that the gap between cultural characteristics and user interface design can be attributed to the absence of subjective cultural issues in interface design. While objective culture analyzes the "surface manifestations of culture that have ben widely accepted" (Kersten et al. 2000, 509 cited in Smith et al. 2004, 89), subjective culture can be considered as the foundations and unconscious actions that create these surface manifestations. Jane M. Carey notes there is an existing difference between comprehension and acceptance and this differentiation is not enough to translate the cultural representations (Carey 1998 cited in Ford 2005). Carey also affirms that in order to increase the usability of an interface, it is important that other cultural conventions are recognizable to the user (Carey 1998 cited in Ford 2005). Furthermore, Ciborowski notes the existence of an inseparable link between knowledge and culture and consequently, members of a cultural group might refuse to acknowledge the particular beliefs and traditions of another cultural group as knowledge (Ciborowski 1979 cited in Ford 2005). Therefore, Ciborowski advises that the assessment of a group's knowledge needs to contemplate the culture of this particular group (Ciborowski 1979 cited in Ford 2005).

From a user interface design perspective, knowledge is a determinant factor of user performance.

Consequently, Ford (2005) notes that culture influences knowledge, which consequently influences the performance of a user. Therefore, culture is intrinsically responsible for influencing usability and performance issues as Del Galdo and Nielsen (1996) support when they discuss the three levels of internationalization. Elisa Del Galdo and Jakob Nielsen affirm that internationalization presents three levels, which are: (1) display the native language, character set and notations; (2) Translation of the user interface and documentation in order to be understandable and usable; (3) Matching the user's cultural characteristics, which is more complex than avoiding offensive icons and must take into consideration the way business is conducted and the way people communicate.

Despite many arguments favoring the use of the culturalization approach, this approach is still not favorable to correctly interpret and understanding the impact of culture in user interface design. The main issue with culturalization is the lack of consideration regarding subjective culture. Hence, culturalization is not the best approach to create interfaces to users of a particular culture because this method does not ease user's understanding and use of the interface. In order for culturalization to be a tool for understanding cultural diversity, subjective culture needs to be properly acknowledged.

2.3.9. Conclusion

The complexity of the concept of culture leads to the development of several ideas regarding what culture represents. Nonetheless, different cultures demonstrate distinctive values and perceptions that need to be recognized, and once these identifiable values and perceptions are differentiated, patterns of culture can be generated without excluding the importance of individuality.

The impact of culture is becoming more noticeable due to the rapid globalization of the world and a number of researchers and practitioners indicate that the influence of culture holds significant value in the development and design of interfaces, namely in the developing regions. Research indicates that cultural influence and cultural interpretation are correlated with perceptive, cognitive, behavioral and neurological characteristics. Furthermore, researchers attempted to structure culture through metamodels of culture and cultural models.

Nonetheless, the development of interfaces for developing regions, namely for ICT, demonstrates the value that culture holds not only on the success of the technologies in the region but also on the acceptance of systems. The importance of culture has been recognized and several approaches have been developed in order to accommodate the cultural values of a particular user. The culturalization approach has been the most popular in interface design and the approach consist in the globalization and localization of an interface. Despite the popularity of the approach, culturalization does not address certain significant cultural values on a subjective level and consequently, is not a flawless approach. Therefore, a significant amount of studies and experiments have been conducted but interfaces still do not address all of the users' cultural values and the users' ease of understanding regarding interfaces is not optional.

Chapter Three
Methods

3. Methods

The previous chapter discussed the literature associated with Human-Computer Interaction and cultural studies, two relevant areas of the research. The review of literature was fundamental to create a coherent research purpose and develop a cohesive research design.

The purpose of the research is to explore and determine the feasibility of culturally sensitive icons with Sub-Saharan people. Its focus consists in establishing icon patterns associated to cultural groups within a wide array of characteristics, including written literacy and technological proficiency. The chapter begins with a concise explanation of the research setting, followed by a description of the research sample and the research approach. Afterwards, the data collection methods and data analysis methods are described.

3.1. Research Setting

Prior to explaining the research sample and the approach, it is important to explain the setting where it took place. The exponential growth of mobile devices in the African continent along with a particular lack of data from certain regions in the continent allowed us to focus the study in the Sub-Saharan region of the African continent. Most studies conducted in the continent pertain to South African nationals but the objective of the research is to gather a significant amount of data from nationals of different countries in the African continent and retrieve conclusions out of the results. Another concern of the research is the integration of illiterate and literate users. A large number of the studies conducted in Africa are aimed at enhancing the quality of life in remote areas, where the illiteracy rate tends to be higher than in the urban areas, but the goal of this research is to determine recognition levels and preference patterns to the plethora of cultural and social groups within a nation.

3.2. Research Sample and Data Sample

The sample utilized in the research was chosen according to the nationality of the subjects, but the variation within a nationality was arbitrary. In other words, the original plan was for the sample to be as diverse as possible and retrieve information regarding recognition and preference values of African subjects from different ages, gender, cultural background and socio-economic status. The variation in the sample was to emulate the different type of individuals residing in the continent, and not just one particular cultural group within a specific age or gender. Diversity is important for the research and different communication channels were utilized to get diverse information from the subjects. The only requirement necessary for the experimental group was being a national from a Sub-Saharan nation, and descriptive characteristics including age and gender were arbitrary. Additionally, a sample of Portuguese nationals was used as the control group for comparative analysis.

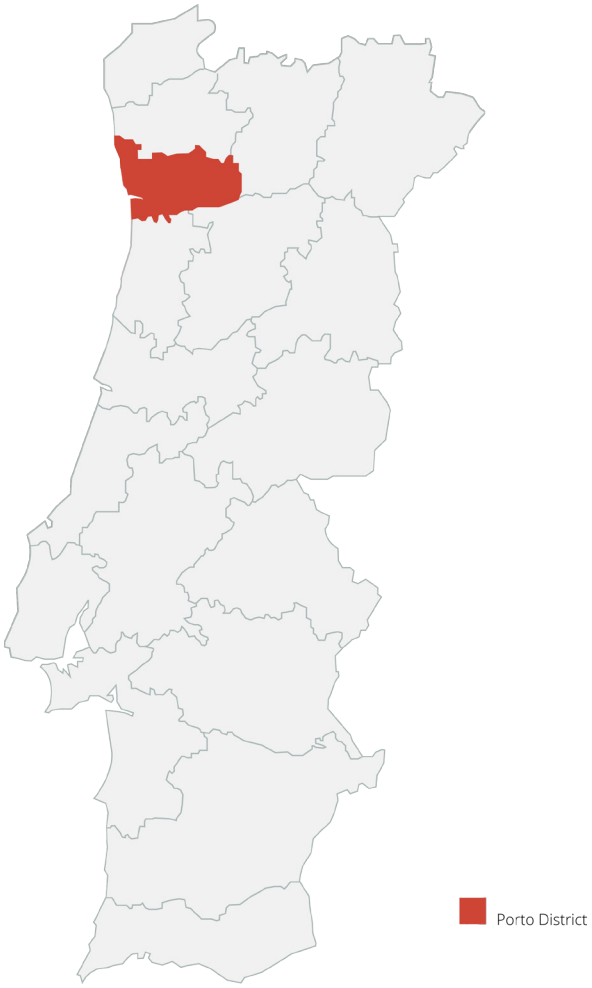


Figure 13. Location of the Sub-Saharan immigrants

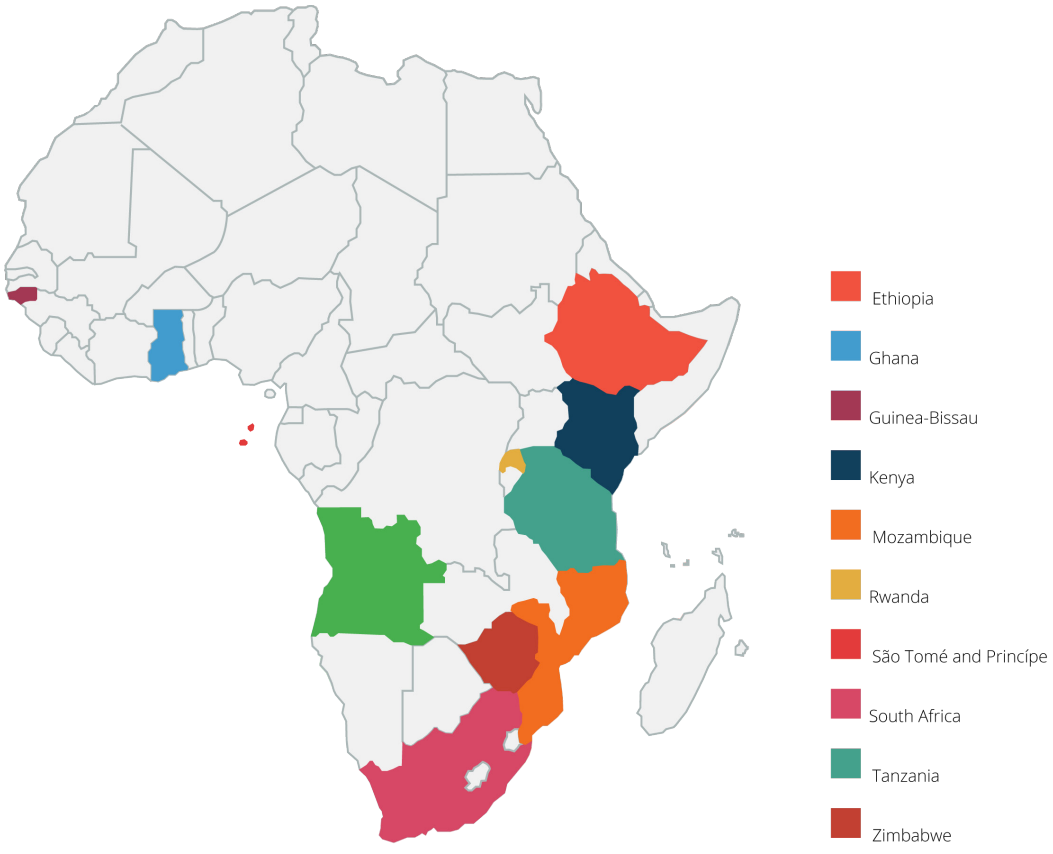


Figure 14. Location of the Sub-Saharan residents

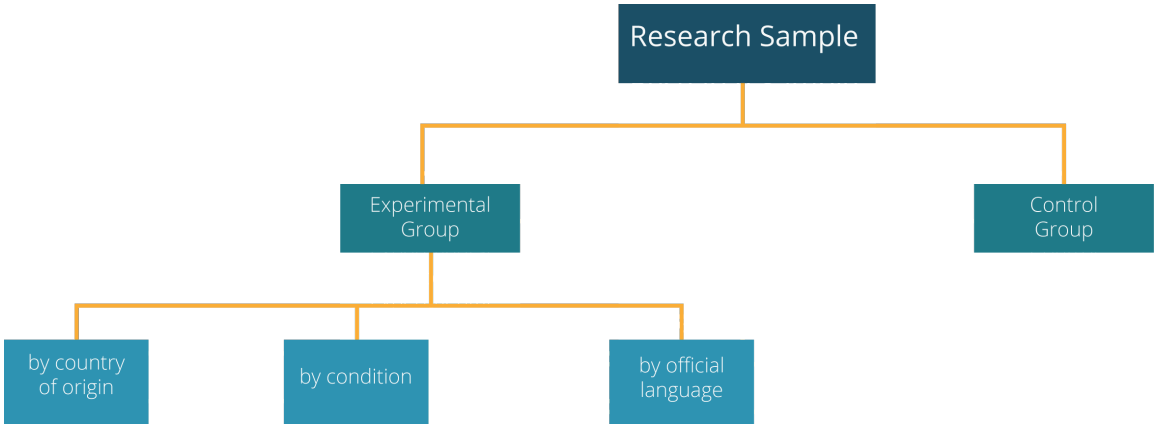


Figure 15. Structure of the Research Sample

Each individual in the data sample was assigned one or more values for the following descriptive variables:

- Gender;
- Age;
- Nationality;
- Native language(s);
- Ability to read and write;
- Ability to use smartphones and/or computers.

The objective of the study was to gather information from a diverse array of African users throughout the six phases. The subjects are characterized by the descriptive variables defined above, but condition, official languages or country of origin also serve to classify the subjects. Regarding the representation of subjects by condition, these can be classified either as immigrants or residents. The official language of the nation to which the subject is associated can also be used for classification purposes. On the other hand, participants classified by country of origin can be categorized within the following countries:

- Cape Verde;
- Ethiopia;
- Ghana;
- Guinea-Bissau;
- Kenya;
- Mozambique;
- Rwanda;
- São Tomé and Príncipe;
- South Africa;
- Tanzania;
- Zimbabwe.

Subjects from other African nations, namely Morocco and Senegal, also participated in the research but they were not in sufficient number to create reliable recognition and preference levels. Nonetheless, the subjects provided valuable information but inappropriate for statistical purposes.

The recruitment of Sub-Saharan residents required the assistance of institutions active in Sub-Saharan nations. The institutions built the bridge connecting us with the local residents of African nations. Prior to sending the material for these organizations, research was performed in order

to determine the most appropriate form to approach the residents of the Sub-Saharan nations. Therefore, the institutions not only assisted us but they also were planned to become valuable members in the data collection process due to trust and distance constraints.

The dichotomy between the conditions of the subjects was deliberate because we wanted to assess and measure the impact of acculturation in the recognition and preference of icons. Consequently, we were interested in the differences between the Sub-Saharan residents and the Sub-Saharan immigrants living in Europe. Acculturation, defined as the process of individuals associated to one cultural context adapting to new cultural contexts from migration patterns, was one of the factors to be explored. (Berry, 1997).

The descriptive variables used to group and classify subjects were classified as primary and secondary. The primary descriptive variables were gender, age, nationality, native language(s), written literacy and technological proficiency of the subject. The subjects whose condition was defined as immigrant were also subjected to an additional number of descriptive variables classified as secondary descriptive variables. The secondary variables were the following:

- Locality where the individual was raised,
- Current locality of residence and time,
- Previous locality of residence and time,
- Educational level,
- Familiar form of education,
- Reading direction the individual is accustomed to.

The secondary descriptive variables were not only used to assess the level of acculturation but also to gain a more valuable insight about the cultural contexts the subjects were inserted.

Personal information was retrieved from the subjects, and therefore ethical considerations were taken into account during the process. Throughout the entirety of the study, the subject could only participate once the consent provided by the researchers was signed. Additionally, in order to participate, the subject needed to be at least 18 years old. Once the consent was signed, the integrity of the individual, the anonymity of the subject and the confidentiality of the retrieved information were granted to the subjects by the researchers. Furthermore, anytime the subjects felt uncomfortable, did not want to provide certain information or did not want to partake in the investigation anymore, we made sure the rights of the participants were respected. In one particular case, an immigrant refused to provide the place of residence due to suspicion and mistrust. In this case, we understood the subject's point of view and allowed the subject to leave the field in blank.

3.3. Research Approach

This section highlights the methodology and processes utilized to find solutions to the research questions. The work had three stages structured into six distinct research phases aimed to answer a number of specific questions.

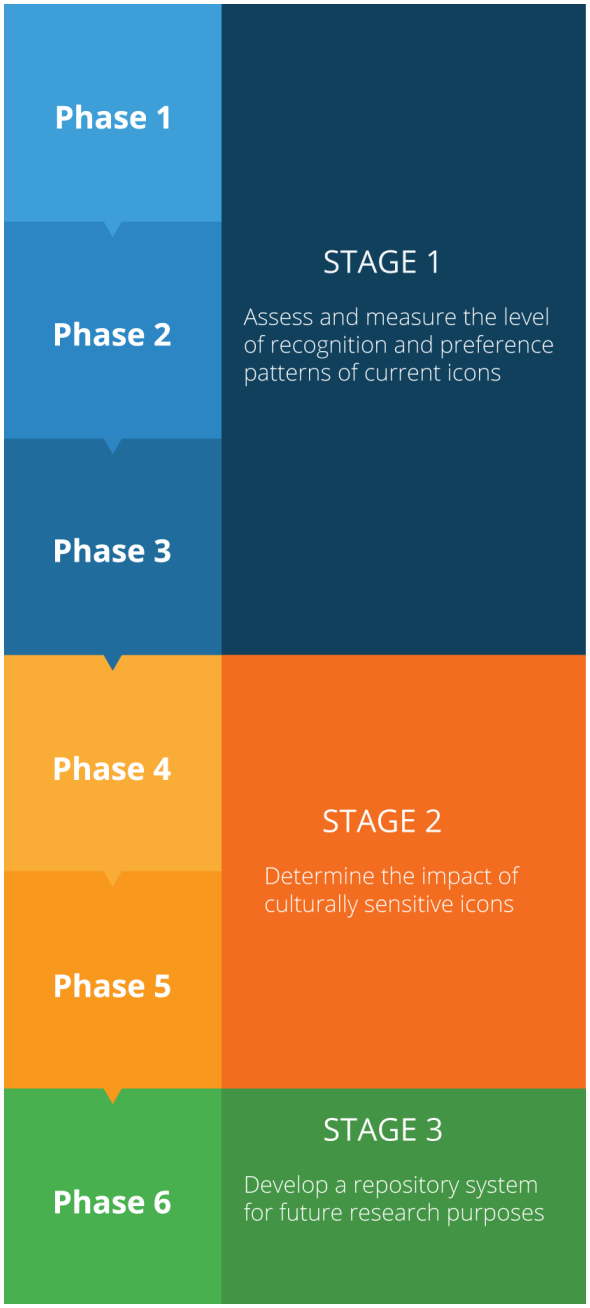


Figure 16. Research Approach of the Study

The first stage of the research aims to assess and measure the recognition level of the subjects regarding existing icons. Afterwards, we attempt to discover preference patterns among African users. This stage employs user research techniques as a form to assess whether the current icon design practices followed by the five most popular operating systems are successful. Subsequently, particular visual elements that constitute an icon are displayed to the subjects as a method to discover whether preference patterns can be correlated to the descriptive variables. This stage of the research approach is comprised by three phases with research questions associated to each phase.

Phase One: Explore the level of recognition of icons utilized in mobile operating system

RQ1: Do African individuals easily understand the icons used in mobile operating systems?

RQ2: Are African individuals without any contact with mobile technology and unable to read and write able to recognize the icons used in mobile operating systems?

RQ3: Is there an evident level of recognition associated to a specific icon?

Phase Two: Determine preference patterns of the users regarding the icons used in mobile operating systems

RQ4: Is there a preference level associated with a specific mobile operating system?
RQ5: Is there a correlation between culture based on nationality and the preferred operating system of the participants?

Phase Three: Establish preference levels of visual elements constituent of an icon

RQ6: Can the preference of the users pertaining to the elements constituents of an icon be correlated to the nationality of individuals?

The next stage determines the impact of culturally sensitive icons and discovers whether or not these icons are preferable compared to icons currently used in the mobile operating systems. This stage is composed by two phases.

Phase Four: Explore the recognition level of culturally sensitive icons

RQ7: Are African individuals more comfortable with culturally sensitive icons than with existing icons from mobile operating systems?
RQ8: Do African individuals recognize and interpret culturally sensitive icons more easily than existing icons from mobile operating systems?

Phase Five: Comparative analysis between culturally sensitive icons and icons from mobile operating systems

RQ9: Do the users prefer culturally sensitive icons or existing icons from mobile operating systems?
RQ10: Can the preference level between the two types of icons be associated with certain descriptive variables?

The last stage of the research is the development of a repository system for future research purposes. The repository aims to inspire and provide solutions for user interface design across multicultural regions. Furthermore, the repository also serves as a platform to decrease the cultural gaps between the Human-Computer Interaction practitioners and the users.

Phase Six: Develop a repository system for user-centered approaches

RQ11: Can a repository system assist in the creation of new culturally sensitive icons?
RQ12: Which elements should be considered as intrinsic in a repository system for user-centered approaches?

To summarize, the six phases are grouped in three stages. The first set aims to assess the recognition level and preference patterns of African users, while the second stage provides a comparative analysis between the icons used in mobile operating systems and culturally sensitive icons. At last, the third stage explains the requirements and explores the benefits of a repository system for user-centered approaches.

3.4. Research Methodology

Quantitative and qualitative methods were used because the combination of methods was optimal to collect substantial statistical values, but also gather significant information about the environment of the subjects and deepen our understanding about the cultural differences in the regions. The combination of objective and subjective results allowed us to understand not only the behavior of the subjects, but also the context that incentivized certain actions, opinions and feelings.

Quantitative methods were used for the majority of the research. These data collection methods enabled us to assess and measure the comprehension and preference values of the subjects and these were administered in two formats, with direct interaction with the subjects or through the use of a smartphone application with a supervisor. Since the evaluations were performed in Portugal and several Sub-Saharan countries, two forms of administration were conceived. The experiments were conducted in natural environments and the difficulties associated with controlling the situation were not a concern. Furthermore, quantitative methods seemed more practical, allowed the collection of data on a larger scale, and the experiments could be conducted in a faster and more objective manner.

Despite having a smaller role due to time limitations, qualitative methods were also used in the research. Even though we needed to quantify the results, we also were interested in collecting opinions, feelings and experiences regarding icons and their role in the user interface. The qualitative approach was used to gather information pertaining to how, why and what made certain icons and its elements preferred over others. The qualitative approaches had additional constraints including the impossibility of the researchers being in the Sub-Saharan countries and the time consumed. Nonetheless, we used qualitative approaches along with quantitative methods, such as observation techniques accompanied by written descriptions for data collection.

The data from the research derived from primary and secondary sources. The primary sources, including interviews, observation and questionnaires, presented a significant larger role compared to the secondary sources. The primary sources were necessary due to support the research with direct input from the end users, but also because these sources were more reliable, and presented more validity and practicality. On the other hand, other primary sources, such as ethnographic research, and secondary sources, namely official statistics and previous research, were utilized for the development of the repository system and the subsequent addition of content in the system.

3.5. Research Design

Figure 17. Research Design of the study

The research was planned with a very clear exploratory design approach. The amount of studies regarding icon design for Graphical User Interfaces in the Sub-Saharan region was limited and we could not establish any predictions or outcomes beforehand. Consequently, an exploratory design approach was implemented in order to gather insight and become familiarized with problems that could be encountered in future research endeavors. An exploratory design approach was necessary to develop a coherent theory but also to determine whether the study is feasible in the future.

The data collected during the research was gathered from direct interaction with the subjects and with the assistance of a data collection applications developed specifically for the project. The data collection application derived from the geographical distance between the researchers and the subjects. The data sent to us, either directly or via e-mail, was analyzed with the help of quantitative and qualitative tools. The results and findings of the experiments came from data analysis methods, and consequently, the data collected always came from primary sources in order to assure reliability.

3.6. Research Process

The research process used in the project generated significant benefits, namely in terms of value and practicality. The process implemented holds significant value mainly because it is able to collect data from a substantial portion of the target population, but at the same time retrieves personal experiences, opinions and values regarding the icons. We used a holistic point of view throughout the entirety of the study and this affected the validity of the information collected in a positive manner. Additionally, the research process has substantial practical value namely due to the lack of information regarding users in the Sub-Saharan region compared to other geographical regions. The large majority of data regarding Sub-Saharan users comes from South Africa, and only a few studies about icon design have been made in the African continent. Therefore, the research has significance to the users located in the African continent, but also for future researchers and practitioners developing solutions for these areas.

The novelty and difficulty of the research is associated with numerous issues that were considered beforehand. Scale of breadth and depth, resources available, time scale of the research, existing resources, existing knowledge and support were issues thought of before designing the experimental procedures. The following figure provides an overview of the issues that were considered before the experimental procedures.

Figure 18. Broad analysis regarding the issues to consider during the study

The scale of breadth and depth was equated since the beginning of the research. Despite our best efforts in collecting data from every cultural group in the African region, the task was unfeasible due mainly to time limitations but also other factors. Nonetheless, we attempted to collect information from every cultural group encountered, meaning our efforts regarding breadth and depth were always to collect the larger amount of data in the most reliable form. The available resources also posed significant issues. The original research data sample consisted only of African immigrants living in Portugal, but we decided that the sample did not only lack to portray the realities of the African people residing in the continent but also did not provide a correct view of the environment surrounding the subjects. Therefore, the data sample was expanded and the availability of resources became more difficult, mainly because it was hard to communicate with people in remote areas.

Time scale, the existing resources, the existing knowledge and the research support were other issues taken into consideration. The time scale for the research was limited because deadlines had to be followed and consequently, certain areas of interest regarding the investigation had to be dismissed. The availability of existing resources and knowledge was also a concern since the beginning of the research because literature associated with icon design in the Sub-Saharan region is fairly limited. Additionally, support from local institutions and organizations were necessary since the beginning of the research in order to approach populations with less experience regarding the use of smartphones and more hesitant towards foreign individuals.

The research process was developed with a strong focus on user research in the initial stage, followed by an iteration phase of design and evaluation. User research was necessary to assess and measure the recognition level and discover preference patterns, while the iteration phase of design

and evaluation was developed to find whether culturally sensitive icons improve user recognition or the use of the current icons in the mobile operating systems are indicated.

The project did not originate from previous research neither is it an extension of previous investigations. On the other hand, certain methodologies and approaches were based on previous research projects, mainly in the fields of Human-Computer Interaction and Cultural Studies. In order to gather valuable and reliable information from the users, the research process was concerned with quantifiable data but also with the opinions, feelings and experiences of the African users. Moreover, even though the focus of the study is to improve user experience and facilitate the integration of Sub-Saharan individuals, the audience of the research is Human-Computer Interaction practitioners and researchers focused on improving the user experience from individuals of different cultural groups.

3.7. Data Collection Methods

The data collection methods used in the research varied according to the situation and can be categorized as manual or computational. The manual data collection methods used pen and paper, while the computational methods required a smartphone and an application specifically designed and developed for data collection in remote areas, titled *Okavango*[2] . The application was developed with web languages, namely HTML5, CSS3, jQuery and jQuery Mobile. JSON was used to store and read the data collected from the subjects. Due to time limitations, the application was only developed for Android devices and the content developed in web languages was adapted for these devices by using Java and XML. Furthermore, the application was available in two out of the most common languages of the African continent: English and Portuguese. A quick user guide to Okavango can be found in Appendix H.

The experimental procedure has three stages with six phases. The experimental procedure related to each phase is discussed below. Additionally, page 92 contains a figure with an overview of the experimental procedure.

2 Okavango is the name of a river in the Sub-Saharan region and this was deemed appropriate not only due to the inexistence of political boundaries but also because rivers carry sediments from one area to another. This analogy seemed appropriate for the research being conducted and consequently, the name was adopted.

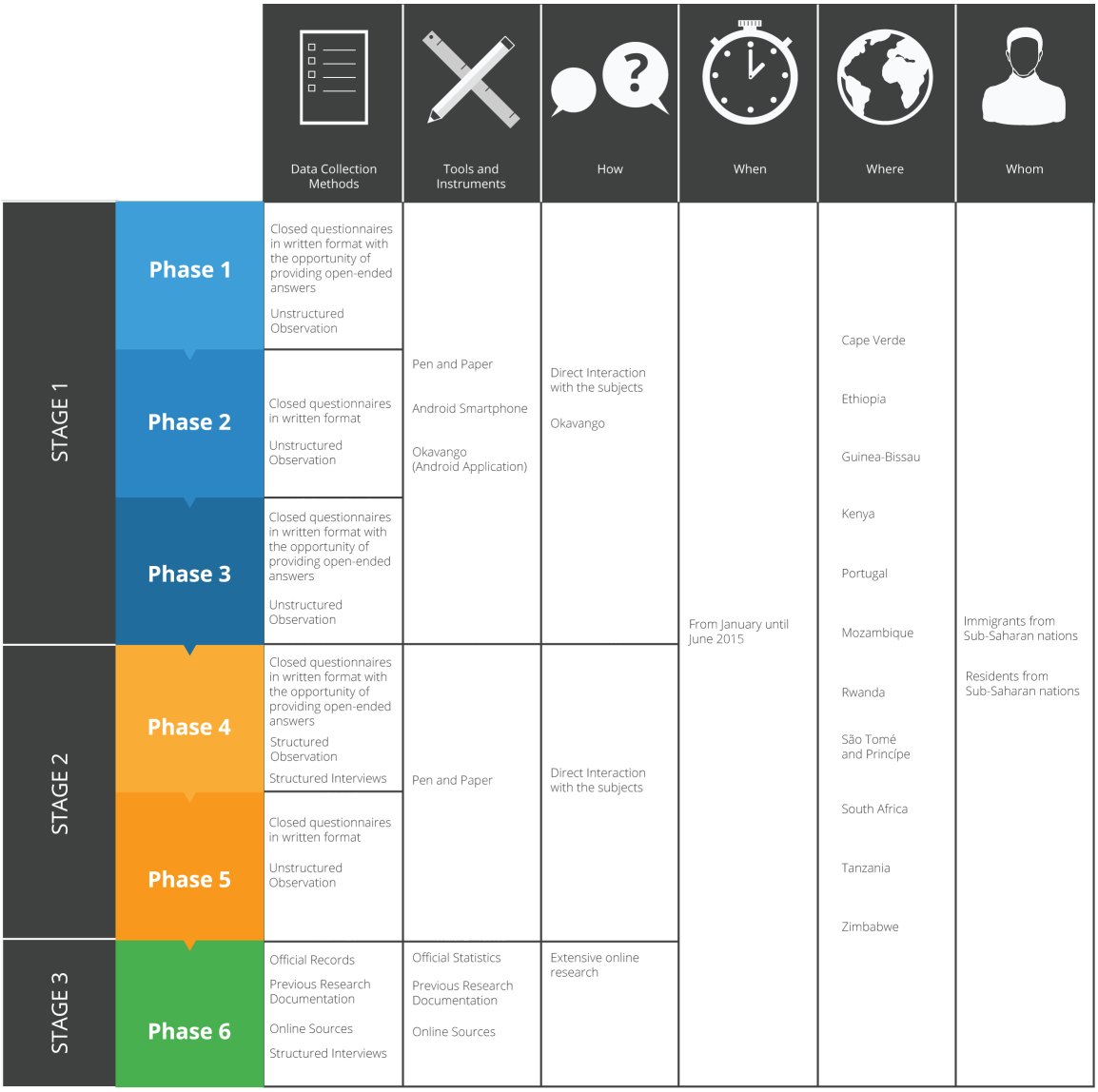


Figure 19. Overview of the Research Stages and Phases

Phase One: Explore the level of recognition of icons utilized in mobile operating system

The first phase of the experiment was preceded by a questionnaire in order to gather information pertaining to the descriptive variables. The procedure in this phase consisted in presenting 16 sets of five icons from distinct mobile operating systems, namely Android, iOS, Blackberry OS, Firefox OS and Windows Phone. Each set conveyed a different action or function associated with smartphones. Afterwards, the subject had to identify the action or function that the set of icons conveyed. For the manual version, open-ended answers were accepted, while the digital version was characterized by having a dropdown list of 58 options (see Appendix E). For the digital version, the subject also had the opportunity to provide an open answer and even though we were not present, a supervisor with mobile proficiency was requested to be present in order to help the subjects with little or no experience with mobile devices. Regardless of the version, the subject could only select or write one option.

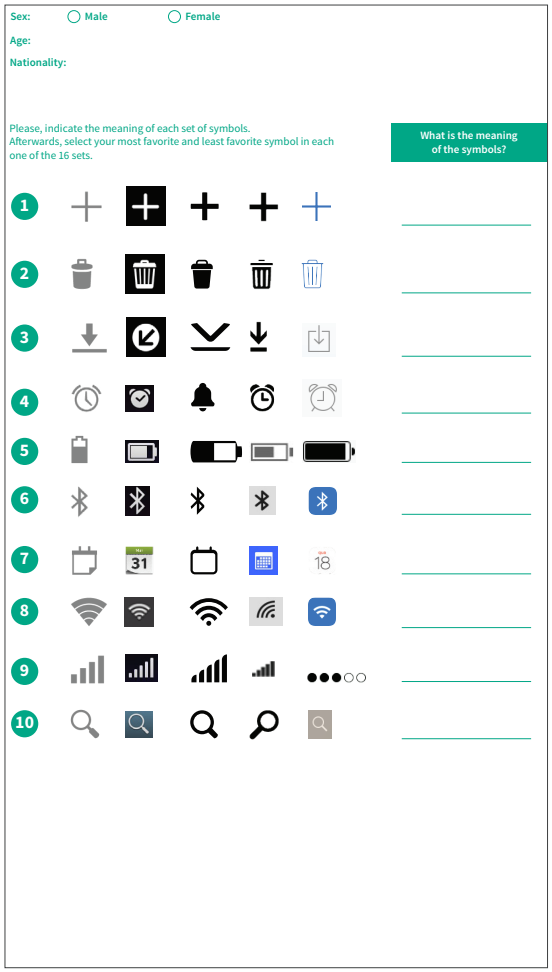


Figure 20. Paper version for Phase One and Two

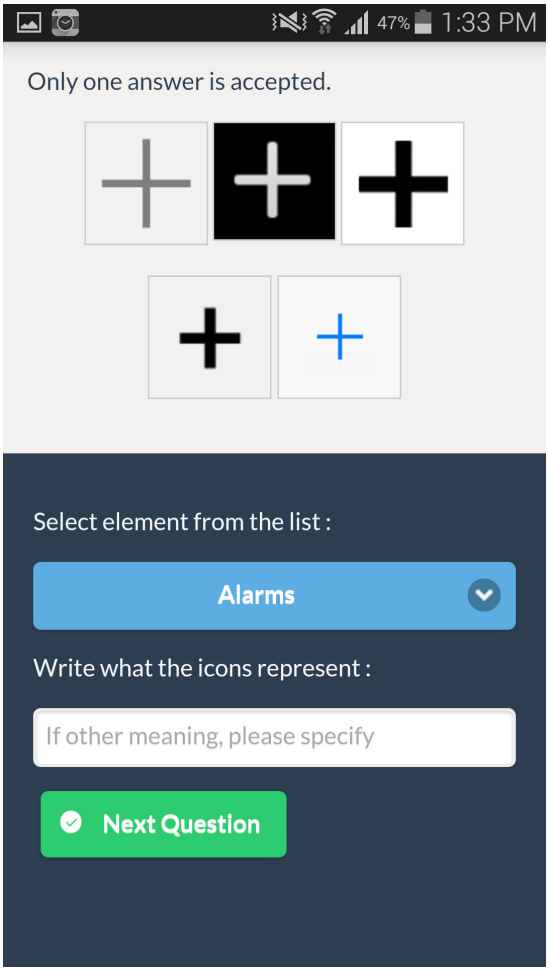


Figure 21. Phase One in Okavango

This phase was performed through direct interaction with the subject and with the use of the application Okavango. The data collection methods utilized consisted of open-answer questionnaires and non-participant observation for the manual version. The digital version used closed form questionnaire with the option of providing an open answer. The tools and instruments utilized were pen and paper for the manual version, and a smartphone with Okavango for the digital version.

Phase Two: Determine preference patterns of the users regarding the icons used in mobile operating systems

The procedure implemented for the second phase was to present the same 16 sets of five icons, and ask the subject to select the favorite and least favorite icon in the set. For the manual version, the subject had to circle the favorite icon and cross the least favorite out of the five options (see Appendix E). In the digital version, the subject was presented with a gallery with the five icons, followed by a dropdown list for each icon of the set. The subject had to select one icon with the option “Favorite” and other with the option “Least Favorite”. Only one icon could be picked as the favorite and another one as the least favorite.

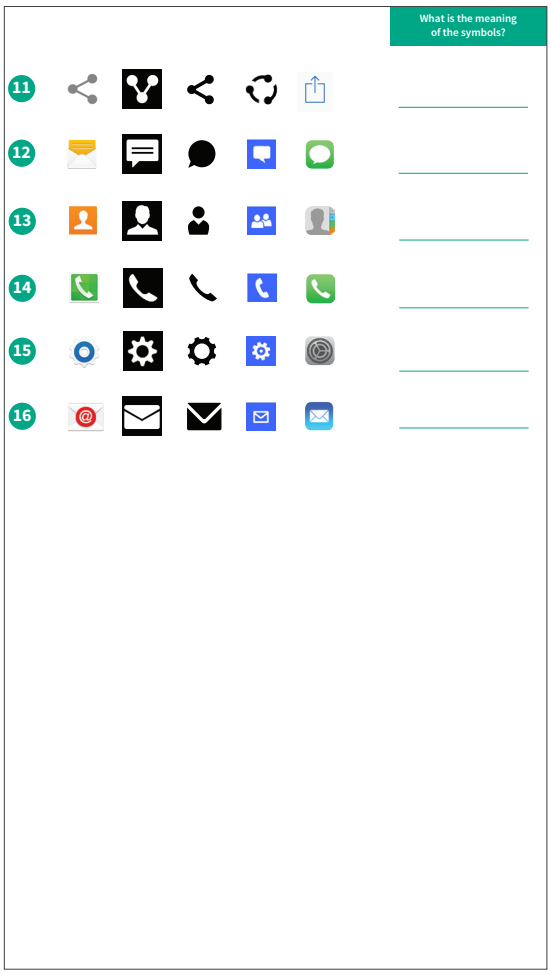


Figure 22. Paper Version for Phase One and Two

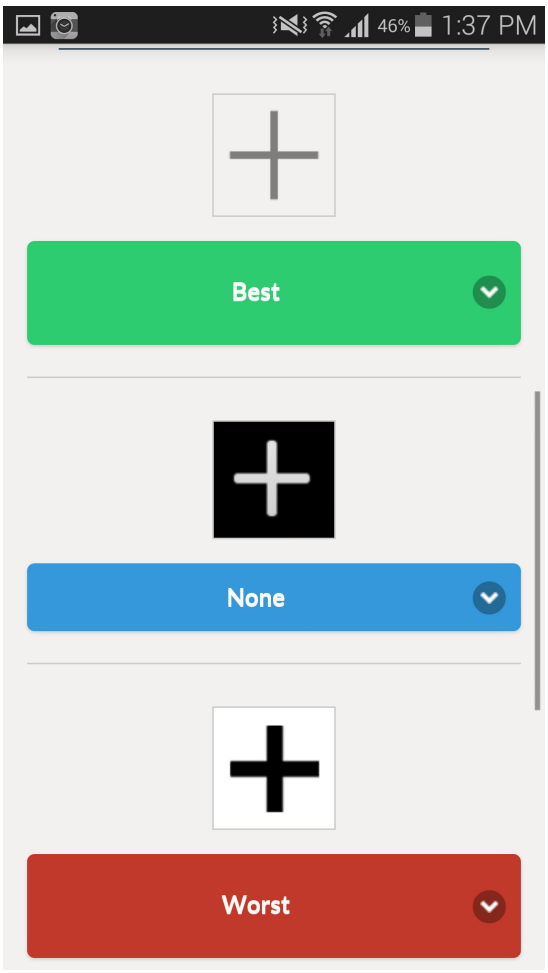


Figure 23. Phase Two in Okavango

Once again, the phase was performed in two different manners, namely through direct interaction with the subjects and with the use of the Okavango application. The data collection method was a closed-form questionnaire, and the tools and instruments used for the manual version were pen and paper and the digital version required the use of a smartphone with Okavango installed.

Phase Three: Establish preference levels of visual elements constituent of an icon

The third phase was concerned with gathering and detecting preference patterns from Sub-Saharan users regarding icon elements. Subsequently, we evaluated the preference of the following elements:

- Semantic Distance;
- Concreteness Level;
- Perspective;
- Background Form;
- Outline thickness;
- Shape and Form;
- Contrast;
- Type;
- Font;
- Color association.

These constituents of an icon were selected due to having a strong visual and aesthetic presence and this phase of the study aimed to categorize these constituents by importance regarding icon recognition. Mcdougall, Curry, and de Bruijn (1999) discuss that symbols are characterized by concreteness, visual complexity, meaningfulness, familiarity and semantic distance. For the purpose of this study, only concreteness and semantic distance appeared to be relevant and other aesthetic elements of an icon were never properly tested. Therefore, the study aims to address the importance of semantic distance and concreteness in the design of icons, but also evaluate whether or not more aesthetic elements have the same amount of relevance for icon interpretation.

For the manual version, the subjects were asked to fill in an eight-page questionnaire in order to gather information about visual elements constituents of an icon. A set of icons was presented to the subject and afterwards, the subject had to select the favorite and least favorite icon from the set (see Appendix F).

The same premise was used in the digital version but the design of the procedure was slightly different. First, the subject was presented with a gallery in order to display the icons together for comparison purposes. Afterwards, the icons were displayed on an individual basis in the screen along with a dropdown list, and the subject had to select the favorite and least favorite out of the options. Once again, only one icon could be selected as the favorite and another one as the least favorite. For the questions regarding color association, each screen contained four colors that the subject had to associate to a list of 38 emotions and traits. The subject was able to select the number of options necessary from the dropdown list, but also write new emotions or traits.

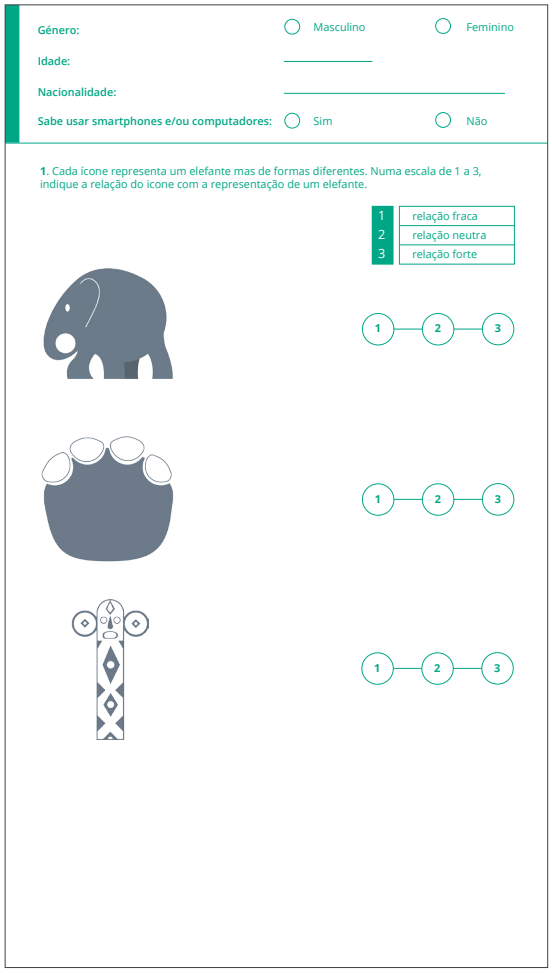


Figure 24. Paper Version for Phase Three

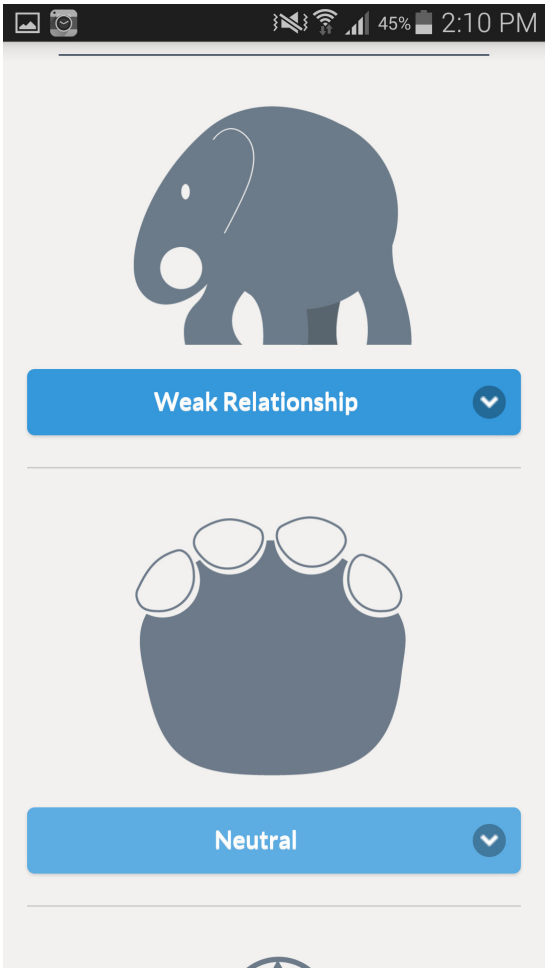


Figure 25. Phase Three in Okavango

Direct interaction with the subjects and the use of the Okavango application were supplied to the subjects. The data collection methods consisted of a combination of close-form questionnaires and open-answer questionnaires. Regarding the tools and instruments used, the manual version required pen and paper, while the digital version needed a smartphone and the Okavango application.

Phase Four: Explore the recognition level of culturally sensitive icons

Due to lack of participation from the Sub-Saharan nations and time limitations, this phase and the subsequent one were only designed in the paper version (see Appendix G). The six icons that represented more difficulties to the subjects were redesigned to retrieve further information. Consequently, six culturally sensitive icons, namely for *add*, *share*, *download*, *search*, *email* and *signal* were created for the São Tomean group. The São Tomean group was the focus of this phase due to São Tomé and Principe presenting the lowest number of mobile cellular subscription per 100 people out of the three groups. Similar to phase one, a culturally sensitive icon was displayed to the participants and they were asked to write the meaning of the icon.

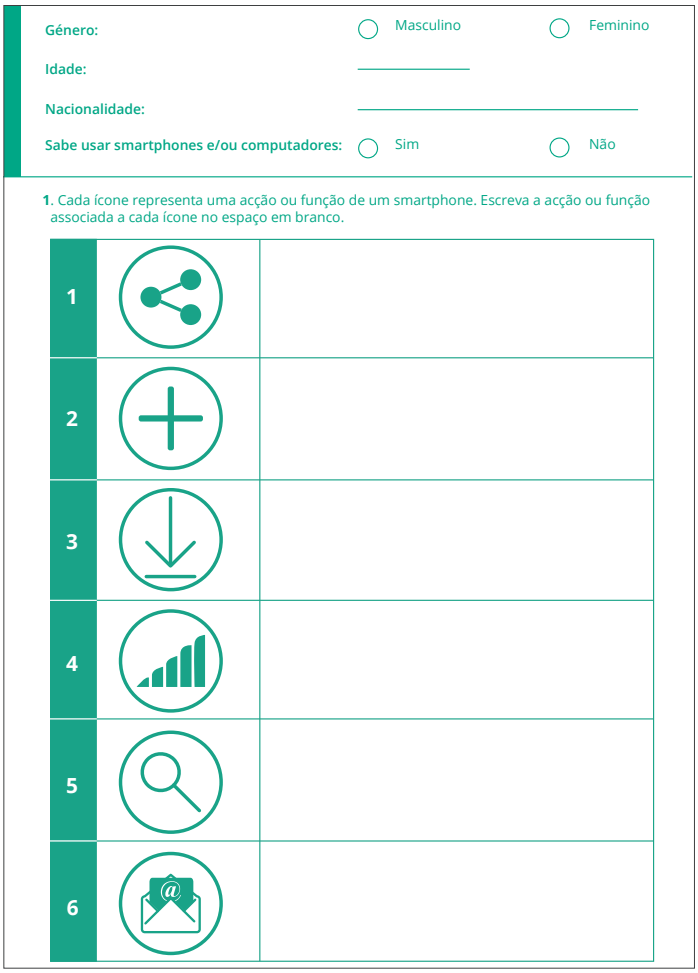


Figure 26. Paper Version for Phase Four

We employed direct interaction with the subjects. The data collection method consisted of open answer questionnaires. The tools and instruments utilized for this phase were pen and paper.

Phase Five: Comparative analysis between culturally sensitive icons and icons from mobile operating systems

In the fifth phase of the research, the subjects had to choose the preferred icon between a culturally sensitive icon (designed using the findings from the previous phases) and one icon from a mobile operating system. The icon from the mobile operating system was always the one with the greatest percentage of recognition level. A page with six sets of icons, comprised by one culturally sensitive icon and one icon from a mobile operating system was supplied to the participants (see Appendix G). Afterwards, the subjects were asked to select their preferred icon out of the two options.

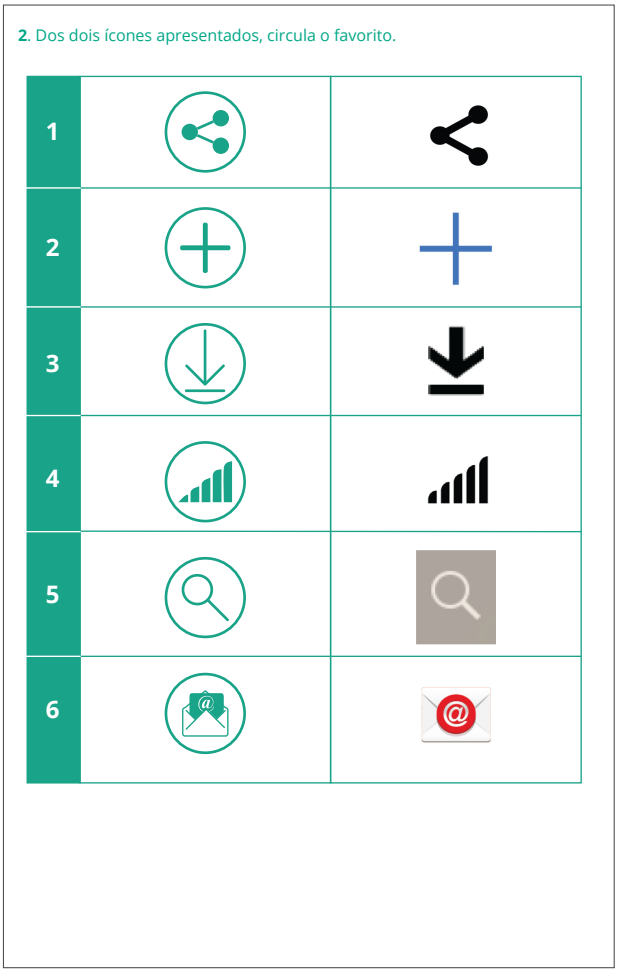


Figure 27. Paper Version for Phase Five

Once again, we employed direct interaction with the subjects. The data collection method used was a closed-form questionnaire, and pen and paper were required.

Phase Six: Develop a repository system for user-centered approaches

The last phase of the research consists in the development of a repository system for design purposes. The repository entitled TIQSI relies on primary data collection and secondary sources, such as official statistics, previous research projects, and online sources, in an equal manner. The secondary sources are categorized into four different typologies: images, video, music and text. The repository system aims to inspire and inform future designers in order to develop user interface elements more indicated for a particular cultural group.

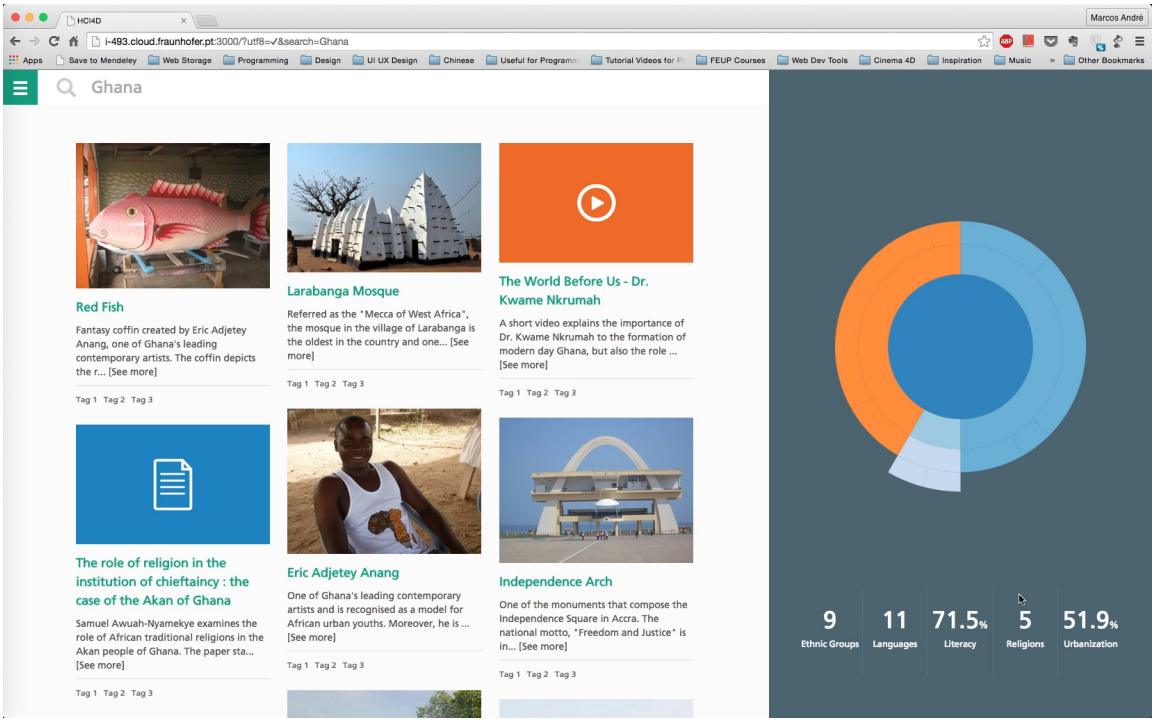


Figure 28. Screenshot of the TIQSI platform

The data was collected from several online sources, and languages such as HTML5, CSS3, JavaScript, Ruby and SQL, were used to develop the system. HTML5, CSS3 and JavaScript were respectively implemented for front-end markup, styling and behavior. Meanwhile, Ruby On Rails for server communication and SQLite to store the information supplemented the back-end development of the platform. During this phase, there was no direct interaction with the subjects regarding data collection. However, interviews about the usability of the system were employed.

Prior to the implementation process, the platform sustained several iterations regarding the most appropriate information architecture for professionals without substantial knowledge about developing nations. In order to refine the navigation, usability and information architecture of the platform, affinity diagrams were utilized with other professionals in the Human-Computer Interaction field, and conversations with specialists in cataloguing and indexing of materials took place.

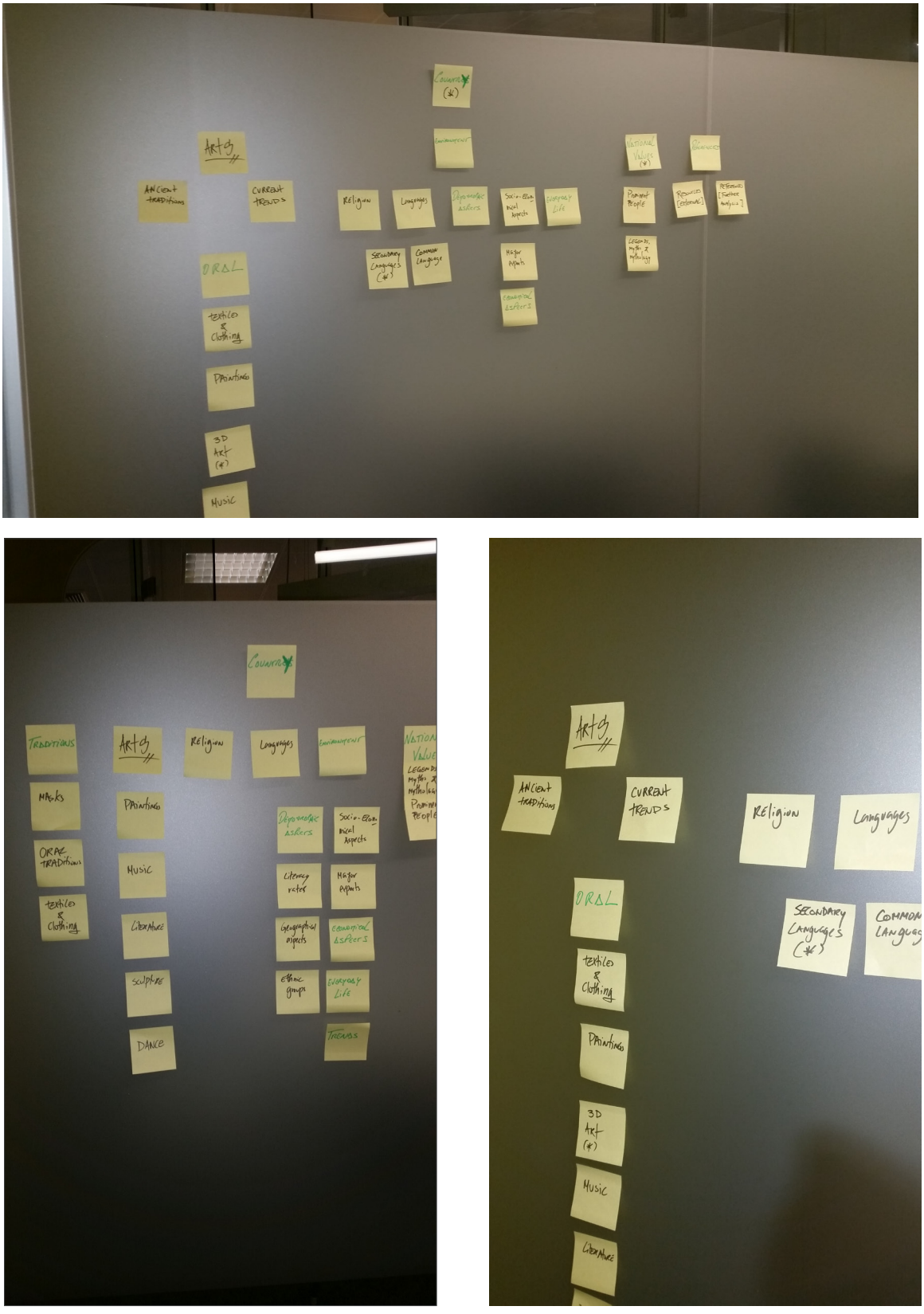


Figure 29. Affinity Diagram to determine the Information Architecture of the platform

The final version of the information architecture in the beta version derived from the expertise of several professionals and went through several changes before the implementation of the platform. A pivotal source in the refinement of the Information Architecture was the Universal Decimal Classification (UDC) developed by Paul Otlet and Henri La Fontaine during the end of the 19th century. UDC aims to arrange the branches of human knowledge in a systematic manner and the enhancement of the interconnectivity between branches was one of the main arguments to utilize

this reference. Similar to the philosophy of this taxonomic system, culture is an interlinked flow of shared information.

The information architecture was designed with the intent to categorize and structure cultural identifiers. Four levels of information, entitled branches, categories, fields and sub-fields, comprise the information architecture. The branches were separated into three areas: *Country*, *Protocols* and *FAQs*. The *Country* branch is the main focus of the platform due to containing the cultural and social information pertaining to each country. The *Protocols* branch contains information pertaining to documentation of the platform and Human-Computer Interaction procedures that assist in the development of user-centered solutions.

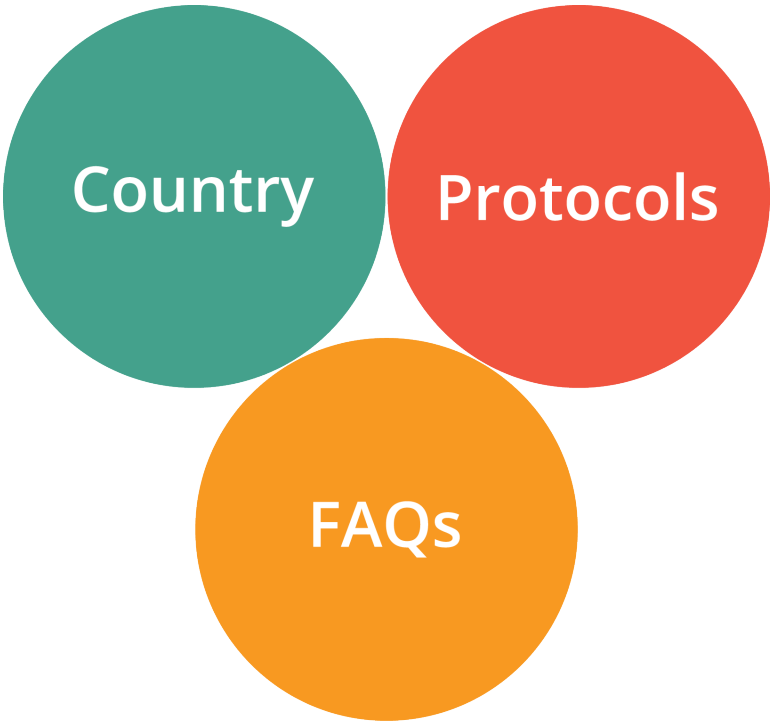


Figure 30. The three branches comprising TIQSI : Country, Protocols and FAQs

The next level of information are the categories, and it is evidenced in the country and protocols branches. The country branch has three categories named *Artistic Forms and Traditions*, *Social Data* and *Shared Values*. The category *Artistic Forms and Traditions* is responsible for storing the visual, literary and auditory information that represent cultural identifiers within a particular cultural group. On the other hand, the category *Social Data* displays statistical data of a particular country. The category *Shared Values* is a malleable area of information that stores data pertaining to shared values within a country but also shared characteristics in rural and urban settings of the country.

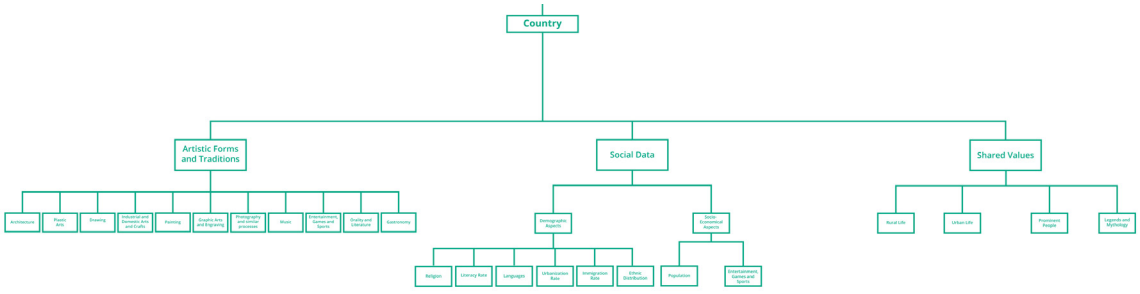


Figure 31. Overview of the *Country* branch

The *Protocols* branch also contains two categories, denominated *Documentation* and *Procedures*. The *Documentation* category stores documents responsible for maintaining the platform organized and sustainable over time, while the *Procedures* category contains documents able to assist researchers in certain Human-Computer Interaction procedures, such as conducting usability tests.

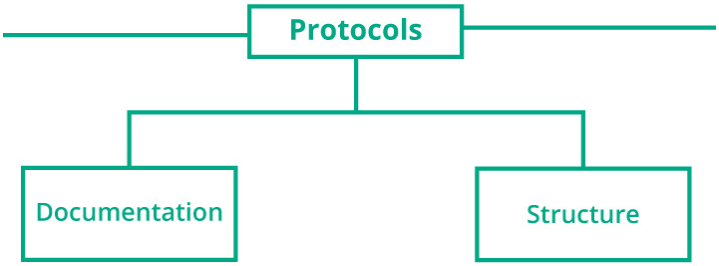


Figure 32. Overview of the *Protocols* branch

The subsequent levels of information are the fields, which can be visualized as the children of categories. This level of information is only depicted in the country branch. The fields whose parent is the *Artistic Forms and Traditions* category are the following:

- Architecture
- Plastic Arts
- Drawing
- Industrial and Domestic Arts and Crafts
- Painting
- Graphic Arts and Engraving
- Photography and Similar Processes
- Music
- Entertainment, Games and Sports
- Orality and Literature
- Gastronomy

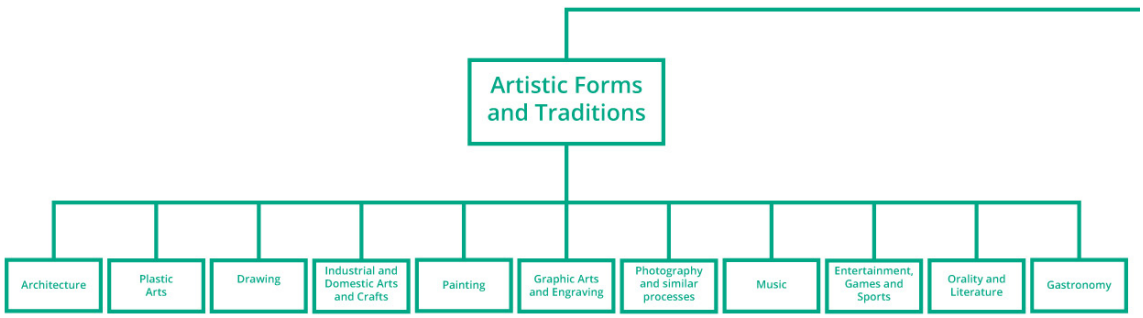


Figure 33. Fields comprising the *Artistic Foms and Traditions* field

The sub-fields inside the fields located in the *Artistic Forms and Traditions* are extensive and detailed by nature and for clarification about these sub-fields, the documentation category of the platform must be visited.

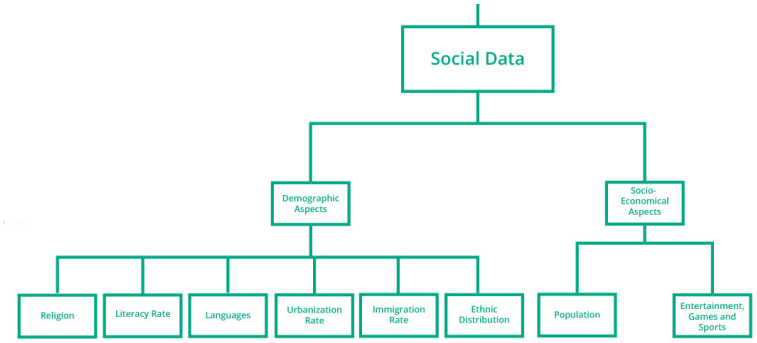


Figure 34. Overview of the *Social Data* field

On the other hand, two large fields, entitled *Demographic Aspects* and *Socio-Economical Aspects*, compose the *Social Data* category. The field *Demographic Aspects* contains the following parameters:

- Religion
- Education
- Languages
- Urbanization Rate
- Immigration Rate
- Ethnic Distribution

Meanwhile, the field *Socio-Economical Aspects*, is comprised by two sub-fields, respectively Population and Entertainment, Games and Sports.

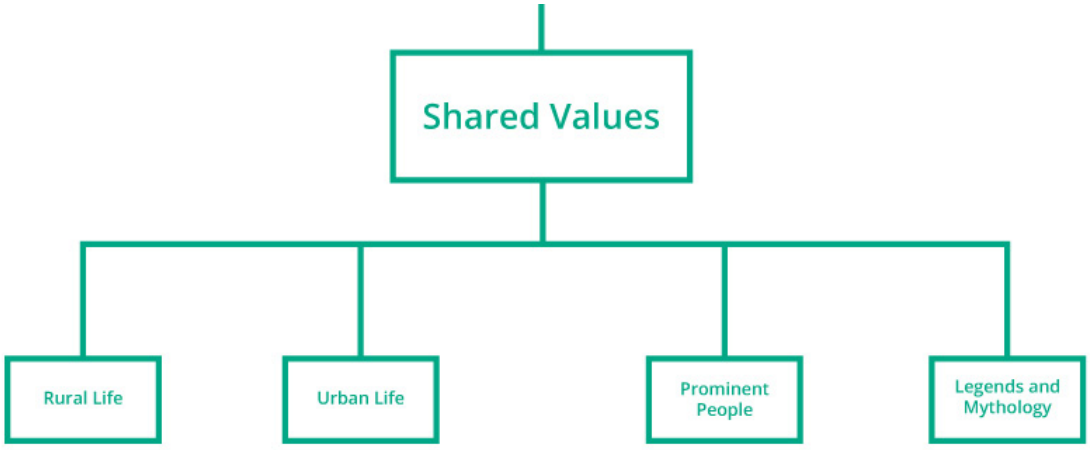
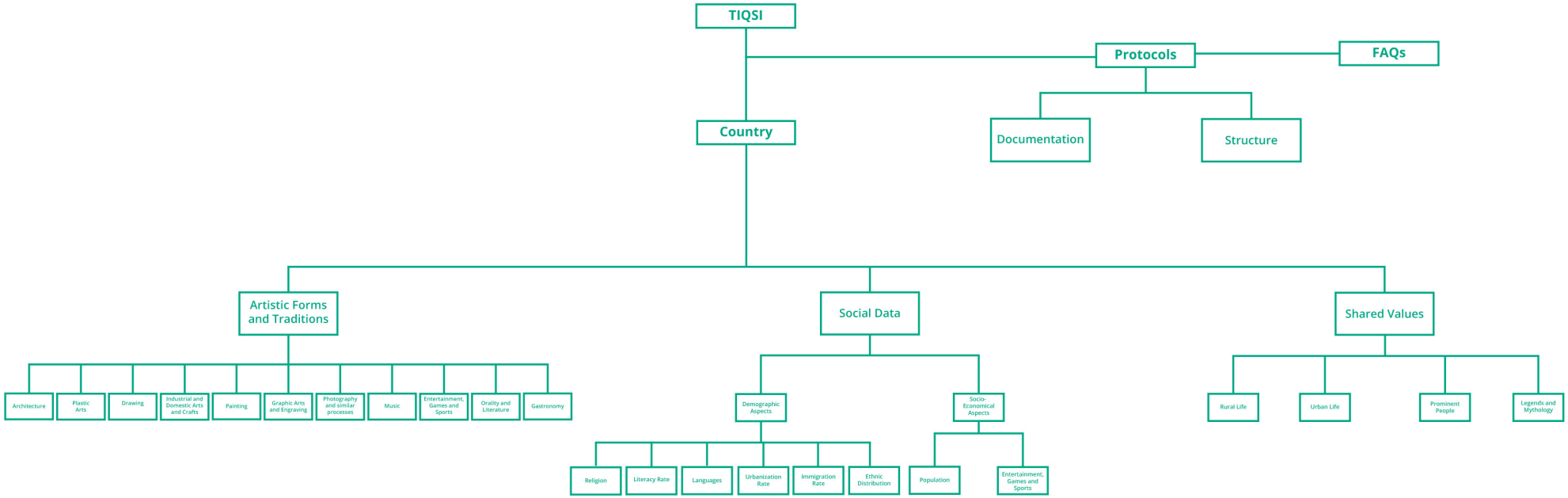


Figure 35. Overview of the *Shared Values* field

Regarding *Shared Values*, four fields, namely rural life, urban life, prominent people, and legends and mythology, compose the category.

Table 07. Information Architecture for TIQSI



After establishing the information architecture of the platform, a beta version was developed. In order to determine the necessity of this platform, a usability testing was administered to twelve professionals in the areas of Design, Human-Computer Interaction, Web Development and Mobile Development. The evaluation of the platform took place at Fraunhofer AICOS due to convenience and because it simulated the type of environment the platform will be utilized. The usability testing only required a laptop computer and therefore, a 15-inch Macbook Pro from Mid-2010 was used for the evaluation of the platform. Moreover, Silverback 2.0 was used to capture the screen during the evaluation and record the emotions and behaviors of the users during the interaction process.

The usability testing was divided into five segments. The first segment of the usability testing consisted in providing general information to the participants, and explaining the problems and issues that lead to the creation of TIQSI. Once the goals of the usability testing were explained, we handed an informed consent to the participant and informed the person that the usability testing was going to be recorded. Afterwards, a small background questionnaire and a couple of questions were administered to the participant. The third segment explained the procedure and sequence of the test. During the fourth segment of the usability testing, the participants were asked to perform the following six tasks:

1. Search for 'Ghana' and open the cultural artifact entitled "Mausoleum of Kwame Nkrumah".

2. Close the modal window, search for 'Liberia' and indicate the values of the following social data indicators: Ethnic Groups, Languages, Literacy, Religion and Urbanization.

3. Search for 'Cameroon', filter the results by Architecture and open the cultural artifact named "*Bandjoun Chefferie*".

4. Return all results for 'Cameroon' and filter the results with the alternative method of navigation. Filter the results by Architecture and open the cultural artifact entitled "Yaoundé Centre".

5. Search for 'Ghana' and play the sound file named "Postal Workers Cancelling Stamps".

6. Search for 'Liberia', and open the text file named "International Human Rights, Gender-Based Violence, and Local Discourses of Abuses in Postconflict Liberia: A Problem of "Culture"?".

After each task was completed, a couple of follow-up questions were asked to the participants. Once all the tasks were performed, a System Usability Scale questionnaire was administered to the participants and a post-session questionnaire was conducted. The post-session questionnaire was conducted as a form to retrieve other valuable feedback from the users. The post-session questionnaire was composed of 15 questions:

1. Can the platform act as a viable repository for cultural material? If yes, why is that?

2. Can the platform assist in the creation of user-centered solutions for culturally different audiences?

3. Do you believe this platform can be used on a regular basis for inspiration and consultation purposes?

4. Do you think the platform is easy to use?

5. Is the navigation within the platform intuitive?

6. Which navigation method out of the two is the easiest to understand and use?

7. What can be done to improve the least intuitive method of navigation?

8. Is the amount of information in the description adequate? If not, do you believe the amount of information is too little or too much?

9. Is the information placed in a consistent manner?

10. Is the information placed in an obvious and explicit manner?

11. Is the content of the platform easy to read?

12. Is the use of local terms in the title appropriate?

13. Are the titles and description helpful?

14. Do you believe the presence of external links with curated material is a good addition to the platform?

15. What is your overall opinion about the platform?

The findings and results of this usability testing were compiled and documented in a report in order to establish the modifications necessary for the next version of the platform.

3.8. Data Analysis Methods

Data analysis is the process of answering research questions as well as determining trends and relationships among the variables. The collected data was processed, displayed in tables and graphs, and subsequently, analyzed and interpreted. Considering qualitative and quantitative data were collected, the data analysis also employed qualitative and quantitative data analysis methods.

Similar to the data collection methods, the majority of the methods utilized in the data analysis process are quantitative. Inferential statistics were used to analyze the quantifiable data, enabling us to draw conclusions about a particular population based on the descriptive variables of the study. Inferential statistics are based on the laws of probability and assisted the researchers in testing hypothesis. SPSS was used to calculate the quantitative data of the study.

Qualitative data analysis was also employed in the research, in particular during the sixth phase of the research process. A deductive approach was used and we looked for similarities and differences regarding the subjects' opinions and experiences. Narrative analysis appeared to be the indicated type of qualitative data analysis due to transcribing the experiences of the subjects. Observations regarding context and setting, people, the process, and issues the people encountered during the process were documented in the narrative analysis. In order to guarantee that no data was lost during the process, Silverback 2.0 was used as a form to record the reactions and behaviors of the participants, as well as the screen during the interaction process. Subsequently, these video files were visualized and analyzed, and conclusions were drawn from these observations.

3.9. Summary

Chapter three began with an introduction of the research setting, namely the Sub-Saharan region of the African continent and afterwards, the research sample was documented. It was determined that the utilization of a treatment group and a control group was optimal for comparative analysis. The treatment group contained immigrants and residents from the Sub-Saharan region of Africa, from 16 different nations whose official languages varied between Portuguese, English and French. On the other hand, the control group consisted of Portuguese nationals.

The next topic of the chapter was the research approach, which has fourteen research questions in six distinct phases of the research. Furthermore, the six research phases are separated into three stages. Pertaining to the research methodology, the majority of the study uses quantitative data collection and data analysis methodologies, but a smaller part of the research utilizes qualitative methods. Moreover, primary sources were preferred during Stage One and Stage Two due to credibility and reliability reasons. The research design was planned with a very clear exploratory design approach and the collected data came from direct and remote interaction methods. In addition, the design of the research employs user research, along with design and evaluation processes. The research process discusses the issues to consider during the study and these range from scale of breadth and depth, availability of resources, time scale, existing resources, existing knowledge and supporting channels. Furthermore, the research process indicates that the target audience of this research is Human-Computer Interaction practitioners and researchers focused on improving the user experience of individuals from different cultural groups.

The data collection methods, data analysis methods and tools are also approached in this chapter. The experimental procedure of each phase of the study is described and the development of TIQSI and Okavango is explained. Regarding Data Analysis methods, software tools including SPSS and Silverback 2.0 were used to analyze and interpret quantitative and qualitative data.

Chapter Four
Findings and Results

4. Findings and Results

4.1. Introduction

Prior to this chapter, the methodology implemented in the work was described. This chapter aims to describe the participants involved in each phase of the work, but also provide a detailed view of collected results and briefly discuss these results. This chapter follows the same structure as the methodology chapter, meaning each phase is grouped under its respective stage.

4.2. Stage One

4.2.1. Phase One

The first step in the research consisted in determining the level of recognition of the users regarding icons from mobile operating systems. The aim of this phase was to assess the levels of recognition and to compare them with the descriptive variables to discover any correlation. As previously mentioned, the research questions for this phase were the following:

RQ1: Do African individuals easily understand the icons used in mobile operating systems?

RQ2: Are African individuals without any contact with mobile technology and unable to read and write able to recognize the icons used in mobile operating systems?

RQ3: Is there an evident level of recognition associated to a specific icon?

Participants

A total of fifty-three subjects participated in the first phase of the study. The experimental group comprised twenty-eight individuals from different African nations. On the other hand, the control group was formed by twenty-five Portuguese nationals (16 males and 9 females) between the ages of 18 and 24. The median age of the control group was 19.40 (SD= 1.47). All subjects were students in Porto. A minimum number of individuals to compose a group was established based in two references (Kim & Lee, 2005; Yumiao, Jiang, & Zhongliang, 2010).

The individuals from the experimental group were divided into two groups: Cape Verdeans, and São Tomeans. The Cape Verdean group had 7 males and 4 females between the ages of 19 and 26. The average age of the Cape Verdean group was 21.55 (SD = 2.50). The São Tomean group had 4 males and 10 females between 18 and 23 years old. The average age from the individuals in this group was 20.78 (SD = 1.85). Participants were recruited around schools and organizations in the Porto area, in Portugal, and in a number of African nations. Unfortunately, the majority of the participants from African nations either did not respond in time or did not want to partake in the research[3]. Only 3 South African nationals residing in their home country participated in the test.

3 The study was designed to include a sample composed of Sub-Saharan immigrants living in Europe and nationals of African nations residing in their home countries. The latter audience hardly participated in the study, and the objective of deploying the Okavango application to several countries was to retrieve information from this audience. Therefore, the participation of individuals across multiple countries was not feasible, and the main focus of the work was switched to immigrants residing in Portugal, which were easier to access in comparison to the residents.

Figure 36. Set of *Add* icons from Android, Blackberry OS, Firefox OS, Windows Phone and iOS in their respective order

Figure 37. Set of *Alarm* icons from Android, Blackberry OS, Firefox OS, Windows Phone and iOS in their respective order

Figure 38. Set of *Battery* icons from Android, Blackberry OS, Firefox OS, Windows Phone and iOS in their respective order

Figure 39. Set of *Bluetooth* icons from Android, Blackberry OS, Firefox OS, Windows Phone and iOS in their respective order

Figure 40. Set of *Calendar* icons from Android, Blackberry OS, Firefox OS, Windows Phone and iOS in their respective order

Figure 41. Set of *Contacts* icons from Android, Blackberry OS, Firefox OS, Windows Phone and iOS in their respective order

Figure 42. Set of *Delete* icons from Android, Blackberry OS, Firefox OS, Windows Phone and iOS in their respective order

Figure 43. Set of *Download* icons from Android, Blackberry OS, Firefox OS, Windows Phone and iOS in their respective order

Figure 44. Set of *Email* icons from Android, Blackberry OS, Firefox OS, Windows Phone and iOS in their respective order

Figure 45. Set of *Message* icons from Android, Blackberry OS, Firefox OS, Windows Phone and iOS in their respective order

Figure 46. Set of *Phone* icons from Android, Blackberry OS, Firefox OS, Windows Phone and iOS in their respective order

Figure 47. Set of *Search* icons from Android, Blackberry OS, Firefox OS, Windows Phone and iOS in their respective order

Figure 48. Set of *Settings* icons from Android, Blackberry OS, Firefox OS, Windows Phone and iOS in their respective order

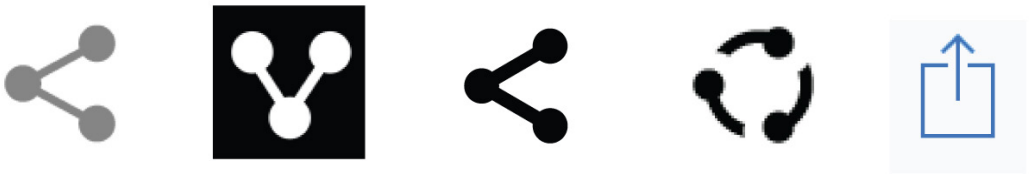


Figure 49. Set of *Share* icons from Android, Blackberry OS, Firefox OS, Windows Phone and iOS in their respective order

Figure 50. Set of *Signal* icons from Android, Blackberry OS, Firefox OS, Windows Phone and iOS in their respective order

Figure 51. Set of *Wi-fi* icons from Android, Blackberry OS, Firefox OS, Windows Phone and iOS in their respective order

Results

The data was collected in order to assess the recognition level of the participants and consequently, the task completion rate and the percentages of the correct answers were annotated. The two metrics aimed to discover the rate of people that do not recognize the icon or have a misconception regarding a specific icon. Two experimental groups and a control group segmented the presented data.

From a general point of view, the Cape Verdean group had a greater level of recognition regarding icons compared to the São Tomean group. The Cape Verdean group presents a task completion rate of 93.2 %, while the São Tomean group displays a percentage of 87.1% regarding the recognition of icons. From the sixteen icons displayed to the participants, only four did not present a perfect task completion rate and these are the *add* icon (54.5 %), the *download* icon (81.8%), the *signal* icon (90.9%) and the *share* icon (63.6%). The other twelve icons had a perfect task completion rate from the Cape Verdean group.

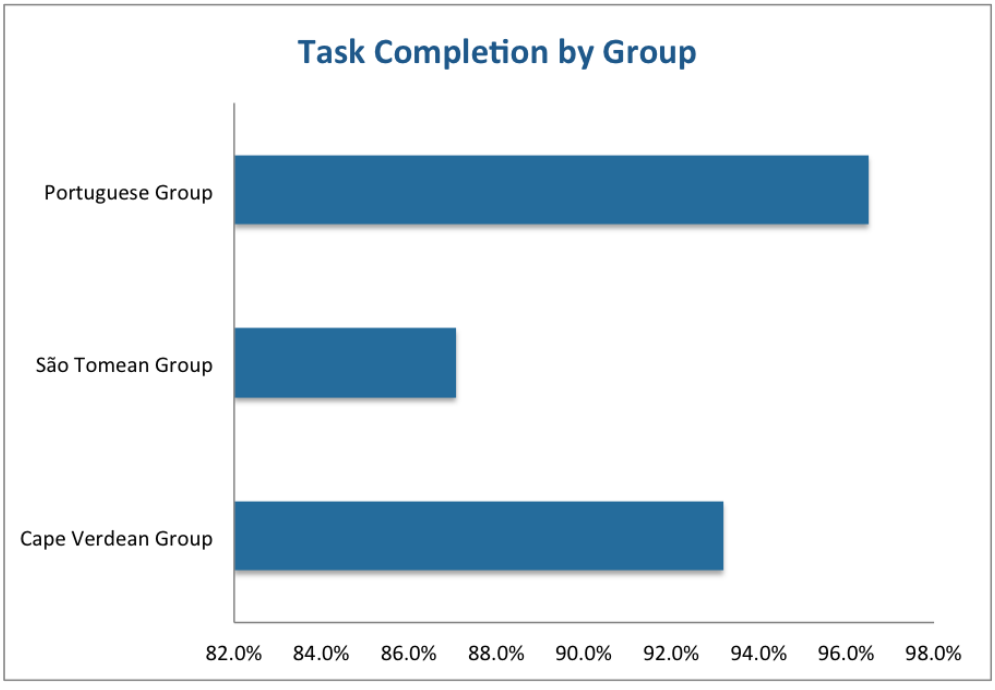
Regarding the percentage of correct answers from the Cape Verdean group, the group displayed an 85.5% of correct answers and 14.2% of incorrect answers. Thirteen icons presented incorrect answers and only three of the icons had a perfect percentage of correct answers. Out of the thirteen icons, five had a percentage below 90% and these were: the *add* icon (45.5%), the *download* icon (72.7%), the *signal* icon (81.8%), the *share* icon (63.6%) and the *email* icon (81.8%).

On the other hand, the São Tomean group had a task completion rate of 87.1 % and only five out of the sixteen icons had a perfect task completion rate. The lowest task completion rate belonged to the *share* icon (35.7%). Other icons, namely *add* (50%), *delete* (92.9%), *download* (85.7%), *Bluetooth* (92.9%), *Wi-Fi* (92.9%), *signal* (92.9 %), *search* (71.4%), *share* (35.7%), *message* (92.9%), *contacts* (92.9%) and *email* (92.9%) also had task completion rate below 100%.

The percentage of correct answers also differs in comparison to the Cape Verdean group. The São Tomean group has a rate of 76.3% of correct answers. On the other hand, the group has 23.7 % of incorrect answers. Three icons, namely *add* (35.7%), *download* (42.9%) and *share* (21.4%) have low percentages of correct answers. Additionally, out of the sixteen icons, only two icons have a perfect percentage of correct answers.

The control group, composed of Portuguese nationals, had better results pertaining to the task completion rates and the percentage of correct answers. The control group presented a task completion of 96.5% and out of the sixteen icons, only three had a task completion rate below perfection. The three icons without a perfect task completion rate were *add* (84%), *download* (88%) and *share* icon (72%). The percentage of task completion of these three icons is superior to the percentage of task completion of the two groups comprising the experimental group.

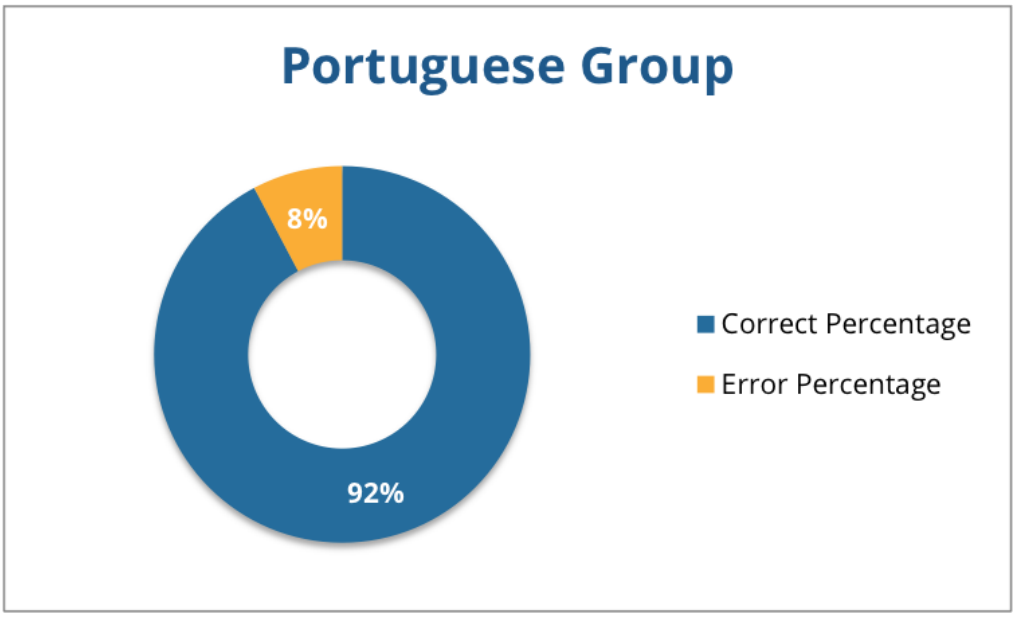
The control group has a percentage of 92.3 % of correct answers and only 7.7 % of incorrect answers. Pertaining to the percentage of correct answers per icon, the control group presents five icons (*delete*, *battery*, *Bluetooth*, *calendar* and *settings*) with a perfect percentage of correct answers. The number of icons with perfect percentage of correct answers is also superior to the ones encountered in the Cape Verdean and the São Tomean group. Besides the *add* icon, which has a percentage of 76%, no other icon has a percentage of correct answers below 84%.



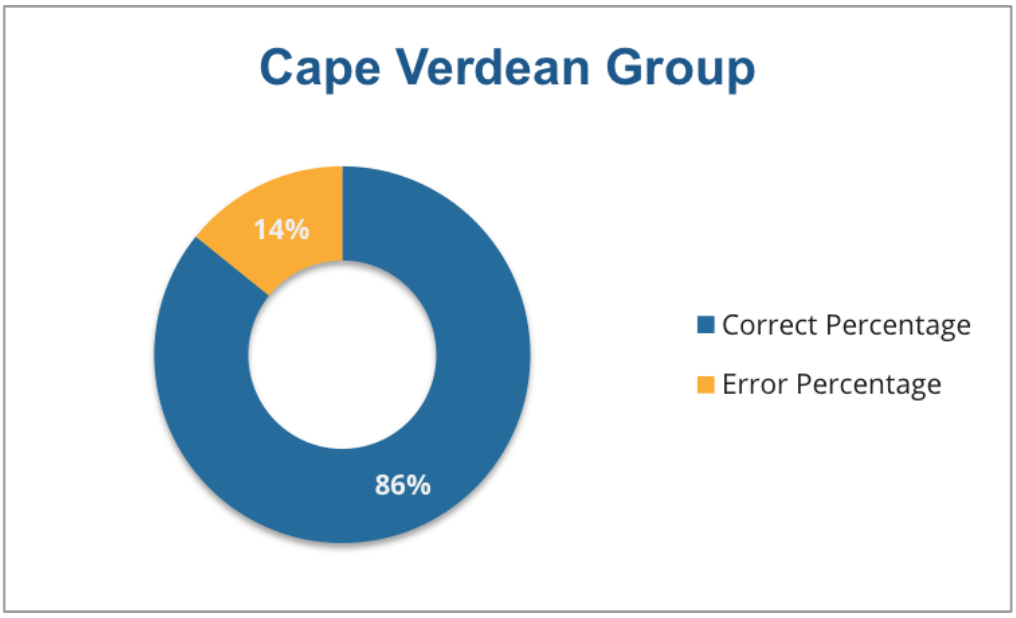
Graph 01. Task Completion of Phase One by group

Task Completion			
Icon	Cape Verdean Group	São Tomean Group	Portuguese Group
Add	54,5%	50,0%	84,0%
Delete	100,0%	92,9%	100,0%
Download	81,8%	85,7%	88,0%
Alarm	100,0%	100,0%	100,0%
Battery	100,0%	100,0%	100,0%
Bluetooth	100,0%	92,9%	100,0%
Calendar	100,0%	100,0%	100,0%
Wifi	100,0%	92,9%	100,0%
Signal	90,9%	92,9%	100,0%
Search	100,0%	71,4%	100,0%
Share	63,6%	35,7%	72,0%
Message	100,0%	92,9%	100,0%
Contacts	100,0%	92,9%	100,0%
Phone	100,0%	100,0%	100,0%
Settings	100,0%	100,0%	100,0%
Email	100,0%	92,9%	100,0%
Task Completion	**93,2%**	**87,1%**	**96,5%**

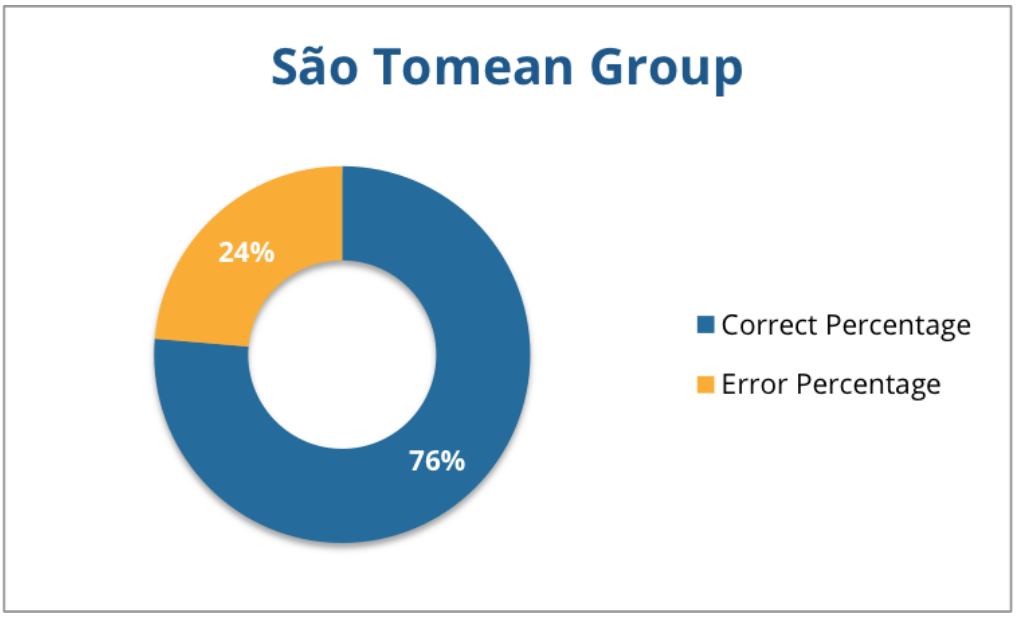
Table 08. Table of Task Completion per icon



Graph 02. Distribution of correct and incorrect answers of the Portuguese Group



Graph 03. Distribution of correct and incorrect answers of the Cape Verdean Group



Graph 04. Distribution of correct and incorrect answers of the São Tomean Group

Correct Answers			
Icon	Cape Verdean Group	São Tomean Group	Portuguese Group
Add	45,5%	35,7%	76,0%
Delete	100,0%	92,9%	100,0%
Download	72,7%	42,9%	84,0%
Alarm	100,0%	85,7%	96,0%
Battery	90,9%	100,0%	100,0%
Bluetooth	90,9%	92,9%	100,0%
Calendar	90,9%	85,7%	100,0%
Wifi	90,9%	100,0%	96,0%
Signal	81,8%	71,4%	84,0%
Search	90,9%	71,4%	96,0%
Share	63,6%	21,4%	68,0%
Message	100,0%	85,7%	96,0%
Contacts	90,9%	85,7%	96,0%
Phone	90,9%	92,9%	96,0%
Settings	90,9%	92,9%	100,0%
Email	81,8%	64,3%	88,0%
Percentage of Correct Answers	**85,8%**	**76,3%**	**92,3%**
Percentage of Wrong Answers	**14,2%**	**23,7%**	**7,7%**

Table 09. Table of Correct Answers per icon

Discussion

A number of interesting conclusions were drawn from this experiment and disparities between the groups were found. The primary conclusions drawn from the study were the following:

The control group displays a higher percentage of recognition compared to the two agglomerates of the experimental group

The control group had a task completion rate of 96.5% and a percentage of correct answers reaching 92.3%. The task completion rate of the control group was 3.3% greater than the Cape Verdean group and 9.4% greater than the São Tomean group. On the other hand, the control group presented a 6.5% increase of correct answers in comparison to the Cape Verdean group and a 16% increase compared to the São Tomean group. The collected data shows the control group recognizes icons better than the two groups from the Sub-Saharan region.

Each of the agglomerates from the experimental group presented percentages of incorrect answers superior to the control group

The São Tomean group was the one that presented the greatest percentage of incorrect answers. 23.7% of the answers provided by the group were incorrect and in comparison to the Cape Verdean group, the São Tomean group had 9.5% more incorrect answers. Moreover, in comparison to the control group, the São Tomean group displayed 16% more incorrect answer. Therefore, the data suggests that out of the three groups, São Tomean were the ones with more issues recognizing icons from mobile operating systems.

Almost 25% of the individuals in the São Tomean group were unable to correctly recognize the icons

As mentioned above, the 23.7% of the individuals in the São Tomean group were unable to correctly recognize the icons in the experiment. Considering the descriptive variables of the participants are fairly similar except for nationality, one can determine that the São Tomeans had more difficulty understanding icons from the most popular mobile operating systems.

From the two agglomerates of the experimental group, the Cape Verdean group had better percentages of task completion rate and correct answers

When the two groups of Sub-Saharan individuals were compared, we found that the Cape Verdean group presented a higher task completion rate and a higher percentage of correct answers. Regarding the task completion rate, the Cape Verdean group was 6.1% more successful than the São Tomean group. Additionally, the Cape Verdean group demonstrated an increase of 10% pertaining to the percentage of correct answers in comparison to the São Tomean group. This may signify that the Cape Verdean individuals are more accustomed and recognize the icons from mobile operating systems better in comparison to the São Tomean individuals.

From the sixteen icons, only five displayed a perfect task completion rate among the three groups

The study consisted in recognizing sixteen icons, but from these icons, only five (*alarm*, *battery*, *calendar*, *phone* and *settings*) displayed a perfect task completion rate by the three groups. On the other hand, the *add* icon and *share* icon presented the lowest task completion rates from the sixteen icons. Therefore, the five icons with a perfect task completion rate suggest the familiarity of the individuals with these specific icons or the meaning they convey.

The control group demonstrated a perfect task completion rate in thirteen icons

From the sixteen icons, thirteen had a perfect task completion rate from the control group. The Portuguese individuals from the control group only failed to complete the tasks pertaining to *add*, *download* and *share* icons. Nonetheless, the task completion rate of the control group in these icons was superior to the results of the agglomerates in the experimental group. The data suggests that the control group is more familiarized and comfortable with icon recognition from the mobile operating systems.

The control group has five icons with a perfect percentage of correct answers

The control group was the agglomerate where most icons had a perfect percentage of correct answers. The control group had five icons with 100% correct answers. On the other hand, the Cape Verdean group had three icons with a perfect percentage of correct answers and the São Tomean group only had two icons. Consequently, the data analysis supports the idea that the control group

recognizes the icons from mobile operating systems better than the other two groups.

The recognition of icons may be correlated with the mobile cellular subscriptions of a country

The data collected from the researchers can be correlated with other statistical data, namely mobile cellular subscriptions per country. The World Bank is an organization responsible for collecting and storing data about the development in countries around the globe and one of the indicators they investigate consists in the number of mobile cellular subscriptions per 100 people. The information presented by the World Bank states that, in 2013, 113 mobile cellular subscriptions were registered in Portugal, while Cape Verde displayed 100 mobile cellular subscriptions and São Tomé and Príncipe had 65 mobile cellular subscriptions.

The data collected in the experiment suggests that the São Tomean group is the one with more difficulties in icon recognition, while the control group, composed of Portuguese individuals, appears to be the group that recognizes icons better. This information can be correlated with the values collected from the World Bank. São Tomé and Principe has the lowest number of mobile cellular subscriptions and this information correlates with the fact that the São Tomean group has the lowest percentages in task completion rate and correct answers. On the other side, Portugal has the highest number of mobile cellular subscriptions out of the three nations and the participants from the control group have the highest task completion rates and correct answers.

The first phase of the study was meant to assess the level of recognition of the participants. As noted, the control group displayed better rates of task completion and percentage of correct answers compared to the experimental groups. Immigrants from the Sub-Saharan region had trouble understanding certain icons. Even though the percentages of task completion and correct answers are above 75%, the Portuguese nationals always performed better than the Sub-Saharan nationals and the São Tomean participants had the lowest percentage in both metrics. As the statistical data supports, the participants from Sub-Saharan region had more trouble recognizing the meaning of the icons in comparison to the control group.

A number of icons displayed an evident level of recognition. For instance, icons such as the *alarm*, *battery*, *calendar*, *phone* and *settings* all presented a perfect task completion rate and the participants felt comfortable when the meaning of these icons was asked. On the other hand, the *add* and *share* icon posed recognition problems to all the groups but the most affected ones were the Cape Verdean and the São Tomean groups.

The first phase of the study was very important for the subsequent phases. This phase allowed us to determine which icons posed issues to the participants, and which ones the three groups easily understood. The control group did substantially better than the experimental group, meaning the icons were not recognized as easily by Sub-Saharan nationals than by Portuguese nationals. Regarding the experimental groups, the Cape Verdean group did substantially better compared to the São Tomean group, even though recognition problems can be traced to the same icons. Despite the participants having similar ages and education level, phase one of the study suggests the need to develop icons that are sensitive to the culture of individuals in order to ease the level of comprehension and provide a better user experience.

4.2.2. Phase Two

The second phase of the research consisted in establishing preference patterns based on the descriptive variables of the participants. The objective of this phase was to retrieve information

regarding the users' preferences and establish which operating system is more indicated for a particular group of individuals. The research questions of this phase are the following:

RQ4: Is there a preference level associated with a specific mobile operating system?

RQ5: Is there a correlation between culture based on nationality and the preferred operating system of the participants?

Participants

Phase two of the study was conducted simultaneously with phase one and, therefore, the participants for this phase were the same as in phase one.

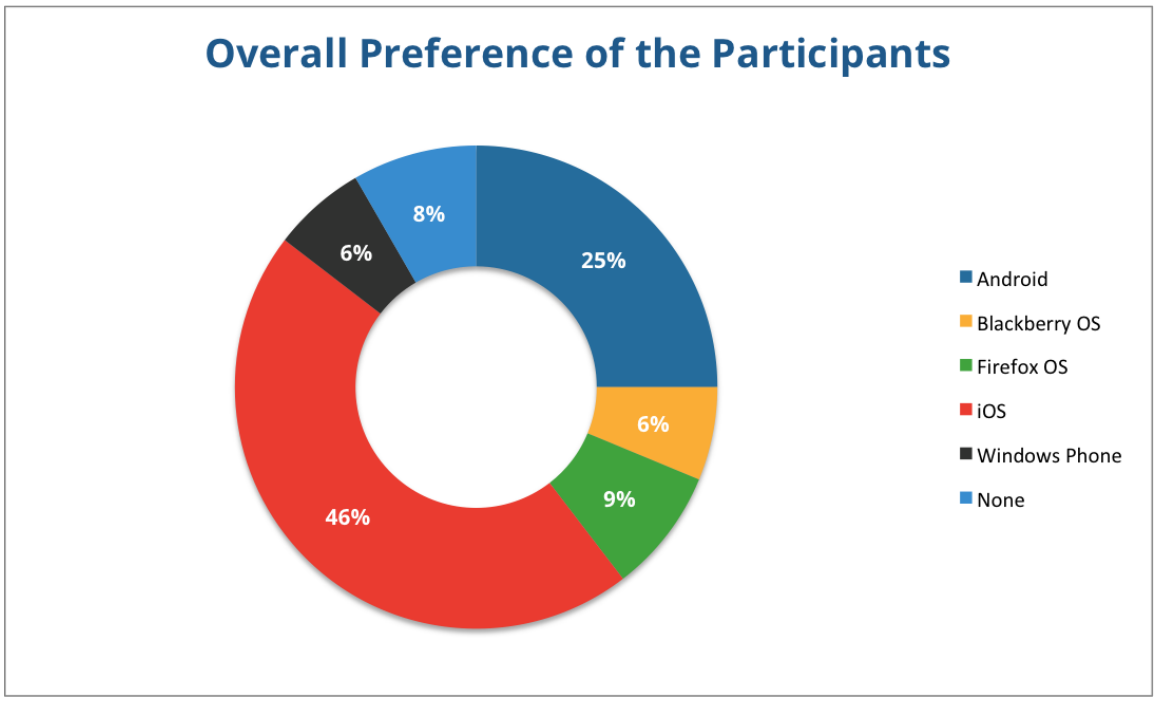
Results

Regarding the Cape Verdean group, the preferred operating system was Android, with 38% of user preference, but the iOS was a close second with 31%. Pertaining to the favorite icon to represent an action, the *calendar* icon from the BlackBerry OS had a 100% user preference. The favorite icon with the least percentage of user preference was the *alarm* icon with a rate of 36.4%. Additionally, the *share* icon presented equal rates of preference and therefore, no preferred icon was establishing regarding this action.

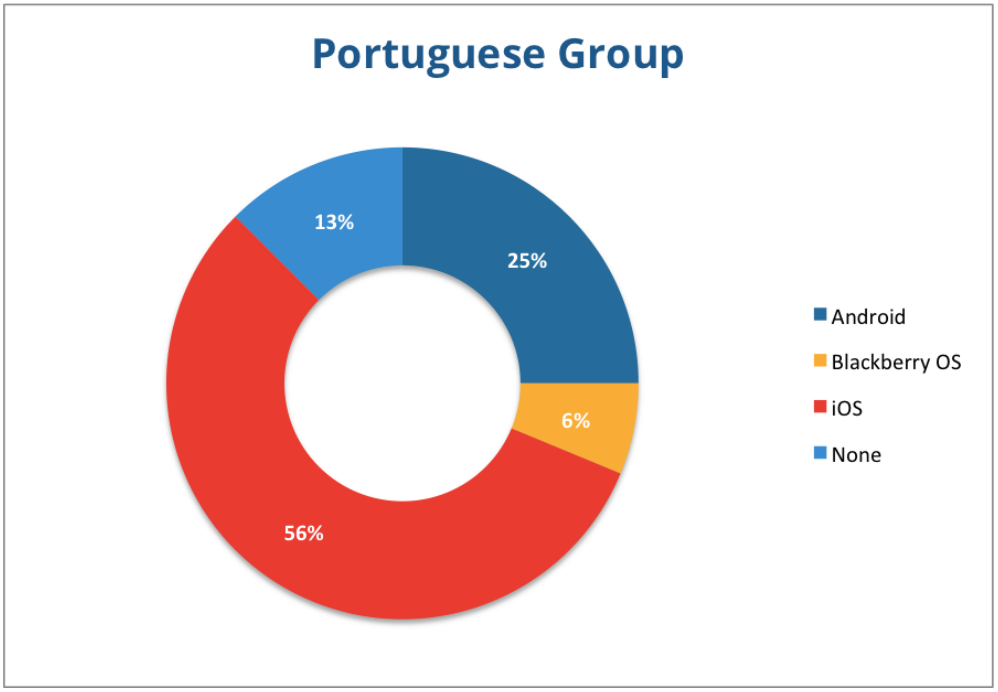
The São Tomean group presented substantially different results. The iOS operating system was the preferred one, with a user preference of 50%. With regards to the favorite icon, the *calendar* icon from the Blackberry OS presented a rate of user preference around 78.6%. The group had four icons with a user preference of 35.7%, which is relatively low compared to the other rates of user preference. The four icons were *delete*, *alarm*, *battery* and *share*. Moreover, the *Wi-Fi* icon presented equal levels of user preference and a favorite icon could not be established.

The control group also appeared to favor the iOS operating system. The operating system had a user preference of 56% and the second most preferred operating system is the Android operating system with a user preference of only 25%. The user preference pertaining to favorite icon was more balanced compared to the groups of the experimental group. Only the *Bluetooth* icon displays a user preference level above 65%. The lowest user preference regarding a favorite icon from the control group pertains to the search icon with 28%. Furthermore, two icons, *alarm* and *signal*, have equal preference rates and a favorite icon cannot be established.

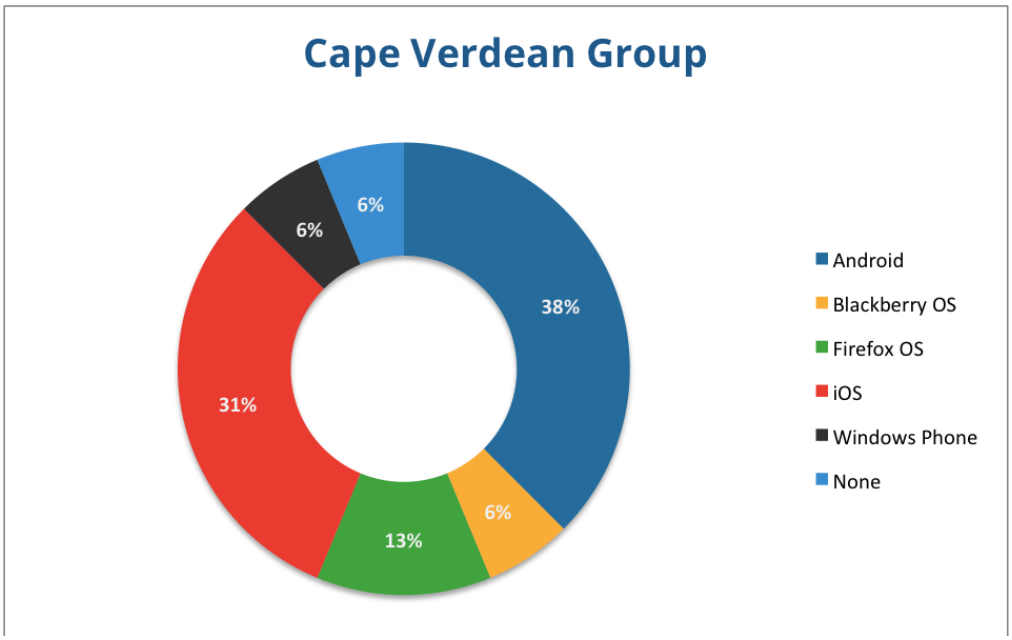
The least favorite icons and mobile operating system were also analyzed. On a general note, the Blackberry OS and the Firefox OS were the least favorite mobile operating systems. When the results of the Blackberry OS and the Firefox OS were combined, the three groups displayed a percentage of 60%, and the remaining 40% were divided between Android, iOS, and Windows Phone. More specifically, the least favorite operating system of the Cape Verdean group was the Blackberry OS with a percentage of 41%. The data analysis determined that only two icons, *battery* and Bluetooth, had an 81.8% disapproval rate from the users. On the other hand, the São Tomean group displays an equal percentage of 31% between the Blackberry OS and the Firefox OS. Moreover, the Bluetooth icon from the Blackberry OS had a disapproval rate of 92.9%. Finally, the least favorite mobile operating system of the Portuguese group was the Firefox OS with 44%. Regarding specific icons, the highest rate of disapproval pertained to the Bluetooth icon of the Blackberry OS, with a percentage of 52%.



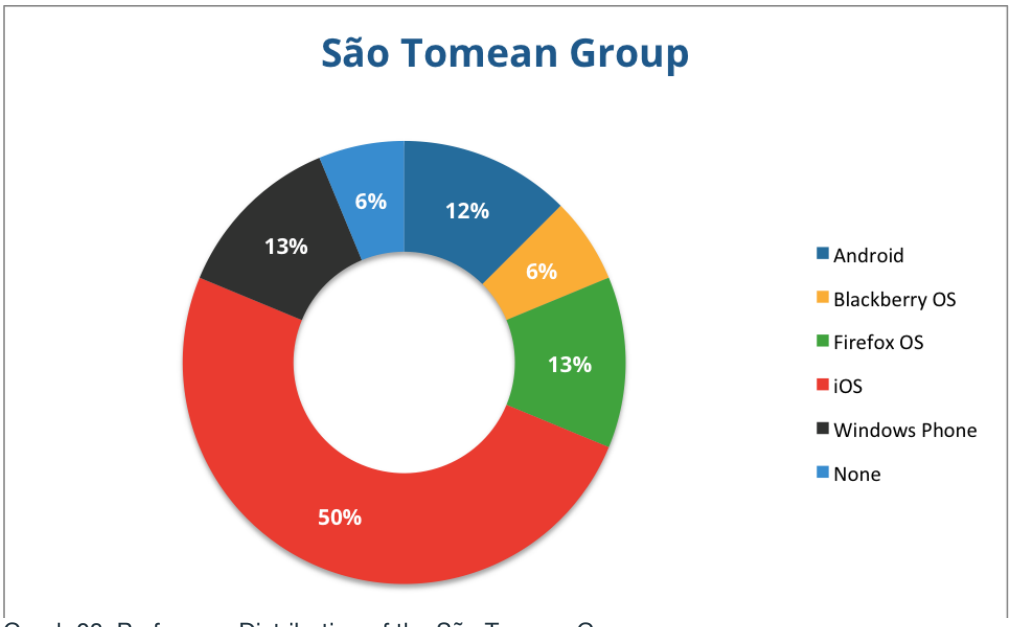
Graph 05. Overall Preference of the Participants



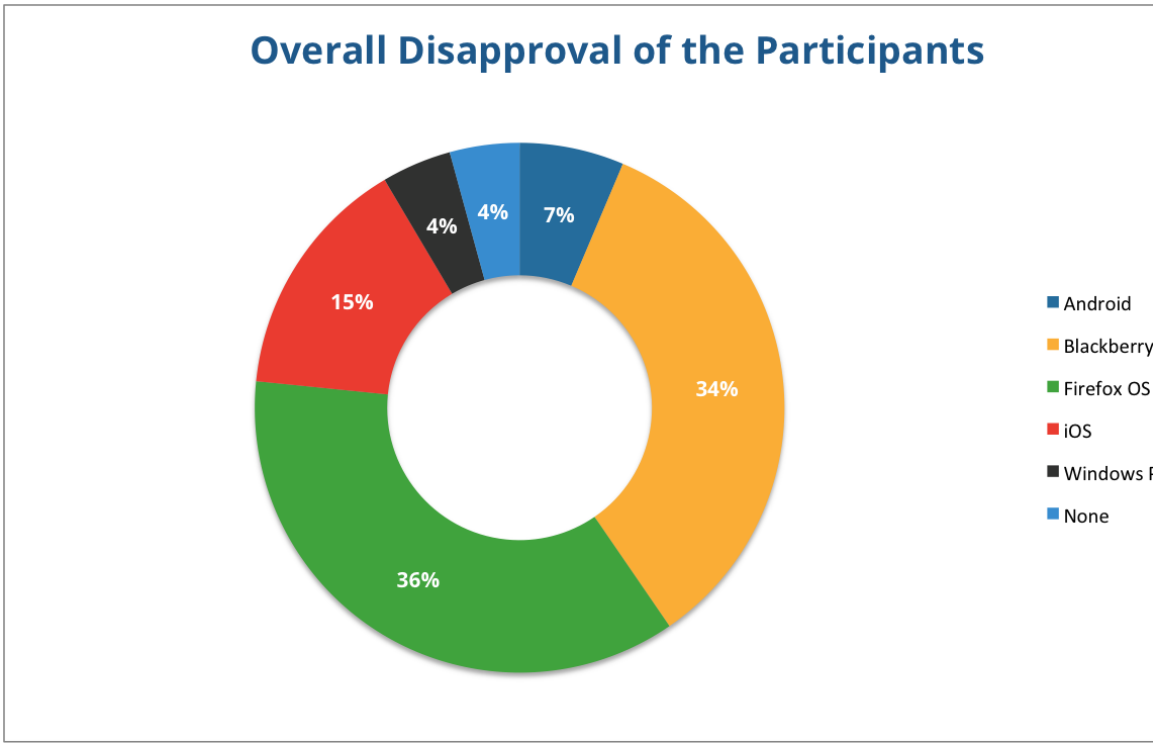
Graph 06. Preference Distribution of the Portuguese Group



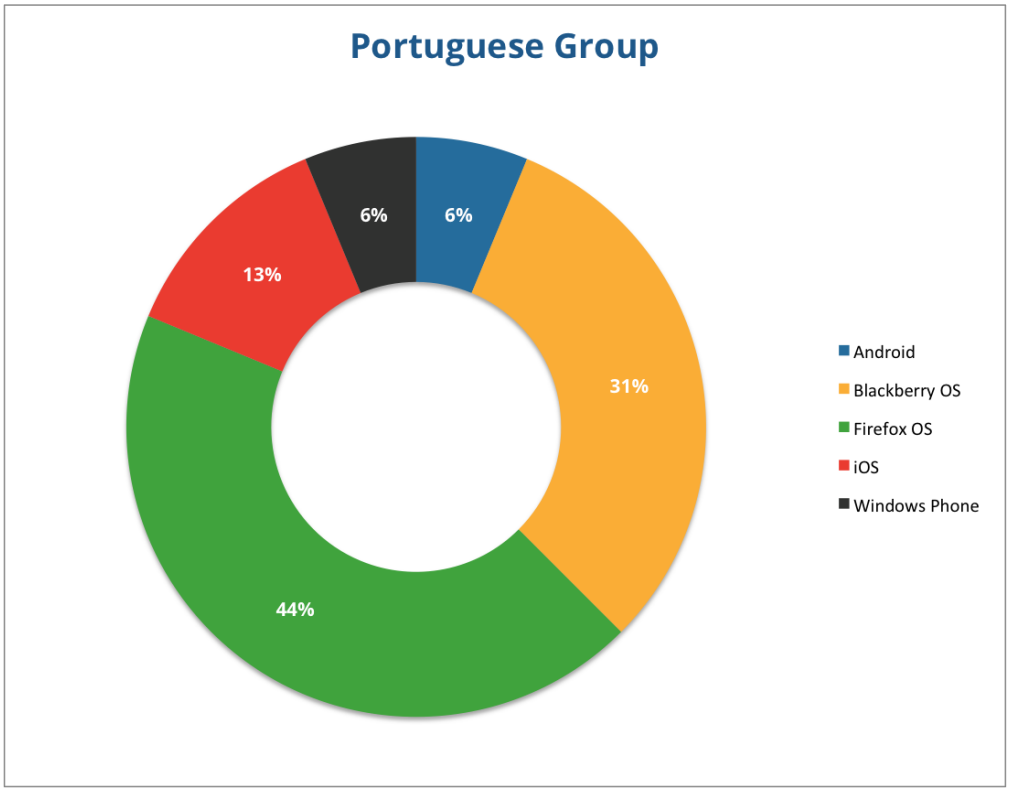
Graph 07. Preference Distribution of the Cape Verdean Group



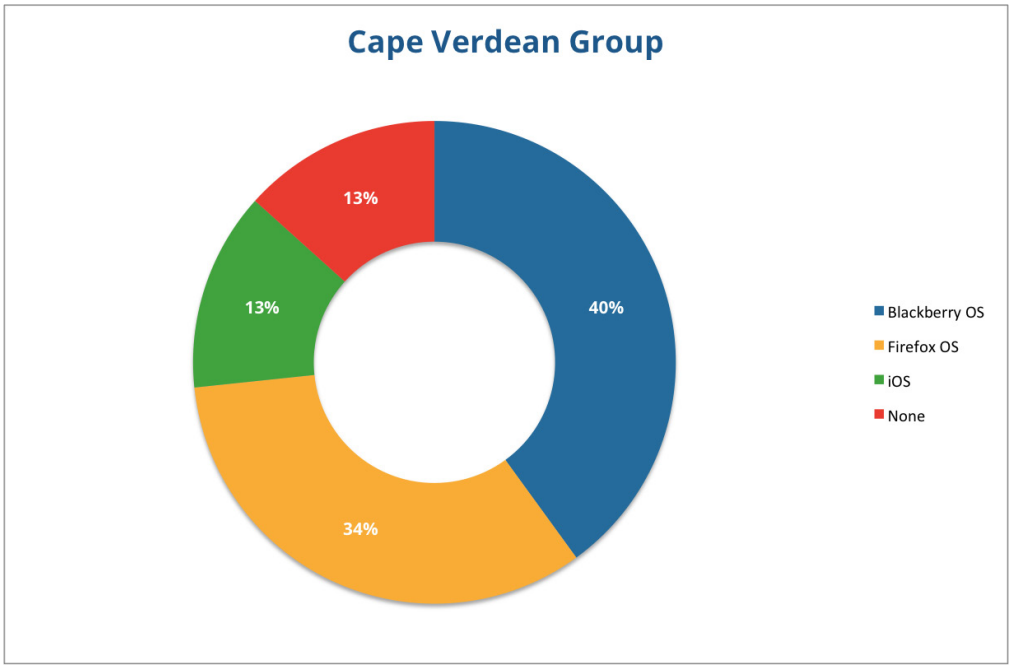
Graph 08. Preference Distribution of the São Tomean Group



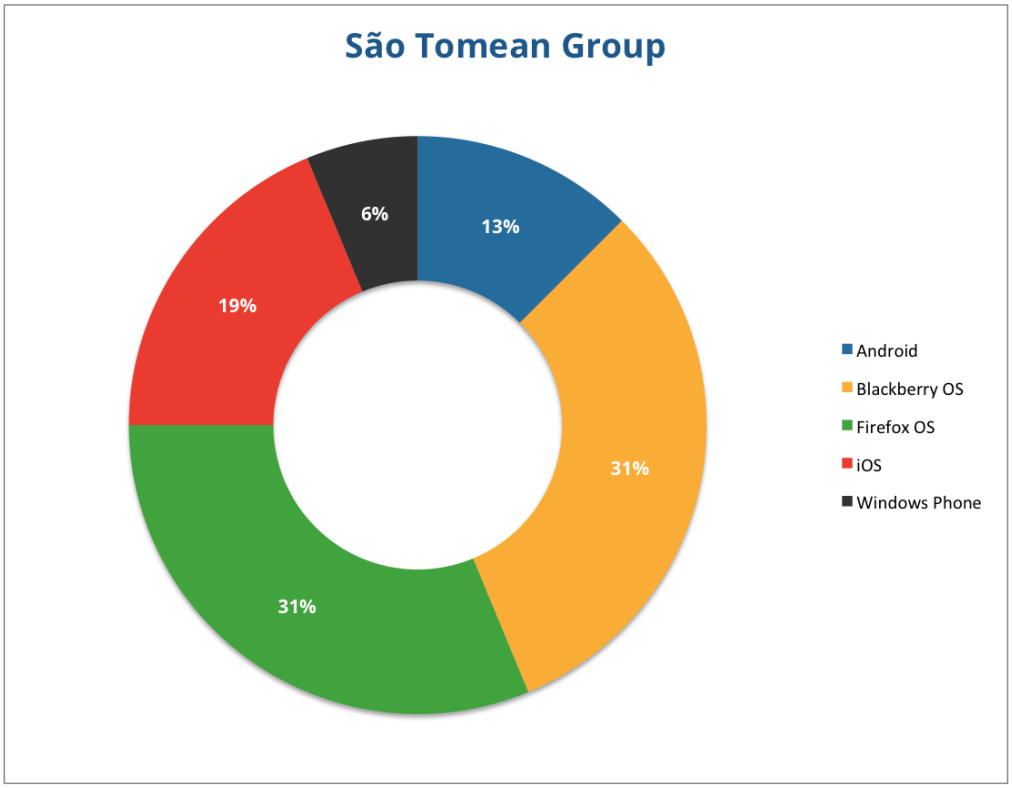
Graph 09. Overall Disapproval of the Participants



Graph 10. Percentage of the least favorite operating systems of the Portuguese Group



Graph 11. Percentage of the least favorite operating systems of the Cape Verdean Group



Graph 12. Percentage of the least favorite operating systems of the São Tomean Group

Discussion

The second phase of the study was important to determine the familiarity of the users with the mobile operating systems but also to establish whether a particular mobile operating system is more indicated to a specific audience. A number of important conclusions were drawn from the study and helped the researchers to better understand the problems and issues of the participants.

The Cape Verdean group is the only group where the favored operating system correlates with the most common operating system in the country

Between May 2014 and May 2015, StatCounter[4] displays that 61.44% of mobile users had an Android operating system and 17.11% used iOS. This data can be correlated with the preference of the Cape Verdean users. 38% of the individuals in the group favored Android and the second most favorite operating system was the iOS with 31%.

The control group has the least diversity regarding preference of mobile operating systems

Fifty six percent of the control group preferred iOS in comparison to the other mobile operating systems. The second most favored mobile operating system was Android with twenty five percent. This data can be correlated with the distribution of mobile operating systems per nation. According to StatCounter, between May 2014 and May 2015, Portugal had 69.89 % of Android users and 24.19% of individuals with iOS. Therefore, the two preferred systems of the group correlate with the most common operating system in the country.

The control group presents a more distributed percentage of favored icons by mobile operating system

The control group, who had the biggest recognition rate out of the three groups, demonstrated an average user preference distribution of 44.3%. Two icons, namely the *alarm* and *signal*, presented equal percentages of user preference. Moreover, the largest disparity in favorite icon per mobile operating system pertains to the Bluetooth icon (88%) from iOS.

In comparison to the two agglomerates of the experimental group, the São Tomean group has an average user preference of 47.8% and the Cape Verdean group displays an average user preference of 55.7%.

The control group had a bigger disapproval rate of the Blackberry OS and the Firefox OS combined in comparison to the agglomerates in the experimental group

44% of the control group selected the Firefox OS as the least favorite mobile operating system. The second least favorite mobile operating system was Blackberry OS with 31%. The combination of these two percentages makes a 75% disapproval rate of the control group regarding these two mobile operating systems. The data can be correlated with the familiarity of other mobile operating systems, namely Android and iOS. When combined, iOS and Android display a percentage of 93.52% of mobile devices in Portugal.

Regarding individual icons, the control group displays a larger distribution of disapproval rate.

The control group demonstrates a larger distribution regarding favored and least favored icons. With regards to the favored icons, the average distribution rate is 44.3%. The Bluetooth icon displays the largest disparity of distribution by favoring the iOS icon by 88%. The average distribution of the least favored icons is 40.3%, and the Bluetooth icon from Blackberry OS (52%) has the highest disparity in terms of percentage.

The alarm icon displayed the largest amount of distribution regarding user preference

4 It is difficult to encounter reliable data pertaining to the distribution of mobile operating systems by country in the Sub-Saharan region and StatCounter is not an optimal source of information, but was, on the other hand, the source available.

The *alarm* icon was the icon with the largest distribution across mobile operating systems. The control group presented equal percentages of distribution and therefore, a favorite icon could not be selected. Meanwhile, 36.4 % of the Cape Verdean group preferred the iOS icon, and 35.7 % of the São Tomean group demonstrated a preference towards the iOS icon.

The Bluetooth icon from iOS and the calendar icon from Blackberry OS presented the largest percentage of user preference

The entirety of the Cape Verdean population favored the *calendar* icon from the Blackberry OS. The reason of this preference was not established but it could be related to the level of concreteness of the icon. The *calendar* icon from the Blackberry OS presents the most realistic level of concreteness out of the five icons and that might have influenced the preference of the Cape Verdean users. Additionally, 88% of the Portuguese population favored the *Bluetooth* icon from iOS. This preference might have occurred due to the association of the word “blue” with the icon, which is the only one presented a blue tonality.

The experiments also answered the research questions associated with the study. Preference levels were assessed with regards to specific mobile operating systems and a correlation between culture based on nationality and the preferred operating system of the participants was established. The data collected from the study allowed us to assess preference levels to specific mobile operating systems. Consequently, the favored mobile operating system of the participants was iOS with a user preference of 46%. The second most favored mobile operating system was Android. The two mobile operating systems make up 71% of preference of the users. The least preferred operating systems by the participants were the Blackberry OS and the Firefox OS, with respective disapproval rates of 34% and 36%.

A correlation between the culture based on nationality and the preferred operating system of the participants was also established in the study. The data claims that the nationality of the participants had a substantial impact in the preference of the users, considering the other descriptive variables, such as age and education level, remained fairly similar. Based on the premise that culture is a flow of shared information and it is molded by the characteristics of the user, the main enabler towards change of preference among the users can be traced to nationality. The control group, comprised by Portuguese nationals, displays a greater preference towards iOS icons and the subsequent mobile operating system. On the other hand, half of the São Tomean group favored the iOS mobile operating system but other mobile operating systems including Android, Firefox OS and Windows Phone also presented a relevant percentage of user preference. Regarding the Cape Verdean group, the preferred mobile operating system had a more distributed nature and Android and iOS displayed a user preference of 38% and 31% respectively.

4.2.3. Phase Three

Phase three of the study was responsible for gathering the preference of users regarding constituent elements of an icon. This phase only had one research question but this question was intrinsic in order to discover whether or not culturally sensitive icons were feasible. The research question pertaining to this phase was the following:

RQ6: Can the preference of the users pertaining to the elements constituents of an icon be correlated to the nationality of individuals?

Participants

A total of 53 subjects of three nationalities participated in the third phase of the study. The participants were comprised of 28 males and 25 females with an average age of 20.24 (SD = 2.04). The minimum registered age was 18 and the maximum was 27. Regarding mobile proficiency, the entirety of the participants presented a mobile proficiency of 86.8%.

The control group, composed by Portuguese nationals, had 25 participants (17 males and 8 females). The average age of the group was 19.32 (SD = 1.40) with a minimum age of 18 and a maximum of 24. The percentage of mobile proficiency was 96%.

As performed in phase one and phase two, two agglomerates, the Cape Verdean group and the São Tomean group, comprised the experimental group. The Cape Verdean group had 12 participants, 5 of which were males and 7 females. The average age of the group was 21.70 (SD = 2.72) with a minimum of 19 and a maximum of 27. All the members of the Cape Verdean group were technologically proficient. The São Tomean group presented a total of 13 participants, more specifically 4 males and 9 females. The average age of the São Tomean group was 20.80 (SD = 1.80), with a minimum of 18 and a maximum of 23. The mobile proficiency of the São Tomean group was the lowest one recorded out of the three groups: 53.8%.

Results

The third phase of the study was concerned with gathering information regarding the constituents of an icon. Ten elements responsible for shaping an icon were selected after extensive research, and subsequently, various versions of each constituent were designed and presented to the subjects. The subjects had to select the version of the constituent they preferred. The ten elements selected for the study were the following:

- Semantic distance (Direct, Implied and Arbitrary),
- Concreteness,
- Perspective,
- Background form,
- Outline weight,
- Line and form,
- Contrast,
- Type,
- Font weight,
- Color association.

80% of the subjects from the control group associated a strong relationship between the action, function or object the icon is trying to represent and direct semantic distance. Out of the 25 subjects, 56% claimed the implied semantic distance represented a neutral relationship, and 84% of the subjects stated the arbitrary semantic distance presented a weak relationship. Regarding concreteness, 56% of the subjects favored the use of realistic icons and 64% of the individuals disapproved the use of abstract icons. 52% of the subjects preferred the isometric perspective, while the one-point perspective and flat perspective were the least desired ones out of the six options. 60% of the participants favored the utilization of thick outlines in the icons and 68% disapproved the use of thin outlines. 96% of the individuals preferred the use of organic forms and line in the icons, and 60% disapproved a weak contrast between the foreground and the background. Additionally, the control group favored the use of serif typefaces. Regarding color association, the following table displays the relationship of certain emotions and traits with sixteen colors:

Portuguese Group	
Color	Meaning
White	Calm, Hope, Faithful, Cold, Peace
Black	Fear, Death, Neutral, Hate, Racism
Light Blue	Pleasant, Courage, Expectation, Happiness, Cold
Dark Blue	Cold, Neutral, Anger, Suffering, Surprise, Sadness
Light Yellow	Joy, Lively, Happiness, Pride, Sympathy
Dark Yellow	Lively, Active, Courage, Desire, Energetic, Happiness, Passion
Light Red	Love, Pride, Passion, Warmth, Anger
Dark Red	Love, Desire, Warmth, Sympathy, Shame
Light Green	Energetic, Hope, Pleasure, Sympathy
Dark Green	Affection, Joy, Hope, Expectation, Faithful, Offensive, Pride, Traditional
Light Orange	Lively, Calm, Happiness, Envy, Optimism, Passive, Pleasure, Warmth, Sympathy
Dark Orange	Affection, Active, Disgust, Energetic, Pleasure, Warmth
Light Purple	Courage, Modern, Nervousness, Pride, Pleasure, Sadness
Dark Purple	Envy, Fear, Nervousness, Offensive, Pleasure, Anger, Sympathy
Brown	Unpleasant, Energetic, Expectation, Hate, Surprise, Sadness
Gray	Faithful, Cold, Neutral, Passive, Sympathy, Suffering

Table 10. Color Association of the Portuguese Group

The Cape Verdean group manifested slightly varied results from the control group. Out of the 12 participants, 83.3% associated a strong relationship with direct semantic distance. 58.3% of the individuals from the Cape Verdean group stated that the implied semantic distance was associated with neutral relationship and 50% displayed that a weak relationship is related to an arbitrary semantic distance. 50% of the participants in the group favored semi-abstract icons and disapproved the use of abstract icons. The isometric perspective was the preferred one out of the six options and on the other hand, 83.3% disapproved the use of one-point perspective. Regarding the form of the background, 58.3% of the subjects disapproved the use of no background. Moreover, 91.7% of the participants from the Cape Verdean group favored the use of organic forms and lines, and 58.3% of the individuals preferred the presence of a strong contrast. The individuals in this group also favored the use of serif typefaces and regular font weights. Regarding color association, the table in page 128 shows the association of certain emotions and traits with the sixteen colors presented to the Cape Verdean group:

Cape Verdean Group	
Color	Meaning
White	Affection, Joy, Calm, Neutral, Sympathy, Shame, Peace
Black	Unpleasant, Death, Hate, Suffering, Sadness
Light Blue	Affection, Joy, Lively, Calm, Desire, Envy, Offensive, Pleasure, Traditional, Dreams
Dark Blue	Courage, Unpleasant, Fear, Death, Hate, Anger, Suffering, Shame
Light Yellow	Joy, Lively, Courage, Desire, Happiness, Sympathy, Wealth
Dark Yellow	Pleasant, Active, Desire, Expectation, Happiness, Nervousness, Offensive, Pride, Surprise, Life
Light Red	Love, Passion, Pleasure, Warmth
Dark Red	Joy, Love, Passion, Warmth, Suffering, Sadness, Solidarity
Light Green	Pleasant, Active, Calm, Hope, Modern, Optimism, Sympathy
Dark Green	Affection, Calm, Hope, Expectation, Faithful, Happiness, Optimism, Pride, Surprise, Shame
Light Orange	Joy, Lively, energetic, Faithful, Happiness, Envy, Warmth, Traditional
Dark Orange	Pleasant, Joy, Disgust, Courage, Desire, Fear, Hate, Surprise, Shame
Light Purple	Affection, Active, Desire, Energetic, Offensive, Passive, Anger, Surprise, Traditional
Dark Purple	Cold, Neutral, Hate, Offensive, Pride, Passive, Suffering, Sadness
Brown	Courage, Unpleasant, Cold, Fear, Neutral, Passive, Anger, Sadness
Gray	Happiness, Cold, Fear, Offensive, Passion, Warmth, Suffering, Shame

Table 11. Color Association of the Cape Verdean Group

The São Tomean group also displayed some interesting results. From the 13 participants of the São Tomean group, 84.6% claimed a strong relationship was related to direct semantic distance, 46.2% stated neutral relationships were associated to implied semantic distance, and 61.5% affirmed a weak relationship was evidenced in the arbitrary semantic distance. 53.8% of the São Tomean group favored the use of semi-abstract icons, while other 53.8% disliked the use of abstract icons. 46.2% of the participants preferred circular background shapes and 53.8% favored the use of thick outlines. Organic forms and lines, as well as strong contrast between the foreground and the background was slightly favored by the participants. Furthermore, the use of serif typefaces was preferred over the sans serif ones, and the individuals comprising the São Tomean group favored regular font weights. Pertaining to color association, the table in page 129 demonstrates the association of certain emotions and traits with the sixteen colors presented to the experimental group:

São Tomean Group	
Color	Meaning
White	Joy, Faithful, Peace
Black	Neutral, Suffering, Sadness
Light Blue	Pleasant, Courage, Sympathy
Dark Blue	Nervousness, Sadness
Light Yellow	Faithful, Offensive, Sympathy
Dark Yellow	Unpleasant, Passion
Light Red	Modern, Death, Passion
Dark Red	Energetic, Warmth
Light Green	Hope
Dark Green	Expectation, Offensive, Pleasure
Light Orange	Joy, Lively, Fear
Dark Orange	Disgust, Calm, Warmth
Light Purple	Cold, Surprise, Shame
Dark Purple	Unpleasant, Envy, Sympathy
Brown	Neutral, Suffering, Shame
Gray	Expectation, Anger, Surprise

Table 12. Color Association of the São Tomean Group

Discussion

The third phase of the study allowed us to reach a number of important conclusions regarding not only the subjects, but also the level of importance that each element constituent of an icon must have. The following conclusions were drawn from this phase of the study:

All the groups associated a strong relationship with direct semantic distance

The three groups associated a strong relationship with direct semantic distance and the lowest percentage registered is 80% by the control group. The Cape Verdean group display a rate of 83.3%, and the group of São Tomean individuals displays the greatest rate of preference relating to direct semantic distance. 84.6% of the participants in the São Tomean group found a strong relationship between direct semantic distance and the actual action, function or object the icon intends to represent. These data suggest that the participants value the use of direct and obvious representations of an action, function or object. For instance, an elephant needs to be represented in the form of an icon. In order to ease the recognition for participants, designers should use the actual shape or form of the elephant and not rely on subtle details unique to the animal, such as a footprint.

Table 13. Color Association Table

Color	Portuguese	Cape Verdean	São Tomean
White	Calm, Hope, Faithful, Cold, Peace	Affection, Joy, Calm, Neutral, Sympathy, Shame, Peace	Joy, Faithful, Peace
Black	Fear, Death, Neutral, Hate, Racism	Unpleasant, Death, Hate, Suffering, Sadness	Neutral, Suffering, Sadness
Light Blue	Pleasant, Courage, Expectation, Happiness, Cold	Affection, Joy, Lively, Calm, Desire, Envy, Offensive, Pleasure, Traditional, Dreams	Pleasant, Courage, Sympathy
Dark Blue	Cold, Neutral, Anger, Suffering, Surprise, Sadness	Courage, Unpleasant, Fear, Death, Hate, Anger, Suffering, Shame	Nervousness, Sadness
Light Yellow	Joy, Lively, Happiness, Pride, Sympathy	Joy, Lively, Courage, Desire, Happiness, Sympathy, Wealth	Faithful, Offensive, Sympathy
Dark Yellow	Lively, Active, Courage, Desire, Energetic, Happiness, Passion	Pleasant, Active, Desire, Expectation, Happiness, Nervousness, Offensive, Pride, Surprise, Life	Unpleasant, Passion
Light Red	Love, Pride, Passion, Warmth, Anger	Love, Passion, Pleasure, Warmth	Modern, Death, Passion
Dark Red	Love, Desire, Warmth, Sympathy, Shame	Joy, Love, Passion, Warmth, Suffering, Sadness, Solidarity	Energetic, Warmth
Light Green	Energetic, Hope, Pleasure, Sympathy	Pleasant, Active, Calm, Hope, Modern, Optimism, Sympathy	Hope
Dark Green	Affection, Joy, Hope, Expectation, Faithful, Offensive, Pride, Traditional	Affection, Calm, Hope, Expectation, Faithful, Happiness, Optimism, Pride, Surprise, Shame	Expectation, Offensive, Pleasure
Light Orange	Lively, Calm, Happiness, Envy, Optimism, Passive, Pleasure, Warmth, Sympathy	Joy, Lively, energetic, Faithful, Happiness, Envy, Warmth, Traditional	Joy, Lively, Fear
Dark Orange	Affection, Active, Disgust, Energetic, Pleasure, Warmth	Pleasant, Joy, Disgust, Courage, Desire, Fear, Hate, Surprise, Shame	Disgust, Calm, Warmth
Light Purple	Courage, Modern, Nervousness, Pride, Pleasure, Sadness	Affection, Active, Desire, Energetic, Offensive, Passive, Anger, Surprise, Traditional	Cold, Surprise, Shame
Dark Purple	Envy, Fear, Nervousness, Offensive, Pleasure, Anger, Sympathy	Cold, Neutral, Hate, Offensive, Pride, Passive, Suffering, Sadness	Unpleasant, Envy, Sympathy
Brown	Unpleasant, Energetic, Expectation, Hate, Surprise, Sadness	Courage, Unpleasant, Cold, Fear, Neutral, Passive, Anger, Sadness	Neutral, Suffering, Shame
Gray	Faithful, Cold, Neutral, Passive, Sympathy, Suffering	Happiness, Cold, Fear, Offensive, Passion, Warmth, Suffering, Shame	Expectation, Anger, Surprise

The three groups displayed very distributed results pertaining to perspective, background shape, outline weight and font weight

The results pertaining to perspective, background shape, outline weight and font weight were very distributed in the three groups and therefore, the results from these elements cannot have the same importance as the ones that have a significant disparity between the choices presented. For instance, very few conclusions could be drawn from the control group regarding background shape due to the fact that three or more participants selected every choice presented as their favorite background shape. These data suggest that, with the available sample, no consensus can be drawn regarding background shape. Another conclusion can be drawn from this information and that is the idea that perspective, background shape, outline weight, and font weight are not as important as other constituents of an icon because the use of these four constituents depend upon context.

Semantic distance, concreteness, typeface and organic forms and lines presented more uniform results and therefore, they can be seen as influential forces in icon recognition and preference

Semantic distance, concreteness, typeface, and organic forms and lines display more uniform rates within the population sample. Therefore, these four constituents must have a greater level of importance in comparison to the other six elements being evaluated in this study. Consequently, in order to design a culturally sensitive icon, the four constituents must have a primary role and the other six have a secondary role dependent on context.

The control group favored serif typefaces and organic forms and lines

The sample from the control group displays a preference for serif typefaces and the use of organic forms and lines. Regarding serif typefaces, 76% of the sample favors the utilization of serif typefaces in an icon. Additionally, the data analysis indicates that 96% of the control group favors organic forms and lines rather than geometric ones.

The Cape Verdean group preferred organic forms and lines

A significant amount of information was retrieved from the Cape Verdean group, but the most evident one was definitely the preference regarding the type of forms and lines. Data from the Cape Verdean group suggests that 91.7 % of the participants in the group favor organic forms and lines rather than geometric ones.

The São Tomean group displayed a preference for serif typefaces

Regarding typefaces, the São Tomean group displays a preference for serif typefaces. 76.9% of the participants in the São Tomean group favor the use of serif typefaces, while the remaining 23.1% prefer sans-serif typefaces.

The third phase of the study also answered the research question. Even though the data sample is small, the conclusions retrieved are encouraging and support the creation of culturally sensitive icons. Certain preferences pertaining to the constituents of an icon can be correlated to the nationality of the individuals and therefore, the method implemented in the third phase of the study is important for data collection. Granted that in future iterations a few modifications must be made to the design of this phase, this form of user research is important in order to receive information about the preference of the users according to nationality. Moreover, the third phase of the study did not only retrieve information from the users, but stated that user preference can be correlated to nationality. Additionally, this phase of the study also determined that some constituents, namely

semantic distance, concreteness, typeface, and organic forms and lines are primary constituents while the other ones are dependent upon context.

4.3. Stage Two

4.3.1. Phase Four

Phase four of the study was concerned with determining whether or not culturally sensitive icons were recognized more easily than the icons from popular mobile operating systems. The following research questions were developed for this phase of the study:

RQ7: Are African individuals more comfortable with culturally sensitive icons than with existing icons from mobile operating systems?

RQ8: Do African individuals recognize and interpret culturally sensitive icons more easily than existing icons from mobile operating systems?

Participants

A total of 35 subjects participated in the fourth phase of the study. 12 participants were male and the remaining 23 were female between the ages of 18 and 27. The mean age of the participants was 20.81 (SD = 2.10) and all of them were proficient with mobile technologies.

11 participants, 5 of whom were males and 6 females between 18 and 24, comprised the control group. The average age of the group was 20.10 (SD = 1.70). On the other hand, 11 participants, 4 of whom were males and 7 females, composed the Cape Verdean group. This group had a mean age of 21.7 (SD = 2.87) with a minimum 19 and 27. The third group of the experiment was comprised of 10 São Tomean nationals, 9 of whom were females and the remaining one was male. The average age of the São Tomean group was 21(SD = 1.51) with a minimum age of 19 and a maximum age of 23.

Figure 52. Culturally Sensitive *Add* icon for the São Tomean group

Figure 53. Culturally Sensitive *Download* icon for the São Tomean group

Figure 54. Culturally Sensitive *Email* icon for the São Tomean group

Figure 55. Culturally Sensitive *Search* icon for the São Tomean group

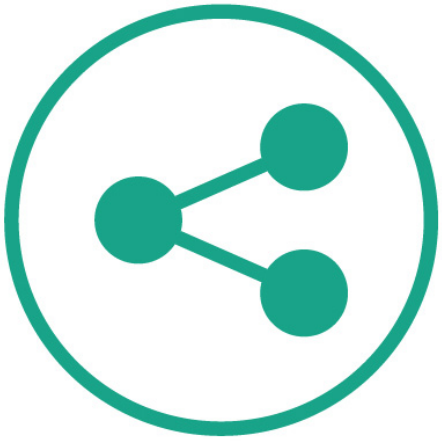


Figure 56. Culturally Sensitive *Share* icon for the São Tomean group

Figure 57. Culturally Sensitive *Signal* icon for the São Tomean group

Results

Due to time limitations, we decided to design culturally sensitive icons specific to the São Tomean population. The São Tomean population was the focus of this phase due to scoring the lowest percentages for task completion rate and percentage of correct answers in the first phase of the study. Additionally, the São Tomean population is the one with the lowest number of mobile cellular subscriptions per 100 people according to the World Bank and therefore, the likelihood of these individuals not recognizing icons from operating systems was deemed higher.

The results of phase four are segmented into two portions, namely task completion rate and percentage of correct answers. The control group presented an average task completion rate of 97.9%. 10 individuals completed all the tasks, which signifies only one individual did not complete all the tasks. Regarding the percentage of correct answers, the control group displayed a rate of 93.9%. Out of the six icons, two had a perfect percentage of correct answers, while the other four presented a 90.9% of correct answers, which means that only one individual did not provide the correct answer or failed to provide answer.

The Cape Verdean presented the most discouraging results. The task completion of this group was 85.9%, which signifies that only 8 out of 11 participants completed all the tasks. The average percentage of correct answers for the Cape Verdean group was 69.7% and only two icons (signal and email)

presented a percentage of correct answers above 80%. The icon with the lowest percentage of correct answers (54.5%) was the *add* icon.

On the other hand, the most encouraging results came from the São Tomean group. The group had a task completion rate of 92.6%, with 7 participants completing all the tasks. The São Tomean group also displayed 86.7% of correct answers. Three icons, namely *download*, *search* and *email*, had a perfect percentage of correct answers. Two icons (*share* and *signal*) presented percentages above 80% and the *add* icon displayed 50% of correct answers.

	São Tomean	Cape Verdean	Portuguese
Task Completion Rate **Test 4**	92,6%	85,9%	97,9%
Task Completion Rate **Test 1**	87,1%	93,2%	96,5%
Difference between values	**5,5%**	**-7,3%**	**1,4%**

Table 14. Comparison between the task completion rate of Phase One and Phase Four

	São Tomean	Cape Verdean	Portuguese
Percentage of Correct Answers **Test 4**	86,7%	69,7%	93,9%
Percentage of Correct Answers **Test 1**	76,3%	85,8%	92,3%
Difference between values	**10,4%**	**-16,1%**	**1,6%**

Table 15. Comparison between the percentage of correct answers of Phase One and Phase Four

Despite phase four showing improvements in icon recognition in comparison with phase one, the data sample in both tests was inconsistent and small due to geographical constraints. In order to determine whether or not the data was significant, independent t-tests were conducted for the São Tomean group. Once again, the São Tomean group was the primary group of this phase due to the fact that the culturally sensitive icons were designed with this group in mind. The tests were performed in order to determine if the probability of the variance in recognition and comprehension between phase one and phase four was significant. On average, the task completion rate of São Tomean individuals was greater in phase four ($M = 93.20$, $SE = 3.76$) than in phase one ($M = 87.50$, $SE = 3.27$). This difference regarding task completion rate was not significant $t(22) = 1.137$, $p > .05$. Moreover, an independent t-test was administered for the percentage of correct answers. On average, the percentage of correct answers in phase four ($M = 86.4$, $SE = 4.94$) was greater than phase one ($M = 76.34$, $SE = 3.94$). The difference in the percentage of correct answers was not significant $t(22) = 1.608$, $p > .05$.

Discussion

The fourth phase of the study allowed us to discover a number of important conclusions pertaining to icon recognition and the viability of culturally sensitive icons. The following conclusions were drawn from this phase of the study:

In comparison to phase one of the study, the task completion rate of the São Tomean population increased 5.5% with culturally sensitive icons.

The São Tomean population was more comfortable to perform the tasks. In comparison to the first

phase of the study, the task completion rate of the group increased from 87.1% to 92.6%. This represents a 5.5% increase in the task completion rate and one the reasons might be because the individuals were able to recognize the icons more easily.

In comparison to phase one of the study, the amount of correct answers of the São Tomean population increased 10.4%.

The São Tomean group also provided more correct answers than in the first experiment. The group registered a percentage of 76.3% in the first phase of the study and in the fourth phase, the percentage of correct answers was 86.7%. This represents an increase of 10.4% which supports the idea that culturally sensitive icons ease the recognition of icons.

The add icon was the only one in the São Tomean group to score a percentage of correct answers below 80%

From the six icons presented to the São Tomean population, only the *add* icon had a percentage of correct answer below 80%. The group scored 50% of correct answers and the reason to explain why the participants scored so low in this particular icon might be due to the fact that context is important for the recognition of this icon. The plus sign should always be accompanied by another element. Therefore, to explain to the user how to add a new person (for example, to a contact list), the plus sign accompanied with the representation of a person is indicated rather than just providing the plus sign by itself.

The Cape Verdean group demonstrated a decrease of 7.3% in the task completion rate, and a decrease of 16.1% for the percentage of correct answers in comparison to the first phase of the study

Since the culturally sensitive icons were developed for the São Tomean population, one of the hypotheses was for the Cape Verdean group to perform worse than the São Tomeans. In comparison to the first phase of the study, the Cape Verdean group demonstrated a decrease from 93.2% to 85.9% in the task completion rate. Additionally, a decrease of 85.8% to 69.7% was registered regarding the percentage of correct answers. Therefore, the Cape Verdean group showed a 7.3% decrease in task completion rate and a 16.1% decrease in the percentage of correct answers. These rates supported the idea that cultural sensitive icons are indicated for the characteristics of a particular cultural group.

Only the email and signal icons presented a percentage of correct answers above 80% in the Cape Verdean group

Besides scoring the lowest percentages in this phase of the study, the percentage of correct answers on an individual basis were also discouraging. From the six icons, only the *share* and *email* icons displayed an average of correct answers above 80%. Three icons, namely *share*, *download* and *search*, had 63.6% of correct answers. The *add* icon demonstrated a 54.5% of correct answers, making this icon the least recognized by the Cape Verdean group.

The control group displayed slight improvements in the task completion rate and percentage of correct answers in comparison to the first phase of the study

The São Tomean group was not the only one to improve the fourth phase of the study. The control group also presented slight improvements, more specifically 1.4% in the task completion rate and 1.6% in the percentage of correct answers. Even though the percentages of the individuals in the control group increased, these improvements are not substantial.

The São Tomean displayed the largest improvement out of the three groups in comparison to the first phase of the study

Considering that the culturally sensitive icons were designed according to the preferences of the São Tomean population, it was reassuring to know that the São Tomean population displayed the largest improvement in icon recognition. These improvements support the idea that culturally sensitive icons are able to ease the understanding of the users.

The fourth phase of the study also answered the research questions. This phase affirmed that culturally sensitive icons not only make the users more comfortable in terms of recognition, but also ease the recognition process of the target audience. For instance, the individuals from São Tomé and Príncipe displayed better rates of task completion and better percentages regarding correct answers. This improvement supports the idea that culturally sensitive icons are able to assist culturally different populations once researchers and practitioners develop solutions according to the cultural values of the users.

4.3.2. Phase Five

This phase of the study attempted to determine the preference rate of culturally sensitive icons. Phase five aims to answer two research questions, which are the following:

RQ9: Do the users prefer culturally sensitive icons or existing icons from mobile operating systems?

RQ10: Can the preference level between the two types of icons be associated with certain descriptive variables?

Participants

The same participants of phase four also performed phase five. Therefore, a total of 35 participants with the average age of 20.81 (SD = 2.10) were evaluated during phase five. They were all proficient with mobile devices with the same educational background.

Three groups were established like the other previous four phases. The control group had 11 participants, 5 of whom were males and 6 were females. The Cape Verdean group was equally comprised of 11 participants, 4 of whom were males and 7 females. 10 São Tomean individuals, 9 females and one male, composed the third group.

Results

This phase of the study was aimed at determining users' preference regarding culturally sensitive icons. This experiment was fairly simple and only required the participants to select their preference between a culturally sensitive icon and the most popular icon from mobile operating systems, according to results from phase two.

51.5% of the control group preferred the use of culturally sensitive icons. Four culturally sensitive icons, more specifically share, *add*, download and search, were preferred over the icons available in mobile operating systems. From the six icons, the one with a better rate of preference was the search icon with 81.8%.

The eleven participants from the Cape Verdean group had a 53% preference for culturally sensitive icons. Three culturally sensitive icons out of the six (*add*, signal and search) were preferred by the Cape Verdean group. 81.8% of the participants favored the culturally sensitive search icon in comparison to the icon from the mobile operating system.

The São Tomean group displayed a 51.6% preference regarding culturally sensitive icons. On an individual basis, three culturally sensitive icons were preferred by the São Tomean group, namely share, download and signal. 8 out of the 10 participants in the São Tomean group favored the culturally sensitive share icon.

Discussion

The fifth phase of the study allowed researchers to determine whether or not culturally sensitive icons are preferred. The following conclusions were drawn from this phase of the study:

Even though the difference was not substantial, the culturally sensitive icons were preferred in every group

Despite the fact that the preference rate of culturally sensitive icons was not substantial in any particular group, they were still slightly favored in comparison to the icons of mobile operating systems. This distribution might have occurred due to the small sample of participants and consequently, more iterations of the same test must be conducted with a larger sample.

The São Tomean population favored three culturally sensitive icons out of 6 and displayed an average preference rate of 51.6%

The São Tomean group favored three culturally sensitive icons, more specifically *share* (80%), *download* (60%) and *search* (60%). Besides the fact that the São Tomean group favored three culturally sensitive icons, the group displayed an average of 51.6% towards culturally sensitive icons. The next step of the study must replicate this phase with a larger sample and with more diversity, in order to find whether or not the target audience favors culturally sensitive icons.

The culturally sensitive share icon was favored by 80% of the São Tomean population

One interesting conclusion drawn from the study is the fact that the *share* icon was the only icon among the São Tomean population to have a preference rate of 80%. A next step of the study should discover what modifications in this particular icon were made in order to have such a substantial impact on the users' preference.

The email icon from Android was always preferred in comparison to the culturally sensitive version of the icon

The *email* icon from Android was always the preferred choice in the three groups. One reason for this preference might be due to the fact that every culturally sensitive icon only had one solid color as a way to increase the contrast between the icon and the background. The *email* icon from Android had more than one color and this might have influenced the user preference.

The three groups favored the culturally sensitive search icon

The culturally sensitive *search* icon was the preferred choice for all groups. Once again, the sample of participants for this phase was small and future iterations must be conducted in order

to determine the feasibility of this icon across cultural groups.

The users participating in the study appeared to show a slight preference for culturally sensitive icons, and with the feedback gathered from this experiment, the next iterations of this process are expected to encourage the use of culturally sensitive icons. Additionally, the level of user preference can be related to the nationality of the individuals.

4.4. Stage Three

4.4.1. Phase Six

Stage three of the study consisted in providing assistance for professionals to develop user-centered solutions for developing regions. Phase six encompasses much more than icon recognition and preference across the Sub-Saharan region. Instead, this phase attempted to provide alternatives to professionals unable to performed ethnographic work due to time, expenses or travelling limitations. The platform does not intend to replace ethnographic work, but rather reinforces the role of user-centered design and promote the use of relevant cultural materials and values. The research questions the phase aims to answer are the following:

RQ11: Can a repository system assist in the creation of new culturally sensitive icons?

RQ12: Which factors should be considered as intrinsic in a repository system for user-centered approaches?

Participants

For the sixth phase of the study, twelve participants evaluated the viability and functionalities of a desktop application intended to assist professionals in the creation of solutions for culturally different populations. Nine participants were males and 3 were females between the age groups of 18 to 24 and 36 to 40. The most common age groups among the participants were from 18 to 24 and from 25 to 29.

The participants were professionals and students from the areas of Human-Computer Interaction, Design, Mobile and Web Development with a varied amount of experience regarding the development of solution in an ICT4D context. Three participants had no experience in developing ICT4D solutions, three had less than a year of experience, three had between one and two years of experience, and the remaining three had over 2 years of experience.

Results

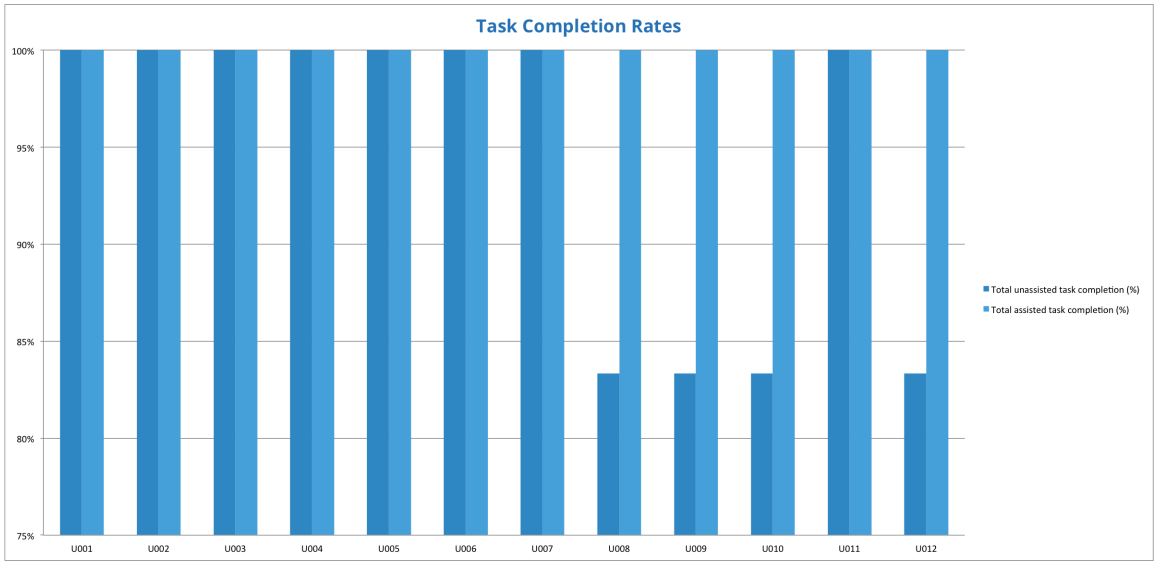
After extensive research, a platform able to guide professionals through a more culture-oriented process was envisioned, designed and deployed. Subsequently, the beta version went through a usability testing procedure in order to refine the platform.

The usability testing process was focused on the effectiveness and satisfaction of the users. Efficiency was not considered due to the lack of metrics for comparison. Regarding effectiveness, we measured the task completion rate, deviations, errors and assistances. For task completion rate, we noted the total unassisted task effectiveness and the total assisted task effectiveness. Deviations were defined as alternative flows to the completion of the task, an error was noted every

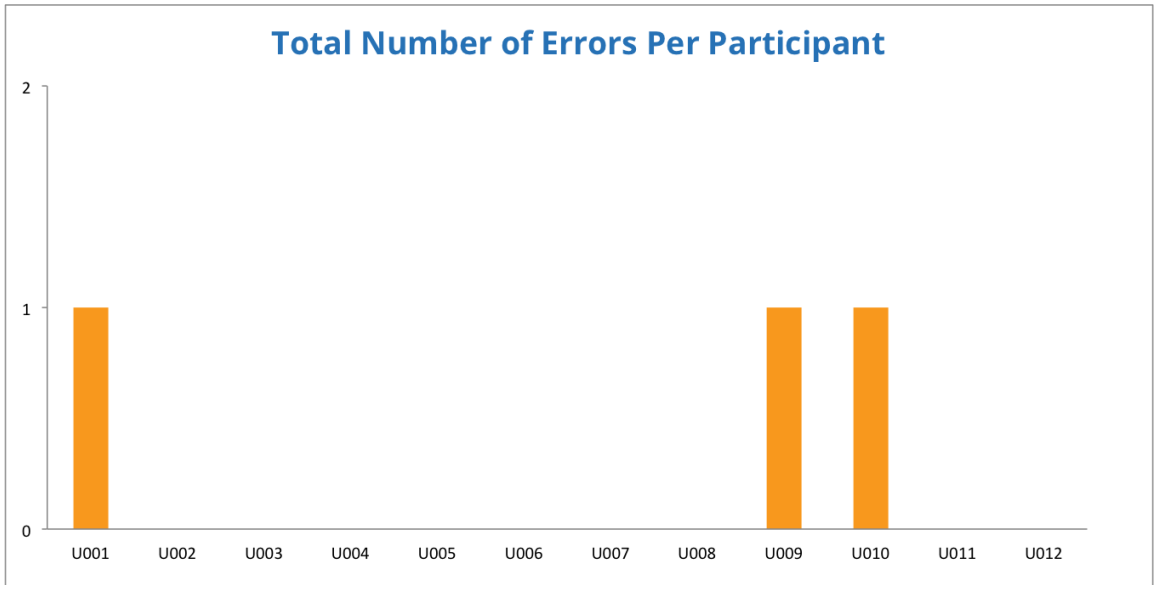
time the participant performed an action that did not contribute to the completion of the task, and an assistance was registered when the participant requested assistance from the facilitator. In addition to the performed tasks, a SUS questionnaire was administered to the participants and a set of 15 questions were asked at the end of the process.

The average of total unassisted task effectiveness was 94% (SD = 8.21%). Among the 12 participants, only four did not present a total unassisted task effectiveness equal to 100%. The minimum registered percentage was 83.33% and the maximum was 100%. The average of total assistance task effectiveness was 100%, and therefore there was no standard deviation.

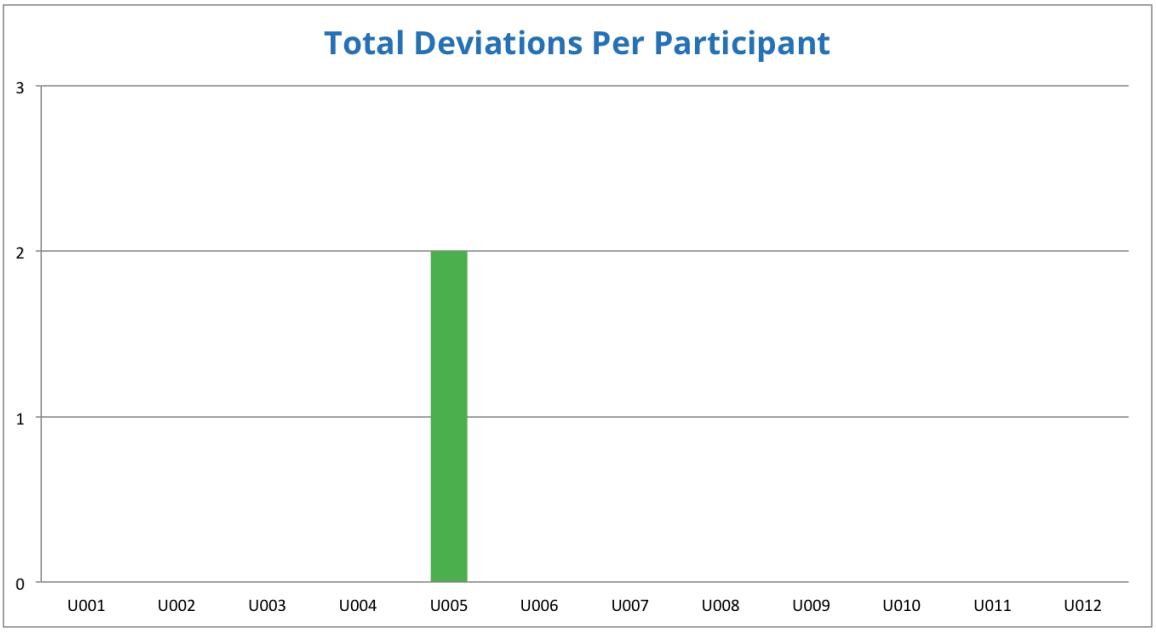
Only three errors were encountered within the six tasks performed by the 12 participants. The mean number of errors was 0.25 (SD = 0.45), with a minimum of 0 and a maximum of 1 error. Regarding deviations, U005 registered 2 deviations and the mean of the group was 0.17 (SD = 0.58). A total of 12 assists were noted combining for a mean of 1.0 (SD = 0.85), with a minimum of 0 and a maximum of 3 errors.



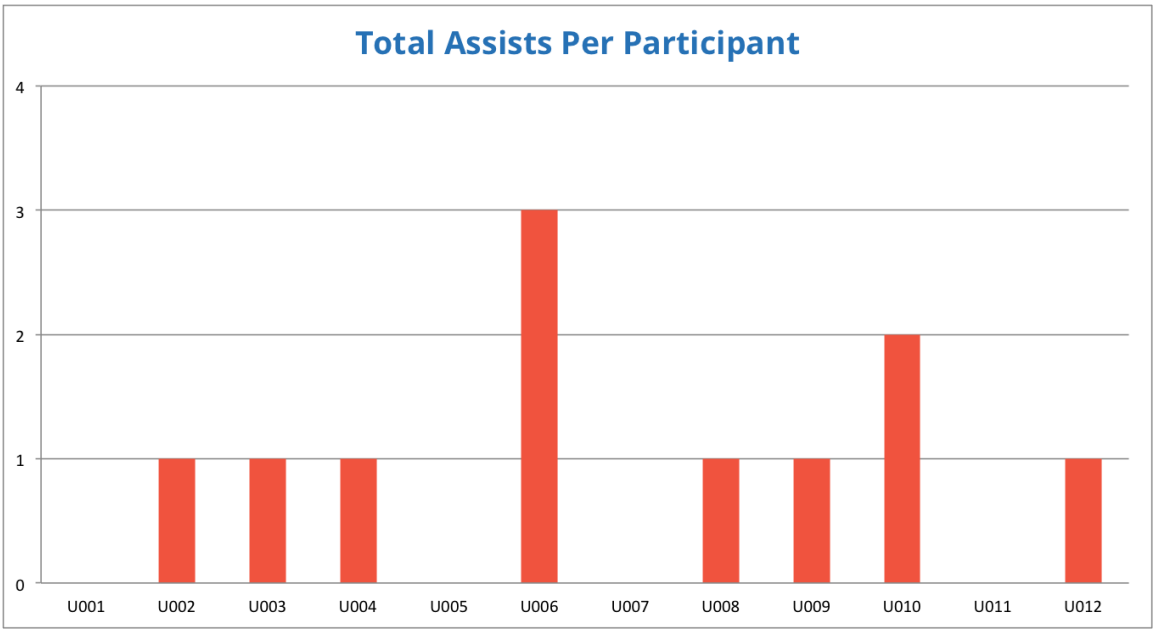
Graph 13. Task Completions Rates of Participants



Graph 14. Total Number of Errors per Participant

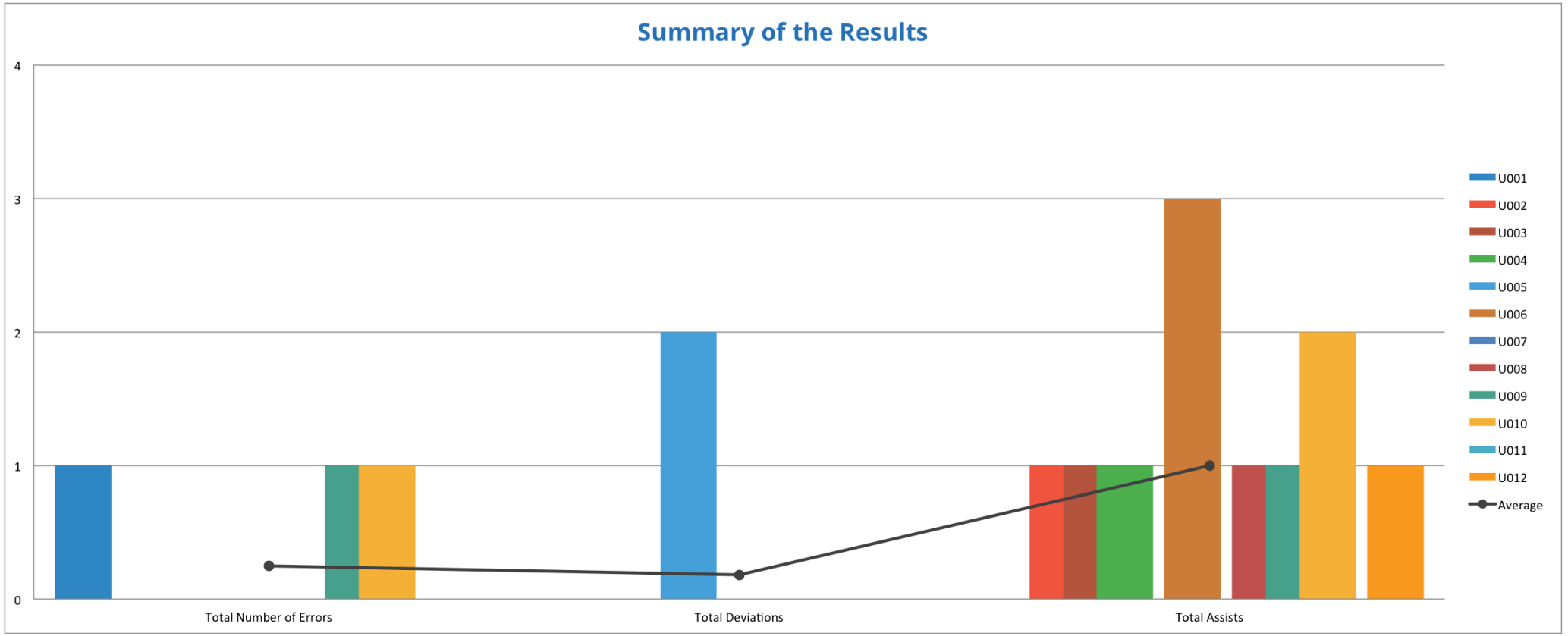


Graph 15. Total Deviations per Participant

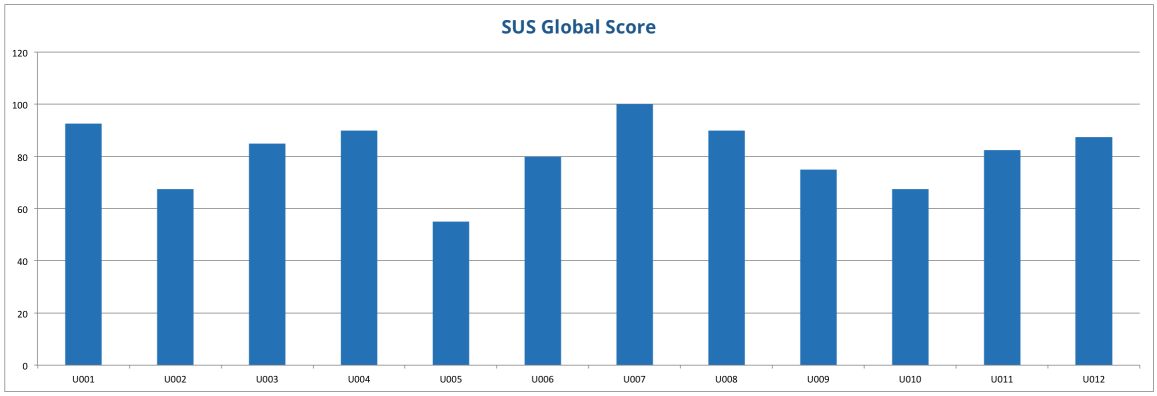


Graph 16. Total Assists Per Participant

Graph 17. Summary of the Results



The mean of the SUS Global Score was 81.04 (SD = 12.77). The lowest score registered was 55 and the highest was 100.



Graph 18. SUS Global Score of the Participants

Discussion

The usability testing led to important conclusions and we were able to discover some drawbacks regarding usability and user experience. The main conclusions drawn from the study are indicated below.

The mean SUS Global Score recorded in the usability testing was 13 points above the average

The mean SUS Global Score of the TIQSI platform was 81.04, which means this score is 13 points above the average. This is a good indicator stating that the platform satisfied the professionals in the areas of Design, Human Computer Interaction, Mobile and Web development. The lowest score registered was 55 while the highest was 100.

The mean total unassisted task effectiveness and the total assisted task effectiveness were, respectively, 94% and 100%

Eight participants displayed a total unassisted task effectiveness of 100%, while the remaining four presented a rate of 83.33%. The mean of the results was 94%, which indicates that the majority of the participants performed the entirety of the tasks without assistance. The individuals that required assistance were all able to perform all the tasks, which explain the 100% total assisted task effectiveness.

The fourth task was the one that required the majority of the assistances registered in the usability testing

The fourth task of the usability testing required the participants to encounter an alternative method of navigation besides the traditional search and filter method. The participants were often confused with this task and had difficulties in finding the alternative navigation method. In fact, six of the twelve assistances registered occurred during the fourth task.

All participants noted the platform was useful and easy to use

After task performance, a post-session questionnaire was conducted with all the participants. During this phase, the twelve participants stated the platform was useful and easy to use. Nevertheless, certain individuals, namely U001, U003 and U007, affirmed the potential of the platform could be increased in terms of usefulness.

All of the participants stated that the platform could act as a viable repository for cultural material

One of the questions in the post-session questionnaire was to assess whether or not the participants believed the platform could act as a viable repository for cultural material. All the participants stated that the platform had great potential as a repository for cultural material due to contextualizing researchers about the characteristics of the population and being able to attenuate the differences between cultural groups. Nonetheless, a couple of participants showed concern regarding the reliability of the information. This may be associated with the level of experience of these individuals in the ICT4D context and therefore, they recognize the challenges in finding reliable information.

The majority of the participants stated the platform could be important in the initial stages of a project

The participants were asked whether or not they would use the platform on a regular basis. The majority of participants stated that the platform would be more relevant during the initial stages of research and the system would be able to save time and effort regarding research. Nonetheless, the use of the platform during the rest of the project was not excluded. For instance, one participant said the system will continue to be a useful tool in other stages of the project but it will be used in a sporadic manner.

Even though the level of importance varied, all participants affirmed the platform was able to assist professionals in the development of user-centered solutions for culturally different audiences

All participants stated the platform would be useful for the creation of user-centered design solutions for culturally different audiences. All believed the platform was able to deliver a generalized contextualization of the scenario where the culturally different audience interacts with mobile devices. Nonetheless, one participant showed a concern about whether or not the information about a nation was properly updated.

The amount of information was adequate, obvious to find and the content was displayed in an visually pleasing fashion

The participants claimed the amount of information displayed in the description of the cultural item was adequate. Moreover, the participants stated most information and functions were easy to find and the content was displayed to the user in a visually pleasing fashion. These three factors had a positive role in the usability and user experience of the participants.

The only recurrent issue among the participants was the interaction with the interactive graph that acted as a navigation tool

There was only one recurrent issue between the participants and it involves discovering the alternative method of navigation. Three participants could not find the navigation method without assistance and they referred a number of reasons why the interactive graph was not visualized as a navigation tool. The participants forwarded the following solutions to enhance the user experience with the interactive graph:

- The color tonality and spacing between the categories needs to be properly evidenced,
- A label scheme should be displayed for identification purposes,
- The back function in the interactive graph needs to be more noticeable,
- The parents and children categories should be differentiated in the interactive graph,
- Titles should be associated to the social data indicators and the interactive graph in order

not to confuse the user.

All the participants saw the presence of external links with curated material as a good addition to the platform

In order to increase the number of entries by country, the developers of the platform considered providing external links with curated material, but prior to implementing this function, they decided to ask the participants whether or not that would be a good addition to the platform. The use of external links arose due to copyright issues with certain cultural materials that are only available at certain websites. Since the information that these cultural artifacts contain is important, a connection between the platform and the website holding the information regarding the cultural material was deemed appropriate. All participants shared the same belief and all of them affirmed the presence of external links was a good addition to the platform.

Regarding the research questions, the participants affirmed that the repository is a viable tool to inspire and assist professionals not only in the design of culturally sensitive icons, but also in the development of culture-oriented graphical user interfaces. The feedback from the participants supported the idea that not only is the repository viable, but also that it may be able to attenuate and ease cultural comprehension and enhance the user experience of individuals with substantially different cultural values and customs. Moreover, factors such as reliability of the information, variance of the cultural items, diversity in the presentation of cultural artifacts and contents, and a correct contextualization of the cultural values of the target audience appeared to be main concerns of the users. Therefore, these factors have a greater level of importance compared to others, including provenience of the source or aesthetic value. In other words, the participants claimed that, from experience, reliability and a correct contextualization of the target audience are more important than current design and technology trends.

4.5. Summary

The first stage of the study aimed to assess the level of recognition of the users and establish the preference levels. 53 participants were used during the first stage of the study. The first phase of stage one established the following conclusions pertaining to icon recognition of mobile operating systems:

- The control group displays the highest percentage of icon recognition;
- Almost 25% of the São Tomean group had problems in icon recognition;
- Between the two experimental groups, the Cape Verdean group was the one to display better task completion rates and percentages of correct answers;
- The recognition of icons may be correlated with the mobile cellular subscriptions of a country.

The second phase of stage one was created in order to establish preference patterns. The main conclusions of this phase were the ones indicated below:

- The Cape Verdean group is the only agglomerate where the favored operating system coincides with the most common operating system in the country;
- The control group demonstrates the least rate of diversity regarding preference of mobile operating system;
- The *alarm* icon displayed the largest amount of distribution regarding user preference

across the three groups;

- The *Bluetooth* icon from iOS and the *calendar* icon from Blackberry OS ranked the highest in user preference.

The last phase of stage one was designed in order to discover preferences pertaining to the elements constituents of an icon. A total of 53 subjects with an average age of 20.24 participated in this phase. The main conclusions were drawn from phase three of the study were the following:

- All the groups associated a strong relationship with direct semantic distance;
- Some elements constituent of an icon displayed very distributed results;
- Semantic distance, concreteness, typeface, and organic forms and lines presented more uniform results and consequently, can be assumed as influential forces in icon recognition and preference.

The subsequent stage of the study was concerned with testing the recognition and preference of culturally sensitive icons aimed for the São Tomean group in comparison to the icons from mobile operating systems. 35 participants with an average age of 20.81 were tested. Phase four established the following main points:

- Task completion of the São Tomean group increased 5.5% in comparison to phase one of the study;
- The amount of correct answers of the São Tomean group increased 10.4% in comparison to the first phase of the study;
- In comparison to the first phase of the study, the São Tomean group demonstrated the largest improvement out of the three groups;
- The Cape Verdean group presented a decrease of 7.3% in task completion rate and a decrease of 16.1% in percentage of correct answers.

The other phase of stage two, phase five, aimed to discover whether or not the participants prefer culturally sensitive icons. The main observations from phase five were as follows:

- Despite the fact that the preference rate is not substantial, culturally sensitive icons were preferred over icons from mobile operating systems;
- The culturally sensitive *share* icon was favored by 80% of the São Tomean population;
- The *email* icon from Android was always preferred in comparison to the culturally sensitive version of the icon;
- The three groups favored the culturally sensitive *search* icon.

Lastly, stage three of the study aimed to provide assistance for professionals in the development of user-centered solutions for developing regions. Twelve professionals in the areas of Design, Human-Computer Interaction, Mobile development and Web development participated in usability testing of a digital platform. The effectiveness and satisfaction of the platform were evaluated and the main conclusions are listed below:

- The mean SUS Global Score recorded in the usability testing was 81.04, 13 points above average;
- The entirety of the participants claimed the platform could act as a viable repository for cultural material;
- All the participants stated that the platform was able to assist professionals in the development of user-centered solutions for culturally different audiences;
- The platform can be important in the initial stages of research of a project.

Chapter Five
Conclusions

5. Conclusions

This work derived from the exponential growth of mobile devices in the Sub-Saharan regions and the need to integrate a wider array of users based on cultural values, customs and traditions. The specification of culturally sensitive icons was based on the fact that it is simply not feasible to analyze every element of a graphical user interface, and icons hold special significance to users not familiarized with the technological environment. The adoption of mobile devices in the Sub-Saharan region presents many opportunities for ICT4D solutions and, consequently, user interfaces for the ICT4D context need to be reimagined in order to integrate novice users with special characteristics. In other words, the work aims to assess the level of icon recognition of the users, determine their preferences, and implement these preferences with the creation of culturally sensitive icons. Through a process of user research followed by design and evaluation reiterations, the culturally sensitive icons attempt to demonstrate that icon recognition and comprehension can be enhanced and therefore, improve the user experience and usability of users with limited or no prior contact with technological devices. Moreover, the dissertation is concerned with the sustainability of user-centered techniques for developing regions, and solutions to cope with cultural and physical distances are presented. The TIQSI platform assists users not only in the development of culturally sensitive icons, but also in understanding the context and particularities of the target population in order to emulate user-centered design techniques if the cooperation of the target audience is limited due to a number factors, including distance, cultural differences and communication issues.

5.1. Summary of Findings and Conclusions

The research approach was comprised by three stages. The first stage assessed and measured the level of recognition and preference of patterns of icons. Stage two determined the impact of culturally sensitive icons. Finally, stage three consisted in the development of a repository system for future research purposes.

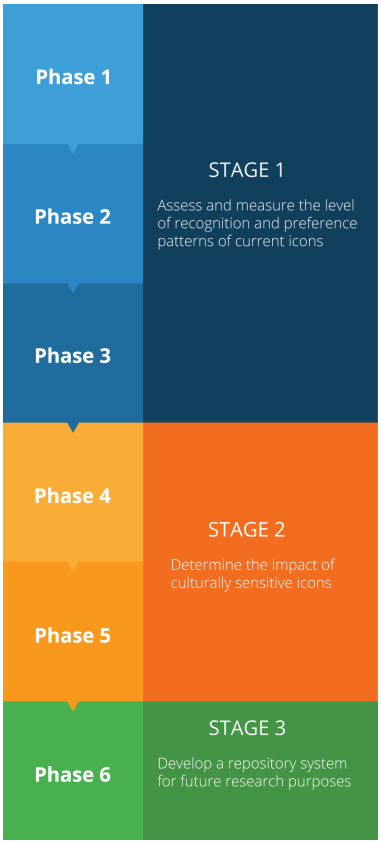


Figure 58. Research Approach of the Study

Stage one of the study was comprised of three phases. Phase one assessed the recognition level of the users pertaining to icons in mobile operating systems. This phase evaluated 53 participants of three nationalities (Portuguese, São Tomean and Cape Verdean) within the same educational background and similar ages. Since the study is focused on Sub-Saharan individuals, the Portuguese group acted as the control group. The main results of this phase stated that icon recognition can be correlated with the mobile subscriptions of a country, and consequently, the São Tomean population had the worst task completion rate and percentage of correct answers.

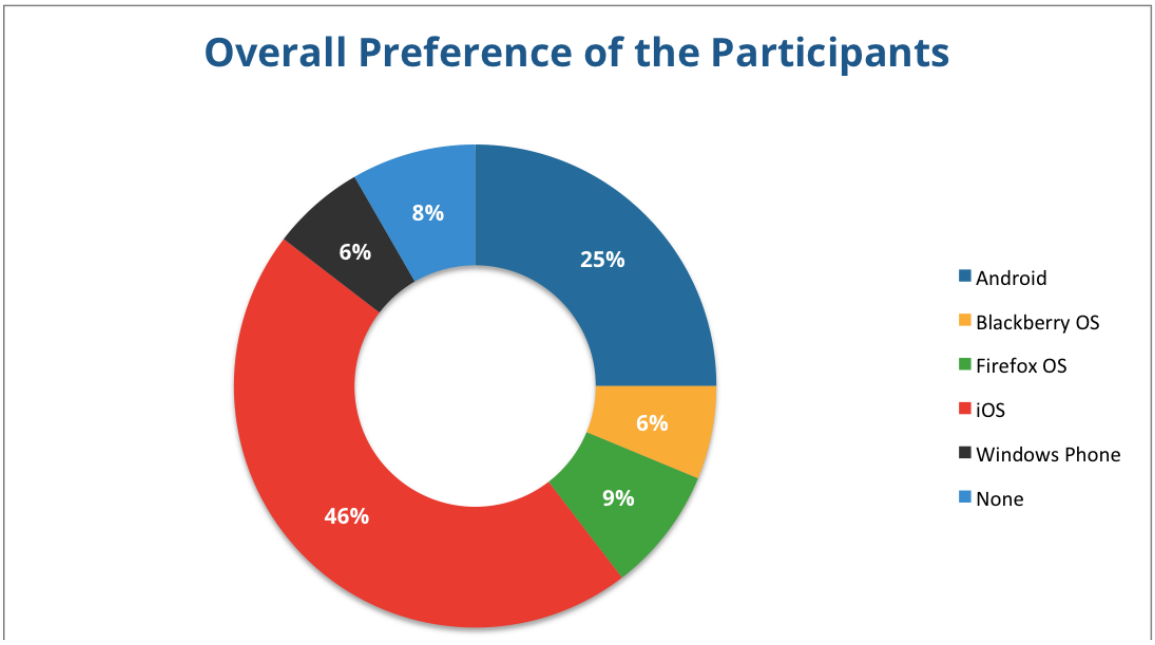
Task Completion			
Icon	Cape Verdean Group	São Tomean Group	Portuguese Group
Add	54,5%	50,0%	84,0%
Delete	100,0%	92,9%	100,0%
Download	81,8%	85,7%	88,0%
Alarm	100,0%	100,0%	100,0%
Battery	100,0%	100,0%	100,0%
Bluetooth	100,0%	92,9%	100,0%
Calendar	100,0%	100,0%	100,0%
Wifi	100,0%	92,9%	100,0%
Signal	90,9%	92,9%	100,0%
Search	100,0%	71,4%	100,0%
Share	63,6%	35,7%	72,0%
Message	100,0%	92,9%	100,0%
Contacts	100,0%	92,9%	100,0%
Phone	100,0%	100,0%	100,0%
Settings	100,0%	100,0%	100,0%
Email	100,0%	92,9%	100,0%
Task Completion	**93,2%**	**87,1%**	**96,5%**

Table 16. Task Completion of icons in Phase One

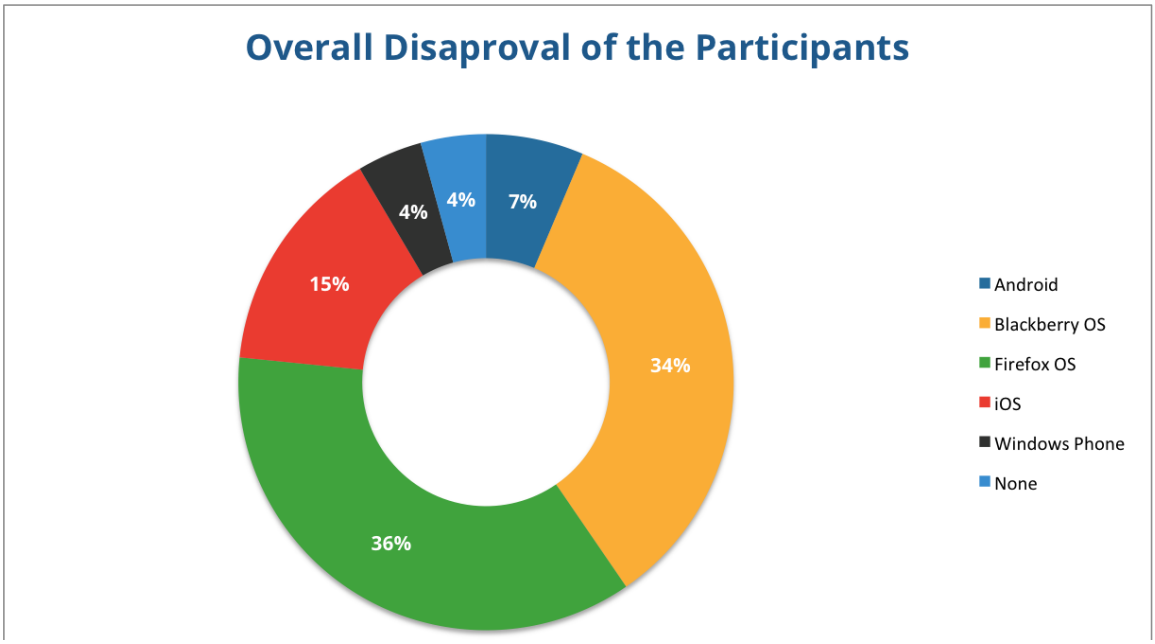
Correct Answers			
Icon	Cape Verdean Group	São Tomean Group	Portuguese Group
Add	45,5%	35,7%	76,0%
Delete	100,0%	92,9%	100,0%
Download	72,7%	42,9%	84,0%
Alarm	100,0%	85,7%	96,0%
Battery	90,9%	100,0%	100,0%
Bluetooth	90,9%	92,9%	100,0%
Calendar	90,9%	85,7%	100,0%
Wifi	90,9%	100,0%	96,0%
Signal	81,8%	71,4%	84,0%
Search	90,9%	71,4%	96,0%
Share	63,6%	21,4%	68,0%
Message	100,0%	85,7%	96,0%
Contacts	90,9%	85,7%	96,0%
Phone	90,9%	92,9%	96,0%
Settings	90,9%	92,9%	100,0%
Email	81,8%	64,3%	88,0%
Percentage of Correct Answers	**85,8%**	**76,3%**	**92,3%**
Percentage of Wrong Answers	**14,2%**	**23,7%**	**7,7%**

Table 17. Distribution of correct and incorrect answers of icons in Phase One

Phase two determined preference patterns of the users pertaining to icons used in mobile operating systems. The same 53 participants of phase one participated in this phase as well. The experiment demonstrated that the Cape Verdean group was the only agglomerate where the favored operating system correlates with the most common operating system in the country. Furthermore, the results indicated that the *Bluetooth* icon from iOS and the *calendar* icon from Blackberry OS displayed the largest rate of user preference.



Graph 19. Overall Preference of the Participants in Phase Two



Graph 20. Overall Disapproval of the Participants in Phase Two

The last phase of stage one was created in order to establish preference levels of visual elements constituents of an icon. Fifty-three participants from the same three groups participated in this phase of the study. The main conclusions note that the three groups associated a strong relationship with direct semantic distance. Furthermore, the data suggest the primary constituents of an icon are semantic distance, concreteness, typeface, and organic forms and lines.

Stage two of the study was composed of two stages and the objective was to determine the impact of culturally sensitive icons. The culturally sensitive icons were developed according to the characteristics of the São Tomean group. The first stage explored the recognition level of culturally sensitive icons. 35 subjects engaged in this experiment. A number of interesting conclusions were discovered, but the most important one for the study was the fact that the São Tomean group demonstrated the largest improvement rate of both parameters in comparison to the other groups. The São Tomean group displayed a 5.5% increase in task completion and a 10.4% increase in percentage of correct answers.

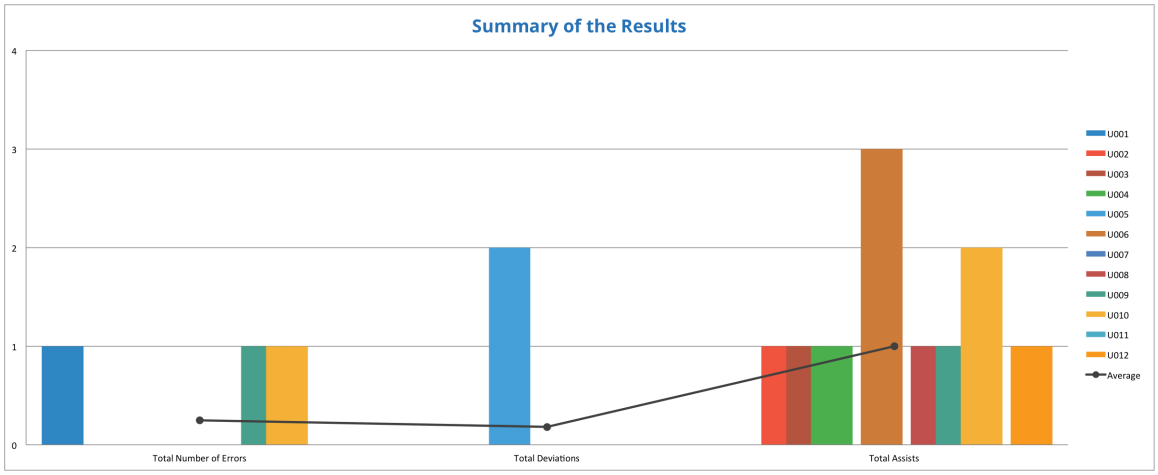
	São Tomean	Cape Verdean	Portuguese
Task Completion Rate **Test 4**	92,6%	85,9%	97,9%
Task Completion Rate **Test 1**	87,1%	93,2%	96,5%
Difference between values	**5,5%**	**-7,3%**	**1,4%**

Table 18. Comparison of Task Completion Rates between Phase One and Phase Four

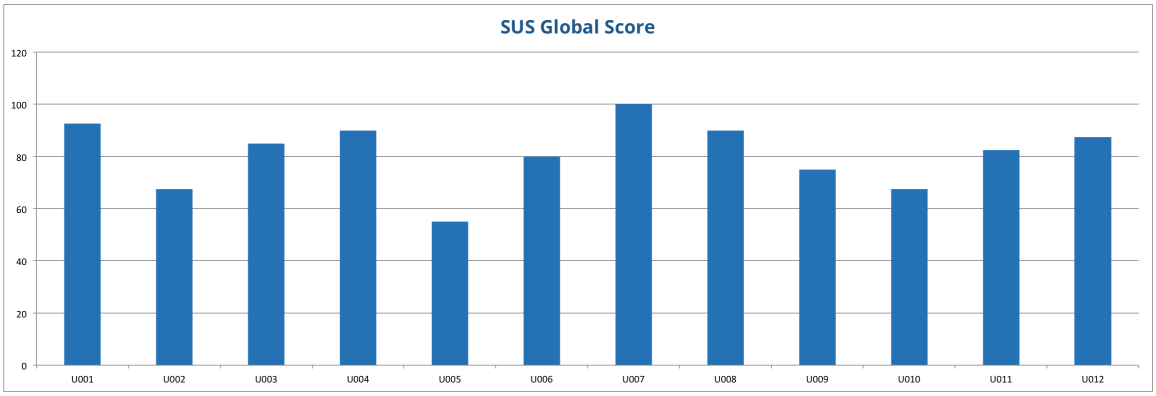
	São Tomean	Cape Verdean	Portuguese
Percentage of Correct Answers **Test 4**	86,7%	69,7%	93,9%
Percentage of Correct Answers **Test 1**	76,3%	85,8%	92,3%
Difference between values	**10,4%**	**-16,1%**	**1,6%**

Table 19. Comparison of Percentage of Correct Answers between Phase One and Phase Four

Phase five was a comparative analysis between culturally sensitive icons and icons from mobile operating systems. The same 35 subjects that participated in phase four were also involved in this phase. The main conclusion from this phase was that the culturally sensitive icons were slightly preferred over the icons from mobile operating systems. Moreover, 80% of the São Tomean population favored the culturally sensitive *share* icon and this finding was important for future design and evaluations of icons.



Graph 21. Summary of the Results from the Usability Testing conducted in Phase Six



Graph 22. SUS Global Scores from Phase Six

The last stage of the study had a broader range and objectives in comparison to the other stages. To promote user-centered design techniques and cultural oriented products, a repository system with cultural material was developed as a way to instruct and incentivize professionals to deliver ICT4D solutions with enhanced user experience and usability. After the design and development of the platform, TIQSI underwent a usability testing process. 12 professionals from the fields of Human-Computer Interaction, Design, Mobile Development and Web Development were interviewed and evaluated the effectiveness and satisfaction of the platform. A mean SUS Global score of 81.04 was attributed to the platform, which shows that TIQSI presented a satisfaction above average. Furthermore, the participants claimed the platform is a viable repository for cultural material and it was able to assist in the creation of user-centered design solutions for developing nations.

5.2. Limitations

A description of the limitations associated with the study is important to understand what can be improved in the future. The large amount of work required to gather significant conclusions was impacted due to time, cultural and distance limitations. One of the most evident limitations relates to the participants. The search for participants was tiresome and certain paths proved to be unsuccessful. One of the main difficulties surrounding the study consisted in finding African participants in general.

On a more specific note, finding participants from the African continent was the most difficult task of the study, in particularly from remote areas. The goal was to seek African participants from a plethora of characteristic identifiers and the most reasonable approach to the researchers was to contact local institutions and organizations performing volunteer work in Sub-Saharan regions. A significant number of institutions were approached and many agreed to participate in the study, but the results from the African continent never came in time. This phenomenon derives from a large array of characteristics, some expected and other unexpected by the participants.

A couple months after the deployment of Okavango in several countries, only university students from South Africa interacted with it. Consequently, the next logical step was to contact the people that received the application and discover the reasons why participants were not actively participating. One argument by a supervisor was the fact that individuals were hesitant in installing applications from unknown sources, and that the application should be web-based instead. Other important argument pertains to the length of the test. People have complained about the length of the questionnaire but this was a necessary evil due to the fact that Okavango was supposed to emulate the entirety of stage one. The method for sending results was also criticized by the subjects, but this form of delivery was due to limited programming skills and the fact that this method appear to be more feasible for the remote areas of the Sub-Saharan region, where internet

connectivity is not always easy.

Another limitation pertains to the participants due to being a very homogenous group. The participants from Porto were all students within the same age and with similar degrees of education. In order to have more accurate results about the target audience, the diversity of the subjects needs to be equated, and in terms of diversity, the sample is very homogenous.

Furthermore, the interaction with the Sub-Saharan immigrants in Europe was not always easy. Additionally, the number of subjects was fairly limited and it was not uncommon for the students to be present and participate in the study and be absent the day after. Therefore, the researchers struggled to find a consistent and reliable number of participants, which explains the sample sizes.

5.3. Future Work

Despite the fact that substantial strides were achieved in this study, there is still a lot to explore in this field. The next step of the study consists in refining and redesigning the tests, in particular the ones in digital version. With the assistance of experienced programmers, the user experience and interaction of Okavango will not be so limited, which allows researchers to more interesting design tasks for the users. Furthermore, gamification techniques will be more prominent as a form to incentivize participants.

At the same time, it is very important to establish networks with local organizations and institutions active in the developing countries. The creation of a reliable network allows the researchers to access diverse and authentic representations of the population residing in developing countries. Furthermore, it allows researchers to reach groups of individuals with little or no prior experience with mobile devices, illiterates and novice users. Once the communication with these organizations is robust, the next step consists in administering the redesigned and refined tests. This process will be comprised of several iterations, and a significant period of time must be established in order to retrieve valid results.

Regarding TIQSI, the next step is to modify the platform according to the suggestions provided by the professionals in the fields of Design, Human-Computer Interaction, Web development and Mobile development. These subtle changes to the platform will enhance user experience and ease the interaction process between the user and the system. Another long term objective is to integrate Okavango with TIQSI. The automatic communication process between the application and the platform would ease the development of user-centered solutions for developing countries.

Finally, the main goal of the study is to deliver culturally sensitive user interfaces and as it was mentioned before, the dissertation only focused in the study of icons due to time limitations. Therefore, another task to be performed in the future is to evaluate and assess other elements of user interfaces, as well as the users' behavior during the interaction process. The large cultural diversity in these regions is an important factor to consider and once the cultural disparity within this region is acknowledged, professionals will be able to correctly implement user-centered design techniques and methods, and consequently, products with a better user experience and usability will be conceived.

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Industrial Design & Conceptual Design (CAIDCD), 2010 IEEE 11th International Conference on.

Appendices

Appendix A

Overview of Literature Review regarding Cultural Influence and Cultural Interpretation

Author(s)	Year	Title	Type of Reference	Experimental Procedure	Objective	Type of Experiment	Focus of the study	Quantative Data	Users	Location	Environment	Relationship
Restyandito et al	2013	Designing Usable Icons for Non e-Literate User	Paper		Explore the use of alternative icons that may improve the user comprehension level	Interview & icon recognition test	Icons	45 respondents	Indonesian (25 from Yogyakarta & 20 from Makassar)	Indonesia	Mobile	Illiteracy and Semiliteracy
Ruano Rincon, S	2013	Integrating Cultural Factors in User Interface Design	PhD Thesis						Nasa People from Colombia	Colombia		Visual Patterns and User Interface Design
Ng, A, Siu, K & Chan, C	2012	The effects of user factors and symbols referents on public symbol design....	Paper		Investigate the influence of user factors and symbol referents on public symbol design among older people	Custom-designed answer book, followed by VVIQ & OSIQ questionnaires	Icons	31 residents	Hong Kong Chinese (16 m & 15 f)	Hong Kong	Perception and Cognition	Visual Patterns and User Interface Design
Reinecke, K & Gajos, K	2011	One size fits many Westerns	Paper							Europe		Visual Patterns and User Interface Design
Chelule, E et al	2010	E-Commerce Usability: Do we need guideline for emerging Economies	Paper		Explore the best approach to design usable websites in South Africa	User Evaluation & Heuristic Evaluation	Usability	9 users and 5 experts	South African subjects	South Africa	Web	Visual Patterns and User Interface Design

Reinecke, K	2010	Culturally Adaptive User Interfaces	Msc Thesis							Switzerland		Visual Patterns and User Interface Design
Yumiao, C , Jiang, X & Zhongliang, Y	2010	Culture Adapted User Interface Design for Mobile Phone	Paper		Explore the design process regarding UI Designers in China and investigates the correlation between user knowledge and icon	User Knowledge Test & Interface Usability Test	Icons	5 males and 5 females	5 males and 5 females	China	Mobile	Visual Patterns and User Interface Design
Heukelman, D & Obono, SE	2009	Exploring the African Village Metaphor for Computer User Interface Icon	Paper		Identify users for whom the African village metaphor is better than the office metaphor	Questionaire	Metaphors	72 participants	Subjects from four universities in the KwaZulu Natal province in South Africa	South Africa	Perception and Cognition	Visual Patterns and User Interface Design
Putnam et al	2009	Mobile Phone Users in Kyrgyzstan	Paper		Meet important user needs and goals for mobile phone users in Kyrgyzstan	Design Ethnography, Large Scale Survey & Prototyping	User Requirements	12 participants for the ethnography & 1000 respondents for the survey	Kyrgyz users	Kyrgyzstan	Mobile	Visual Patterns and User Interface Design
Sherwani, J et al	2009	Orality-grounded HCID	Paper							Worldwide		
Yang, X & Gong, L	2009	Design and Culture Innovation	Paper							Worldwide		

Young, P	2008	Integrating Culture in the Design of the ICTs	Paper							Worldwide		
Huiyang,L , Sun, X & Zhang, K	2007	Culture-Centered Design	Paper							Worldwide		
Kim, Ji Hye & Lee, Kun Pyo	2007	Culturally Adapted Mobile Phone Interface Design	Paper		Understand the correlation between culturally different cognitive styles and issues of information architecture and flow	Prototype Test & Cognitive Style Test	Perception and Cognition	60 subjects	30 Korean (20m & 10f) & 30 Dutch(16m & 14f)	Korea & Netherlands	Mobile	Visual Patterns and User Interface Design
Albirini, A	2006	Cultural Perceptions	Paper		Explore the cultural perceptions of high school EFL teachers in Syria towards ICT	Questionaire & Follow-up Interviews	ICT Adoption	326 participants for the questionnaire & 15 for the follow-up interviews	326 EFL (English as Foreign Language) Teachers	Syria	Physical	Illiteracy and Semiliteracy
Mihalcea, R & Leong, B	2006	Towards Communicating Simple Sentences Using Pictorial Representations	Paper		Evaluates the hypothesis that pictorial representations can be used to convey simple sentences across language barriers	Evaluation of an Automatic Pictorial Translation System	Translation with pictures		Users from different ethnic groups, e.g. Caucasians, Hispanics, Latin Americans and Indians	United States of America	Software	Visual Patterns and User Interface Design
Ning, B & Liang, W	2006	Design Symbol in Culture Context	Paper							Worldwide		

Shen, S , Wooley, M & Prior, S	2006	Towards culture-centered Design	Paper		Address culturally rooted factors within user interface design	User Evaluation	Metaphors	8 multi cultural Chinese group, 6 from the non-chinese group and 14 from the International group	3 user groups (Chinese, non Chinese and International)	China, Japan, Malaysia, Indonesia, Thailand, South Korean, U.K., Denmark, Netherlands, Greece, Israel, India, Uruguay and Norway	Software	Visual Patterns and User Interface Design
Zhiqiang, Z , Zhao, Y & Zhao, Q	2006	Discussion on the Necessity of Absorbing Chinese Culture into Chinese Design	Paper									
Erumban, AA & de Jong, SB	2005	Cross-Country Differences in ICT Adoption : A Consequence of Culture?	Paper									
Ford, G	2005	Researching the Effects of Culture on Usability	Msc Thesis									Visual Patterns and User Interface Design
Ford, G , Kotze, P & Marcus, A	2005	Cultural Dimensions: Who is Stereotyping Whom?	Paper									
Ford, G & Kotze, P	2005	Designing Usable Interfaces with Cultural Dimensions	Paper		Research the influence of cultural dimensions on usability	Usability Test, supported by questionaires	Cultural Influence	50 test subjects	Multi cultural group	South Africa	Perception and Cognition	Visual Patterns and User Interface Design

Hemayssi, H et al	2005	Designing an Arabic User Experience	Paper							Arabic Nations		
Kim, Ji Hye & Lee, Kun Pyo	2005	Cultural Difference and Mobile Phone Interface Design	Paper		Investigate the possibility of cultural impact on icon recognition according to the level of abstraction	Icon Recognition Test& Icon Preference Test	Icons	20 subjects (10 from each nation)	Korean, American	Korea and America	Mobile	Visual Patterns and User Interface Design
Nisbett, R & Miyamoto, Y	2005	The Influence of Culture: Holistic vs Analitical Perception	Paper									
Xinyuan,C	2005	Culture Based User interface Design	Paper							Worldwide		
Dowse, R & Ehlers, M	2004	Pictograms for conveying Medicine Instructions	Paper		Explores that the idea of implementing pictograms may ease the comprehension in rural areas	Interview, Pictogram interpretation & Pictogram preference	Perception and Cognition	304 respondents	Participants from eight language groups	South Africa	Physical	Illiteracy and Semiliteracy
Fitzgerald, W	2004	Models for Cross-Cultural Communications for Cross-Cultural Website Design	Paper									

Jagne, J et al	2004	Cross Cultural Interface Design Strategy	Paper									
Ford, G & Gelderbloom, H	2003	The effects of cultural on performance achieved through the use of HCI	Paper		Determine if Hofstede's cultural dimensions affect the performance achieved through the use of HCI	Five sets of test interfaces and two questionaires	Usability	120 students	Students at the University of Natal, Durban	South Africa	Web	
Juric, R , Kim, I & Kuljis, J	2003	Cross Cultural Web Design	Paper							United Kingdom and Korea		
Nisbett, R & Masuda, T	2003	Culture and Point of View	Paper									
Taylor & De Villiers	2003	Culturalization of Interfaces	Paper							South Africa		
Chau, P et al	2002	Cultural Differences in the Online Behavior of Consumers	Paper		Investigate the online behavior of consumers from two different cultures	Survey about general use of the Internet; visit a website from an automotive manufacturer; follow up surveys	Perception and Cognition	60% participants from Hong Kong and 40% Americans	119 participants from the US and 150 from Hong Kong	Hong Kong & United States of America	Web	

Marcus, A	2002	User Interface Design, Culture and the Future	Paper							Worlwide		
Norton, D	2002	Implementation of an Electronic Report Viewing Applications for Multi Cultural Users	Paper		Explore the need to customize user interfaces from users of different cultural backgrounds	Questionnaires	Usability		28 multicultural users	South Africa	Web	Visual Patterns and User Interface Design
Walton, M et al	2002	Visual Literacy' as a challenge to the Internationalizatio n of Interfaces	Paper							South Africa		
Chan, A & Courtney, A	2001	Color Associations for Hong Kong Chinese	Paper		Explore the association colors and concepts	Color Blindness Test followed by a test of color associations	Color Association	10 colors for 16 concepts in the color association test	117 Hong Kong University Students	Hong Kong	Perception and Cognition	
Bourges-Waldegg, P & Scrivener, S	2000	Applying and Testing an approach for design for culturally diverse user groups	Paper		Intends to illustrate how designers can apply the Meaning in Mediated Action (MIMA) approach to design for culturally diverse user groups	MIMA evaluation, analysis, design and testing	Subjective Culture		11 participants	Worldwide	Web	
Marcus, A & Gould, E	2000	Crosscurrents Cultural Dimensions and Global Web User Interface Design	Paper							Worldwide		

Chen, A et al	1999	Cultural Issues in the Design of Technology	Paper									
Evers, V et al	1999	Cross Cultural Understanding of Interface Design	Paper		Investigate cultural aspects of understanding the website of a virtual campus	Website evaluation, task/question list and individual interview sessions	Perception and Cognition	16 multicultural participants	4 English, 6 Dutch, 4 Sri Lankan and 2 Japanese participants	Worldwide	Web	
Honold, P	1999	Learning How to Use a Cellular Phone	Paper		Investigate whether and how 'cultural standards' influence the use of typical daily products by German and Chinese Users	Focus Groups, Questionnaires and Usability Tests	Perception and Cognition	4 Focus Groups in Shanghai and Munich; Usability Tests also in this locations, but limited to 12 people per country	**Focus Group:** 5 to 8 participants; **Usability Test**: 12 people per country	Germany and China	Mobile	
McLoughlin, C	1999	Culturally Responsive Technology Use	Paper									
Bourges-Waldegg, P & Scrivener, S	1998	Meaning, the Central Issue in Cross-Cultural HCI Design	Paper		Elicit and understand culturally determined usability problems in a web context	Several evaluation methods used to evaluate a WWW server and browser	Subjective Culture	Five sessions where two subjects separated were linked by a computer	6 participants	Worldwide	Web	
Choong, Y & Salvendy, G	1998	Design of Icons for use by chinese in mainland China	Paper		Investigate the impacts of cultural differences in cognitive abilities between the American and Chinese users on their performance with icon displays	Icon Recognition Test	Icons	30 American and 30 Chinese	Americans (Caucasian background) & Chinese	China	Software	Visual Patterns and User Interface Design

Khaslavsky, J	1998	Integrating Culture into Interface Design	Paper							Worldwide		
Evers, V & Day, D	1997	The Role of Culture in Interface Acceptance	Paper		Examine users culturally specific design preferences and evaluate the attitudinal and behavioral consequences os satisfying or not such preferences	Eight page Questionaire	User Acceptance	206 students from UNSW in Sydney	Indonesia (44 m & 31 f), Chinese and Hong Kongese (27 m & 39 f) , Others - mostly Japanese, Taiwanese and Singapore (33m & 27f)	Australia	Software	Visual Patterns and User Interface Design
Noah,M	1997	Beyond Individual Differences - Social Differentiation from First Principles	Paper									
Ginsburg, F	1996	Mediating Culture: Indigenous Media, Ethnographic Film and the Production of Identity	Paper									
Hoft, N	1996	Developing a Cultural Model	Paper							Worldwide		
Yeo, A	1996	Cultural User Interfaces	Paper							Worldwide		

Davis, F	1993	User Acceptance of Information Technology	Paper		Address why users accept or reject information systems and how user acceptance is affected by system design features	Questionnaire	User Acceptance		112 subjects	North America	Software	
Russo, P & Boor, S	1993	How Fluent is your Interface	Paper							Worldwide		
Trompenaars, F	1993	Riding the Waves of Culture	Book							Worldwide		
Davis, F	1989	Perceived Usefulness, Perceived ease of use and User Acceptance ...	Paper		Develop and validate new scales for two specific variables - perceived usefulness and perceived ease of use - which are hypothesized as fundamental determinants of user acceptance	Questionnaire & User Evaluation	User Acceptance	2 types of study	**Study 1 :** 120 users; **Study 2:** 40 participants	Worldwide	Software	
Petterson, R	1982	Cultural Differences in the Perception of Image and Color in Pictures	Paper							Worldwide		
Geertz, Clifford	1973	The Interpretation of Cultures	Book							Worldwide		

Benedict, R	1934	Patterns of Culture	Book							Worldwide		
Chua, HF , Boland, J & Nisbett, R	2005	Cultural Variation in Eye Movements during Scene Perception	Paper		Examine the possibility that cultural differences arise from culturally different viewing patterns when confronted with a naturalistic scene	**1)** Study Phase; **2)** Object Recognition Phase; **3)** Demographic Questionnaire and Debriefing; **4)** Data Analysis	Memory and eye-tracking	25 Americans and 27 Chinese	European American and Chinese Students	United States	Perception and Cognition	
Lindsey, D & Brown, A	2004	Sunlight and 'Blue'	Paper									
Choi, B et al	2005	A Qualitative Cross-National Study of Cultural Influences on Mobile Data Service Design	Paper		Determine the role that cultural factors play in the design of mobile data sevices	Long interviews with video clips	Cultural Influence	1 Japanese, 1 Finnish and 4 Koreans	Japanese, Finnish and Korean	Finland	Mobile	Visual Patterns and User Interface Design
Gutchess, A, Welsh, R, Boduroglu, A & Park, D	2006	Cultural Differences in neural function associated with object processing	Paper		Evaluate neural blasts for cultural differences in an event related fMRI study	Behavioral (Questionnaire and 2 speed of processing tasks) | Neuroimaging methods (cognitive tasks)	Cultural differences	11 Americans and 11 East Asians	Americans and East Asians	United States	Perception and Cognition	

Appendix B

Overview of Literature Review regarding Illiteracy

Author(s)	Year	Title	Type of Reference	Experimental Procedure	Objective	Type of Experiment	Focus of the study	Quantitative Data	Users	Location	Environment	Relationship
Ahmed,S.I. , Zaber,M & Guha,S	2013	Usage of the Memory Phone by Illiterate People	Paper		Discover how iliterate people use the memory of mobile phones	User Observation	Illiterate users	15 participants (half males and half females)	Half of them lived in Dhaka and half outside Dhaka	Bangladesh	Mobile	Visual Patterns and User Interface Design
Cuendet, S, Medhi, I, Bali, K & Cutrell, E	2013	VideoKheti: Making video content accessible to low-literate and novice users	Paper		Explore the use of text-free graphical interfaces and speech-based applications to overcome literacy and linguistic issues	User evaluation and usabilty Testing	Low-literacy users	20 participants	8 females and 12 males	India	Mobile	Visual Patterns and User Interface Design
Dew, K et al	2013	Karaoke: An Assistive Alternative Interface for Illiterate Mobile Device Users	Paper		Develop an assistive alternative interface for illiterate mobile device users in the US		Illiterate users			United States	Mobile	
Hauge, A & Jorgensen,C	2013	Voice and avatar face recognition with focus on familiarity and recall accuracy for use in a contact book designed for illiterates	Paper		Explore how voice and avatar faces can improve how iliterate users use a contact book	User Evaluation	Illiterate users	16 people for the **Voice-avatar Identification Test** | 10 people for the **Sound Quality Test** | 18 people for the **effect of voice recognition over time**	16 people for the **Voice-avatar Identification Test** | 10 people for the **Sound Quality Test** | 18 people for the **effect of voice recognition over time**		Mobile	Visual Patterns and User Interface Design
Friscira, E, Knoche, H & Huang, J	2012	Getting in touch with text: Designing a moile phone application for illiterate users to harness SMS	Paper		Allow illiterative users to listen received SMS and composed messages using text-to-speech support and icons	**Study 1**: semi-structured interviews | **Study 2**: questionnaire, semi-strucutured interview, usability test and debrief interview	Illiterate users	**Study 1:** 9 participanst (2 male and 7 females) | **Study 2** : 3 paid participants from study 1	Immigrants from Africa and Brazil living in Switzerland	Switzerland	Mobile	Visual Patterns and User Interface Design

Gavaza, T	2012	Culturally Relevant Augmented User Interface for Illiterate and Semi-Literate Users	Msc Thesis									Cultural Influence and Cultural Interpretation; Visual Patterns and User Interface Design
Chaudry, B et al	2012	Mobile Interface Design for Low-Literacy Populations	Paper		Explain how few mobile health applications focus on low literacy users	**Study 1** : GUI Components | **Study 2** : Ideal Navigation Structure	GUI components and Navigation Structure	17 participants	16 African American and 1 Latino	United States	Mobile	Visual Patterns and User Interface Design
Knoche, H & Huang, J	2012	Text is not the enemy: How illiterates use their mobile phones	Paper		Examine the mechanisms that illiterate immigrants use in their mobile phones	Semi-structured interviews	Role of text for illiterate people using mobile devices	9 participants (7 females and 2 males)	Immigrants from Latin America and Africa living in Switzerland	Switzerland	Mobile	Visual Patterns and User Interface Design
Carvalho, M	2011	Designing for Low-literacy Users: a Framework for analysis of user-centered design methods	Msc Thesis									Cultural Influence and Cultural Interpretation; Visual Patterns and User Interface Design
Medhi, I et al	2011	Designing Mobile Interfaces for Novice and Low Literacy Users	Paper		Discover which type of interface the novice and low literacy users are more comfortable with	**Experiment 1**: Text vs Voice and Graphics | **Experiment 2**: Text vs Live Operator	Novice and Low-literacy users	90 subjects	All subjects were functional illiterates, with low educational levels and zero experience with computers	India; Kenya; South Africa; Philippines	Mobile	Visual Patterns and User Interface Design
Sherwani, J et al	2009	Speech vs Touch-tone : Telephony Interfaces for Information Access by Low Literate User	Paper		Develop and test spoken language prototypes aimed at low-literate users	Content Validation and User Feedback	Low-literacy users	30 subjects	Users from 3 different locations and speak 2 different languages (Urdu and Sindhi)	Pakistan	Mobile	Visual Patterns and User Interface Design

Findlater, Leah et al	2009	Comparing Semiliterate and Illiterate Users ability to transform from Audio+Text to Text Only	Paper		Explore how semiliterate users with very little education might benefit from a combination of text and audio compared to illiterate and literate users	User Testing	Semiliterate users	14 participants	9 females and 5 males	India	Mobile	Visual Patterns and User Interface Design
Medhi, I, Gautama, S, Toyama, K	2009	A comparison of Mobile Money Transfer Uis for Non-Literate and Semi-Literate Users	Paper		Invesigate usability of existing mobile payment services	Usability Test	Illiterate and Semiliterate	16 users had experience with mobile banking	90 subjects in first study | 58 users in the usability testing	India; Kenya; South Africa; Philippines	Mobile	
Joshi, A & Welankar, N et al	2008	Rangoli: A Visual Phonebook for Low-Literate Users	Paper		Explore the creation of a visual phonebook for low-literate users	User Evaluation	Low-literacy users	11 users	11 users	India	Mobile	
Prasad, A et al	2008	Exploring the Feasibility of Video Mail for iliterate Users	Paper		Explores the capability of peer-to-peer communication capabilities can be accessible to illiterate people	User Evaluation	Illiterate users	20 participants (10 male and 10 female)	Participants range in age from 25 to 45 years	India	Web	
Lalji,Z & Good, Judith	2008	Designing new technologies for iliterate populations	Paper		Investigate the design of a mobile phone for illiterate persons	User Evaluation	Illiterate users	**Phase 1**: 5 participants (3 males and 2 females) | **Phase 2** : 8 mobile phone owners and 22 non-owners	5 participants for Phase 1 and 30 for Phase 2	India	Mobile	
Medhi, I et al	2007	Optimal Audio-visual Representations for Illiterate Users of Computers	Paper		Understanding of the optimal audio-visual representation for illustrating concepts for illiterate and semiliterate users of computers	User Evaluation	Illiterate users	Subjects with 13 different health symptoms	200 subjects	India	Software	Visual Patterns and User Interface Design

Bhamidipaty, D	2007	SymAB: Symbol-Based Address Book for the Semi-Literate User	Paper		Explores the creation of a system-based design address book to cater for the semiliterate user						Mobile	
Plauche, M et al	2006	Speech Recognition for Illiterate Access to Information and Technology	Paper		Generate the linguistic resources needed for automatic recognition of their speech	Data Collection and Prototype	Illiterate and Semiliterate	The age of volunteers ranges from 18 to 80 years old, with an average of 40	77 volunteers for speech recording	India	Software	
Medhi, I et al	2006	Text-Free User Interfaces for Illiterate and Semi-Literate Users	Paper		Determine design principles for illiterate users and establish cultural considerations	User Testing	Illiterate users	Two groups of five participants	Interacted with over 80 people	India	Software	Visual Patterns and User Interface Design
Chipcase, J	2005	Understanding non-Literacy as a Barrier to Mobile Phone Communication	Paper		Understand the communication habits of non-literate people and how we might improve their communication experience	User Observation	Illiterate users	11 non-literate participants	11 non-literate participants	India, China and Nepal	Mobile	
Medhi, I, Pitti, B, Toyama, K	2005	A Text-Free User Interface for Employment Search	Paper		Develop a text-free application that can lower the barriers to computer use for illiterates and computer illiterates	Focus Groups	Illiterate Users	During the study, the authors interacted with at least 75 women	40-50 Women in the focus group discussions	India	Software	Visual Patterns and User Interface Design
Dowse, R & Ehlers, M	2004	Pictograms for conveying Medicine Instructions	Paper		Explores that the idea of implementing pictograms may ease the comprehension in rural areas	Interview, Pictogram interpretation & Pictogram preference	Low-literacy users	Participants from eight language groups	304 respondents	South Africa	Physical	Cultural Influence and Cultural Interpretation

Huenerfauth, M	2002	Develop Design Recommendations for Computer Interfaces Accessible to Illiterate Users	Msc Thesis				Illiterate Users					Visual Patterns and User Interface Design
Dowse, R & Ehlers, M	2001	The Evaluation of pharmaceutical pictograms in a low-literate South African Population	Paper		Find a solution for the non-compliance in countries with high illiteracy rates	User Testing	Low-Literacy Users	23 pictograms	46 Xhosa respondents	South Africa	Physical	

Appendix C

Overview of Literature Review regarding Icon Design

References	Salman, Kim and Cheng (2010) - Senior-Friendly icon design for the mobile phone	McDougall, Curry and De Bruijn (1999) - Measuring symbol and icon characteristics	* Rogers (1988) - Pictorial Representation of Abstract Concepts in relation to Human-computer Interaction
Actions	Read Message	Add task	Go to bottom of text
	Write Message	Adjust Contrast	Insert a Line
	Set Scheduler	Building	Delete a Block of Text
	Add to Phone Book	Calendar	Save a File
	Set Alarm	Co-Operate	Quit
	Search Phone Book	Communication	
	Take Photo	Connect	
	Ring Tone Settings	Crop	
	Play Game	Diagnose	
	Change Wallpaper	Discard Files	
		Draw	
		Educate	
		Eject	
		Entrance	
		Fast Forward	
		Fast Rewind	
		File Manager	
		Handle with care	
		Hierarchy	
		Information	
		Library	
		Lock	
		No Entry	
		Note	
		Pause	
		Portable Files	
		Return to homepage	
		Safe	
		Search	
		Sound	
		Time	
		Undo	
		Zoom	
		More in the article	

References	Restyandito et al. (2013) - Designing usable Icons for the Non eLiterate User	Yumiao, Jiang and Xhongliang (2010) - Culture Adapted User Interface Design Method for Mobile Phone	Kim and Lee (2005) - Cultural Differences and Mobile Phone Interface Design
Actions	Short Messaging Service	Game	Call Log
	Setting the alarm		Message
	Make a Call		Downloads
	Playing Games		Voice Recording
	Chipchase (2005) - Understanding Mobile Barriers	Knoche and Huang (2012) - Text is not the Enemy	Lalji and Good 2008 - Designing New Technologies for Illiterate Populations
	Creating a Contact	Call Logs are the "core"	Step by Step Instructions
	Save a text message	Organize and Search Information	Organize and Search Information
	Create a text message	Child mode (read only)	
	Joshi et al. (2008) - Rangoli: A visual phonebook for low-literate users	Ahmed et al. (2013) - Usage of the memory of mobile phones by illiterate people	
	Organize and Search Information	Organize and Search Information	

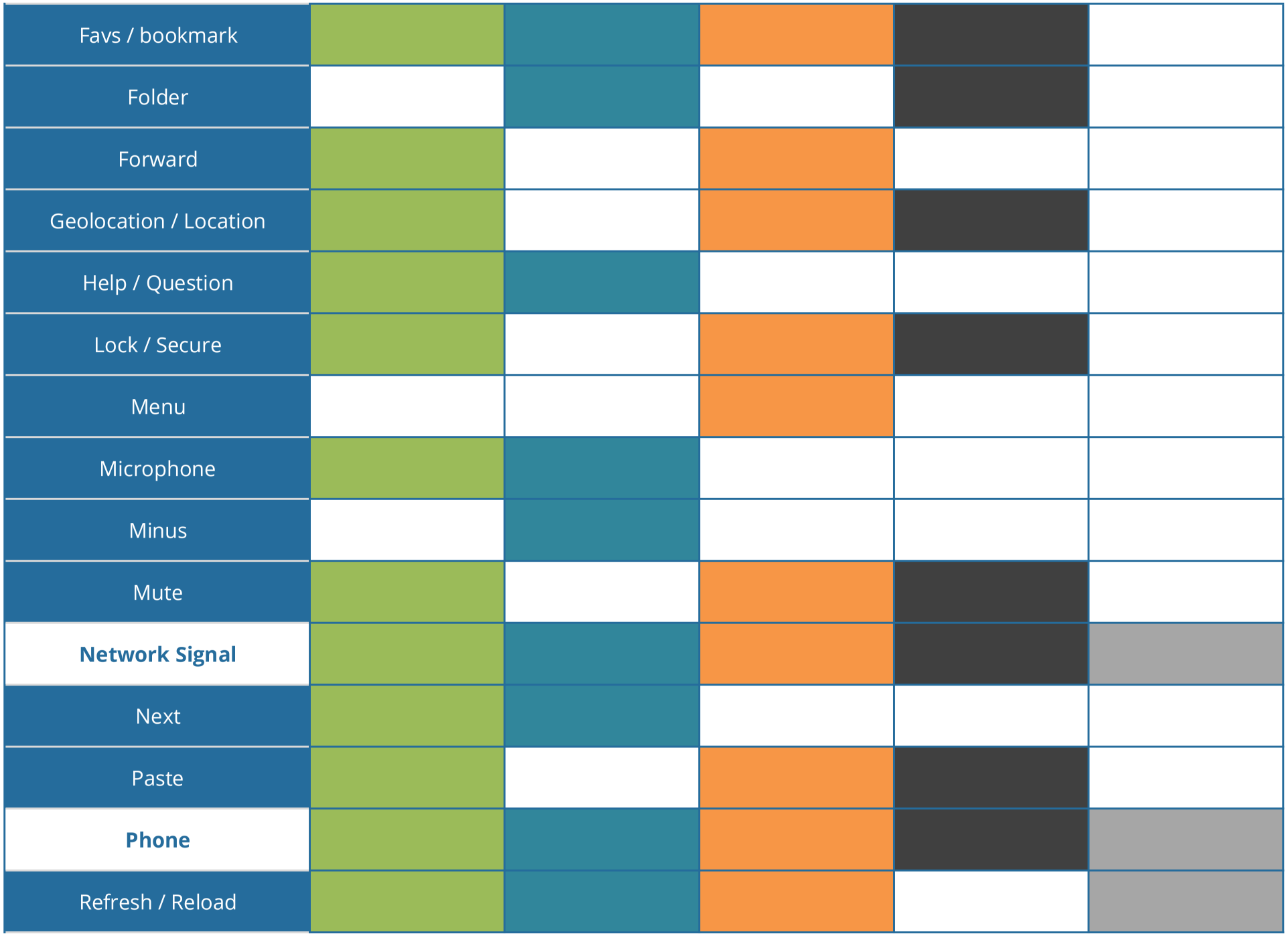
*	cited in McDougall, Curry and De Bruijn (1999)

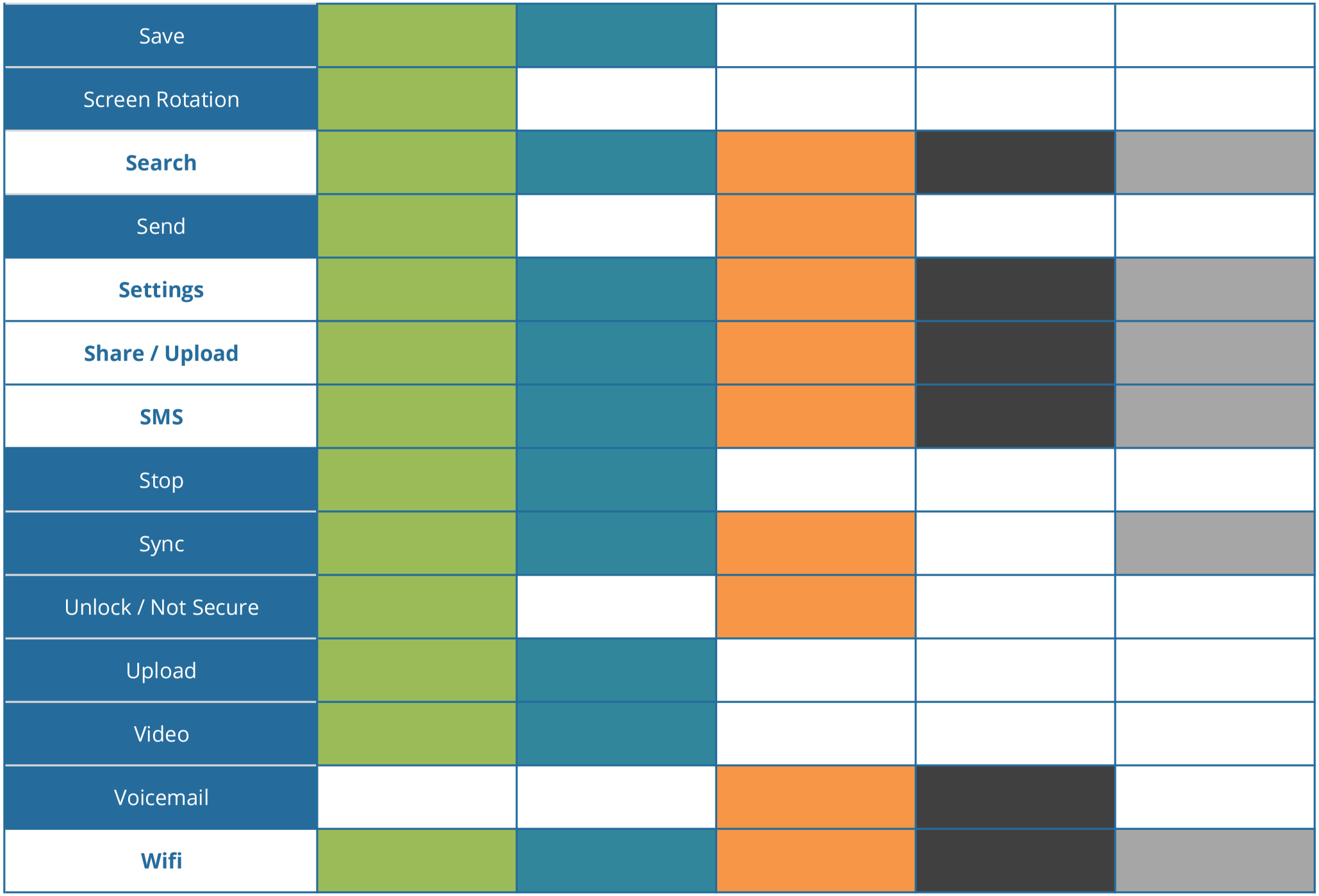
Appendix D

Comparative Analysis of Mobile Operating Systems and their respective icons

	Android	Windows Phone	Firefox OS	Blackberry OS	iOS
Access SD Storage					
Access Storage					
Access time					
Access USB					
Add / New					
Add contact / Add Person					
Add to					
Alarm					
Back					
Basecircle					
Battery					
Bluetooth					
Brightness					

Calendar/ Event					
Camera					
Cancel					
Check					
Close					
Contacts / Accounts / People					
Copy					
Cut					
Data usage					
Delete / Discard					
Device Storage					
Download					
Edit					
E-mail					
End Call / Hang up					


Favs / bookmark
Folder
Forward
Geolocation / Location
Help / Question
Lock / Secure
Menu
Microphone
Minus
Mute
Network Signal
Next
Paste
Phone
Refresh / Reload


Save
Screen Rotation
Search
Send
Settings
Share / Upload
SMS
Stop
Sync
Unlock / Not Secure
Upload
Video
Voicemail
Wifi

Appendix E

Paper Version for Phase One and Phase Two of the Experimental Procedure

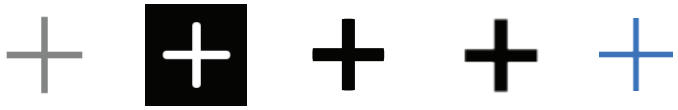
Género: ◯ Masculino ◯ Feminino

Idade:

Nacionalidade:

Por favor, indique o signicado de cada conjunto de simbolos.
De seguida, selecione o seu simbolo preferido e o menos favorito em cada um dos 16 conjuntos.

Qual é o significado do símbolo ?

1 

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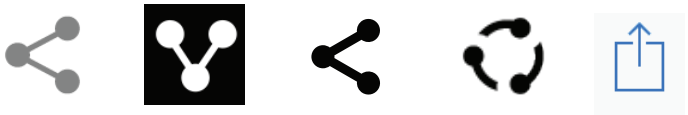
Qual é o significado do símbolo ?

11 

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15 

16 

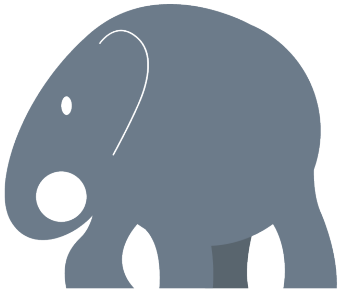
Appendix F

Paper Version for Phase Three of the Experimental Procedure

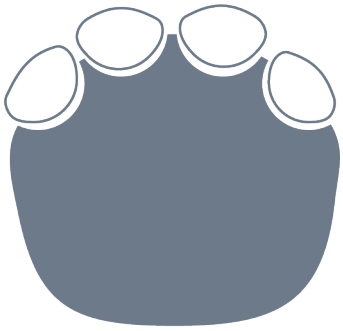
Género:	◯ Masculino ◯ Feminino
Idade:	_____
Nacionalidade:	_____
Sabe usar smartphones:	◯ Sim ◯ Não

1. Cada ícone representa um elefante mas de formas diferentes. Numa escala de 1 a 3, indique a relação do icone com a representação de um elefante.

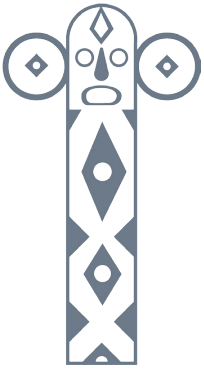
1	relação fraca
2	relação neutra
3	relação forte



1 — 2 — 3



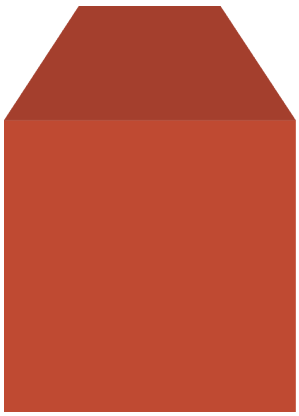
1 — 2 — 3

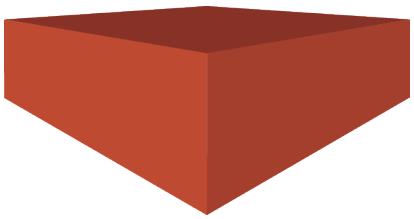


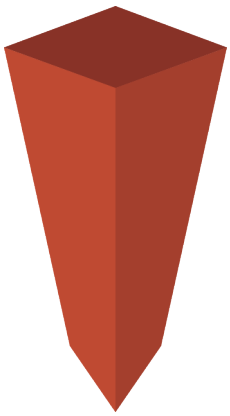
1 — 2 — 3

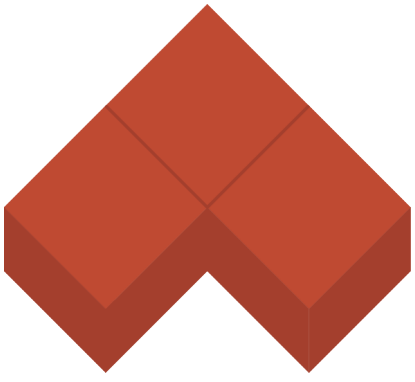
2. Dos três icones apresentados, indique o preferido com o número 1 e o menos preferido com o número 2.

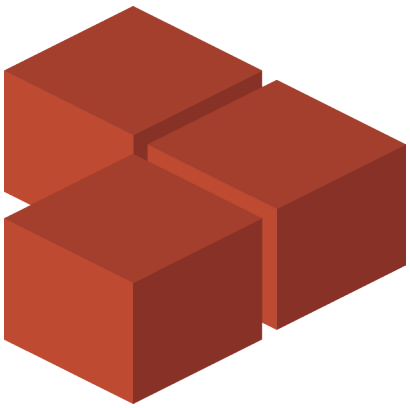
3. Das seis perspectivas apresentadas, indique a preferida com o número 1 e a menos preferida com o número 2.



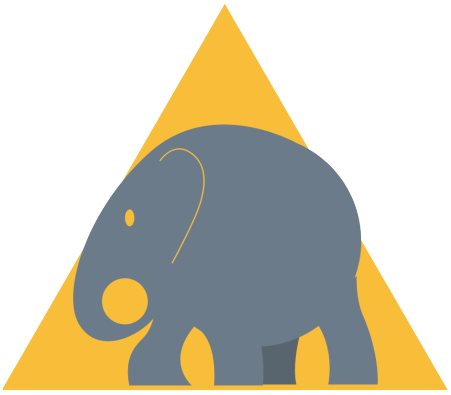


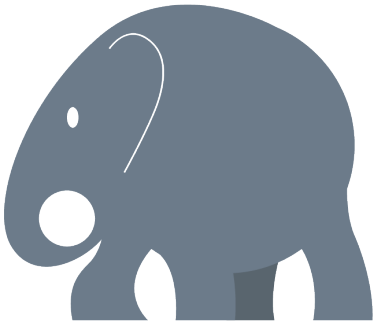


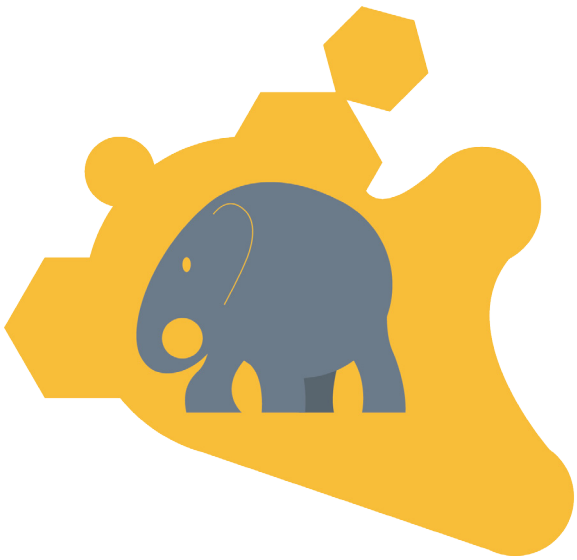




4. Dos seis ícones apresentados, indique o preferido com o número 1 e o menos preferido com o número 2.







5. Dos três ícones apresentados, indique o preferido com o número 1 e o menos preferido com o número 2.

6. Das duas formas apresentadas, indique a sua preferida com o número 1 e a menos preferida com o número 2.

7. Dos três icones apresentados, indique o preferido com o número 1 e o menos preferido com o número 2.

☐

☐

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8. Dos dois conjuntos de ícones apresentados, indique o preferido com o número 1 e o menos preferido com o número 2.

☐

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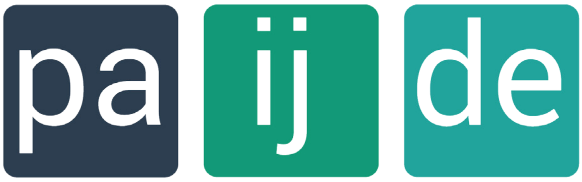
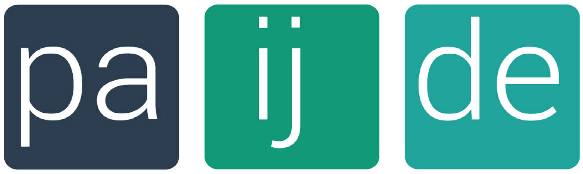
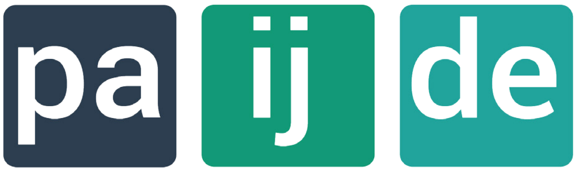
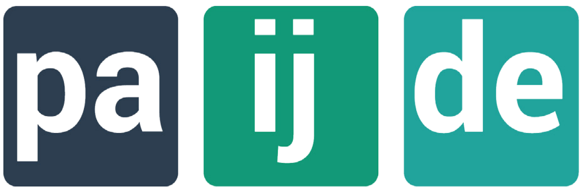
9. Dos sete conjuntos de ícones apresentados, indique o preferido com o número 1 e o menos preferido com o número 2.

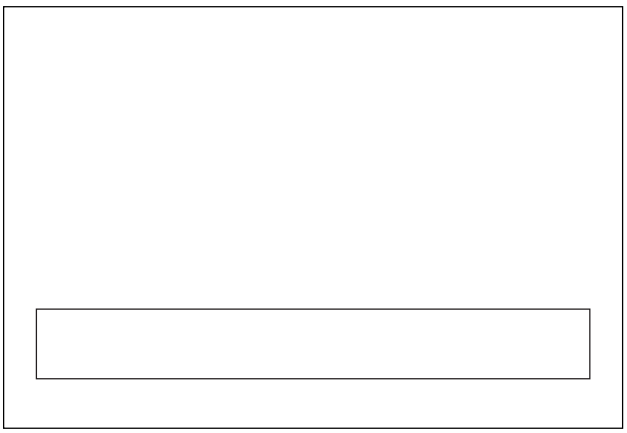








10. Para cada uma das 16 cores apresentadas, indique uma emoção ou acção associada com a cor. Por exemplo, em vários países europeus, o cor de rosa está associado com o sexo feminino e memórias de infância.










Appendix G

Paper Version for Phase Four and Phase Five of the Experimental Procedure

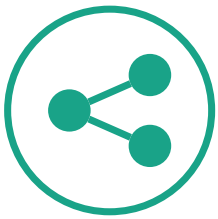
Género: ◯ Masculino ◯ Feminino

Idade: _____

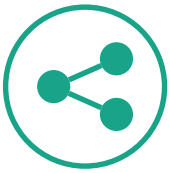
Nacionalidade: _____

Sabe usar smartphones e/ou computadores: ◯ Sim ◯ Não

1. Cada ícone representa uma acção ou função de um smartphone. Escreva a acção ou função associada a cada ícone no espaço em branco.

1		
2		
3		
4		
5		
6		

2. Dos dois ícones apresentados nos seis conjuntos, circule o favorito.

1		
2		
3		
4		
5		
6		

Appendix H

Quick User Guide to Okavango

OKAVANGO

Quick Guide to the Application

Table of Contents

Introduction

The objective of Okavango is to collect data from African residents through a process similar to a game. This data will be used for the creation of visual elements considering the cultures of African users. The role of the supervisor is fundamental in this data collection task because he/she is able to communicate with the African users on a deeper level and in a more coherent form.

The application and the data collected from it can only be used for research purposes in order to develop systems able to integrate the African users more easily and improve the user experience. The application also aims to understand how the degree of written literacy, technological literacy, prominence of oral-based traditions and other factors impact the comprehension and preference of icons.

Supervisor: Person leading the process

Participant: African resident answering the questions in the application

A Few Guidelines

- The participants must be over 18 years old and the answers should always correspond to the opinion of the users, not the supervisor. It is important to tell the participants that there are no right or wrong answers.

- A supervisor must always be present during the process in order to assist the participants.

- The participant must play the three games continuously or else all the data will be lost.

- The ideal supervisor is someone able to read, write, and interact with smartphones. The supervisor is able to communicate with the local people and if possible, translate the information of the application to local languages.

- If the participant is unable to read and write, the supervisor can read the information out loud and fill the information for the participant.

- The results can only be sent via e-mail and therefore, an Internet connection is necessary to send the results. To play the games, an Internet connection is not required and the people only require a smartphone.

- If the participants have access to an Internet connection, the results should be sent daily or at the end of the week, as a form to secure and provide better data processing.

- The average duration per participant is between 30 and 40 minutes.

- Whenever possible, please take photographs and notes of the people and the locations, and send it to us via email. Besides the data collection, it is important to understand the environment in which the participants interact with the application.

Example of a note:

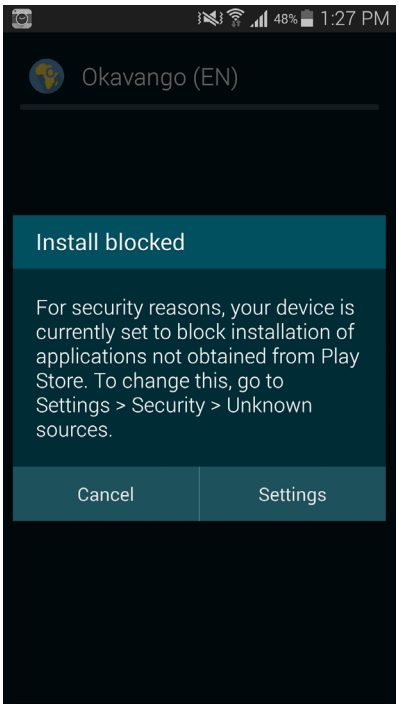
The application was utilized in [name of location], a remote location in the Northern Cape, 25 km from Kimberley, the capital of the region. The participants were eager to use the application, despite their lack of experience with smartphones.

How to install Okavango in the smartphone

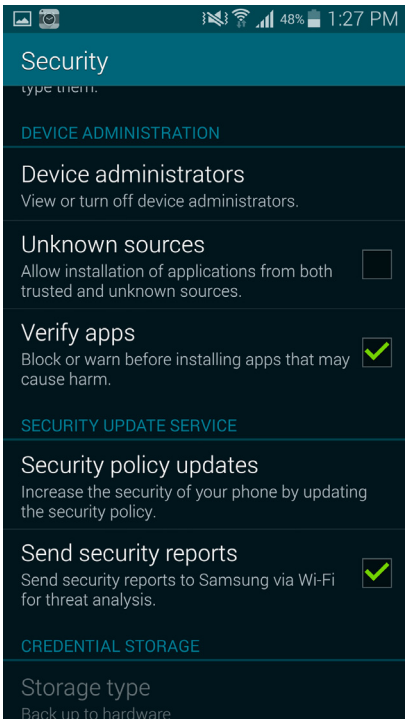
To install the application in the smartphone, the supervisor needs to perform the following steps:

- Open the email containing the application for Android devices
- Open the file **Okavango-EN.apk**
- If the smartphone accepts the installation of applications from unknown sources, the supervisor just needs to install Okavango.
- In case the smartphone does not accept the installation of applications from unknown sources, the installation will be blocked. If the supervisor encounters an **Install Blocked** message, the following steps must be followed:

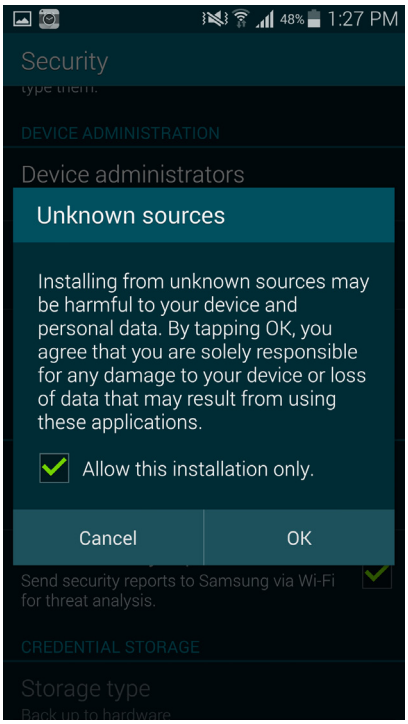
1) Select **Settings**



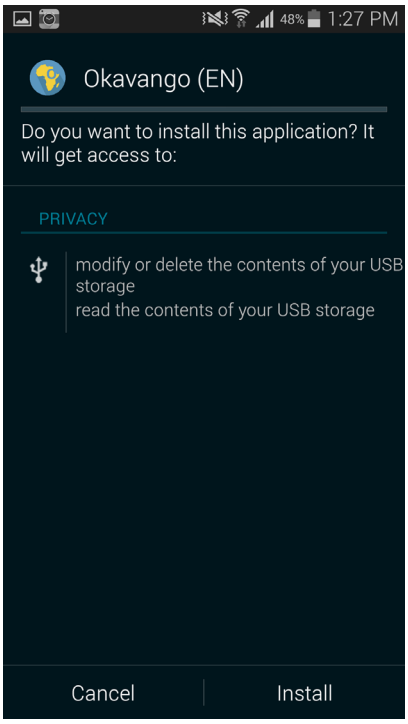
2) Once the supervisor is redirected to the **Security** settings, he/she must go to the **Device Administration** section.



3) Afterwards, the supervisor must check **Unknown Sources**. A window with the name **Unknown Sources** will show up and the supervisor must select **OK**.



4) The supervisor is taken to a page with the name **Okavango (EN)** and the **Install** button must be pressed.



5) At last, the supervisor must select **Open** to start the application or just press **Done** if the supervisor does not want to open the application.

Access the application

- To access the application, the supervisor needs to enter the password indicated below.

  Password: IconResearch15

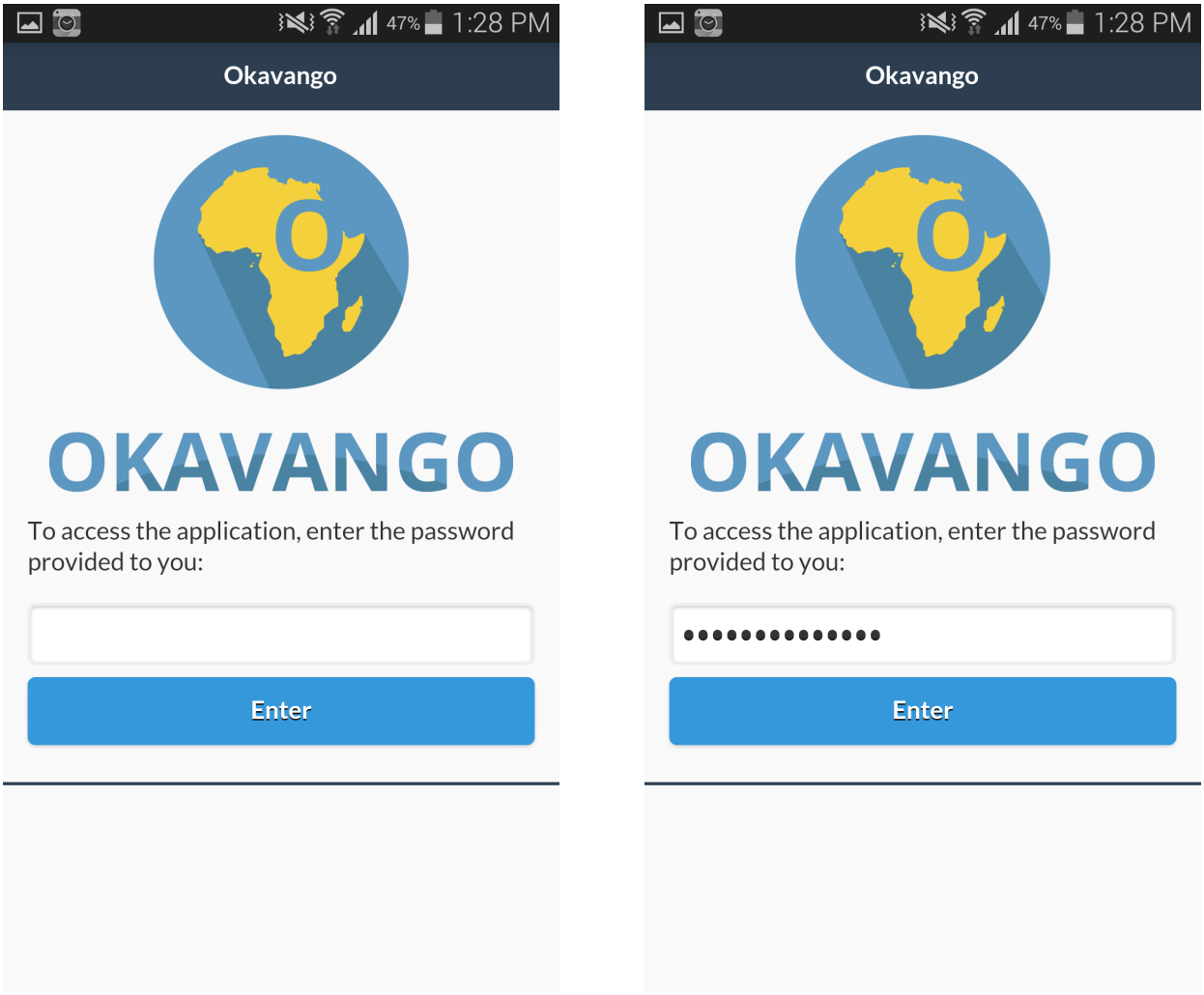


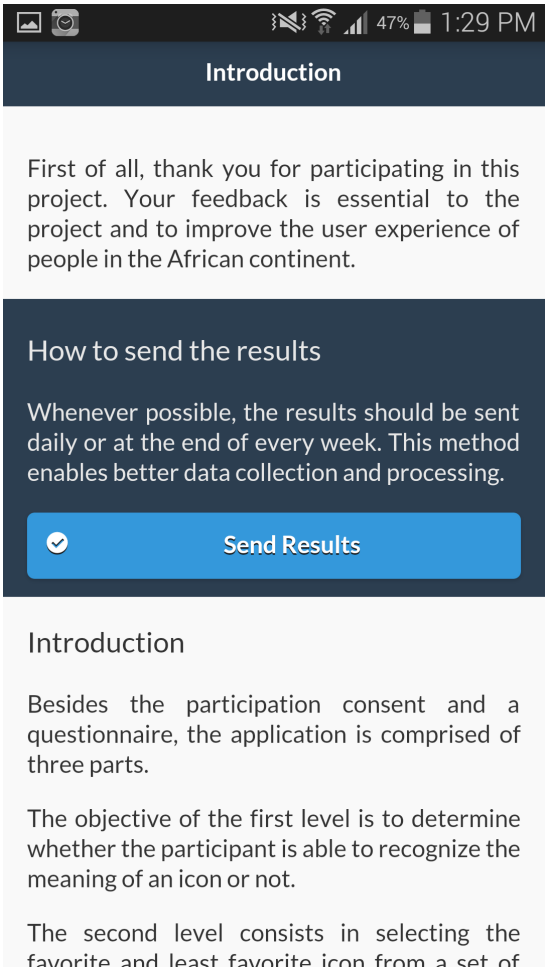
Figure 1 – Access the application

Introduction Page

The introduction page is divided in three parts:

- First part: welcome screen of the application.
- Second part: instructions on how to send the results to the research facility.
- Third part: brief introduction and description of Okavango's structure.

To advance to the next pages, press **Start**.



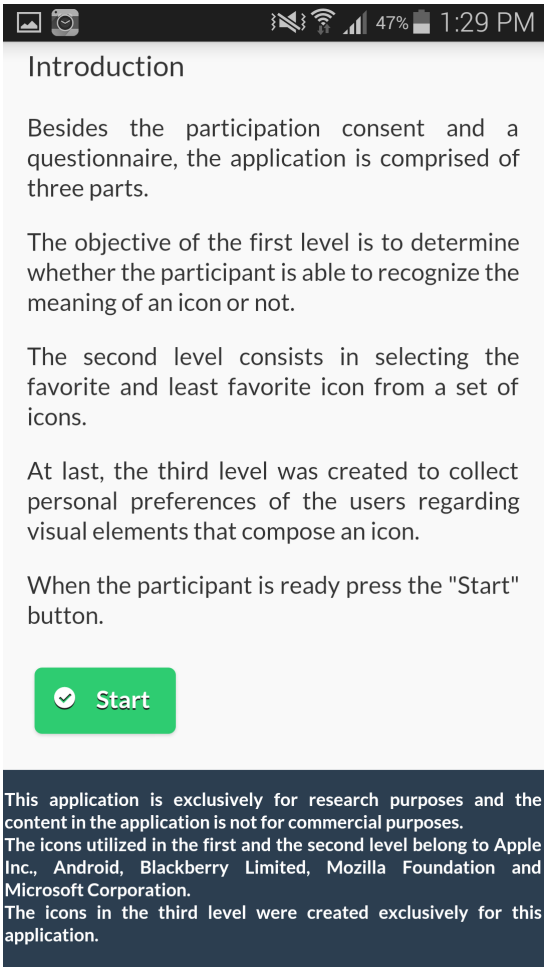


Figure 2 – Introduction Page

Consent Page

After the introduction page, the participant encounters the consent page.

- The user must read and agree with the terms provided.
- The user is only able to proceed once he agrees with all the provided terms.
- If the user does not agree with the terms, the supervisor must encounter another participant and return to the introduction page.

- It is important to refer that no sensible data is going to be published and the anonymity of the users is fundamental for the research.

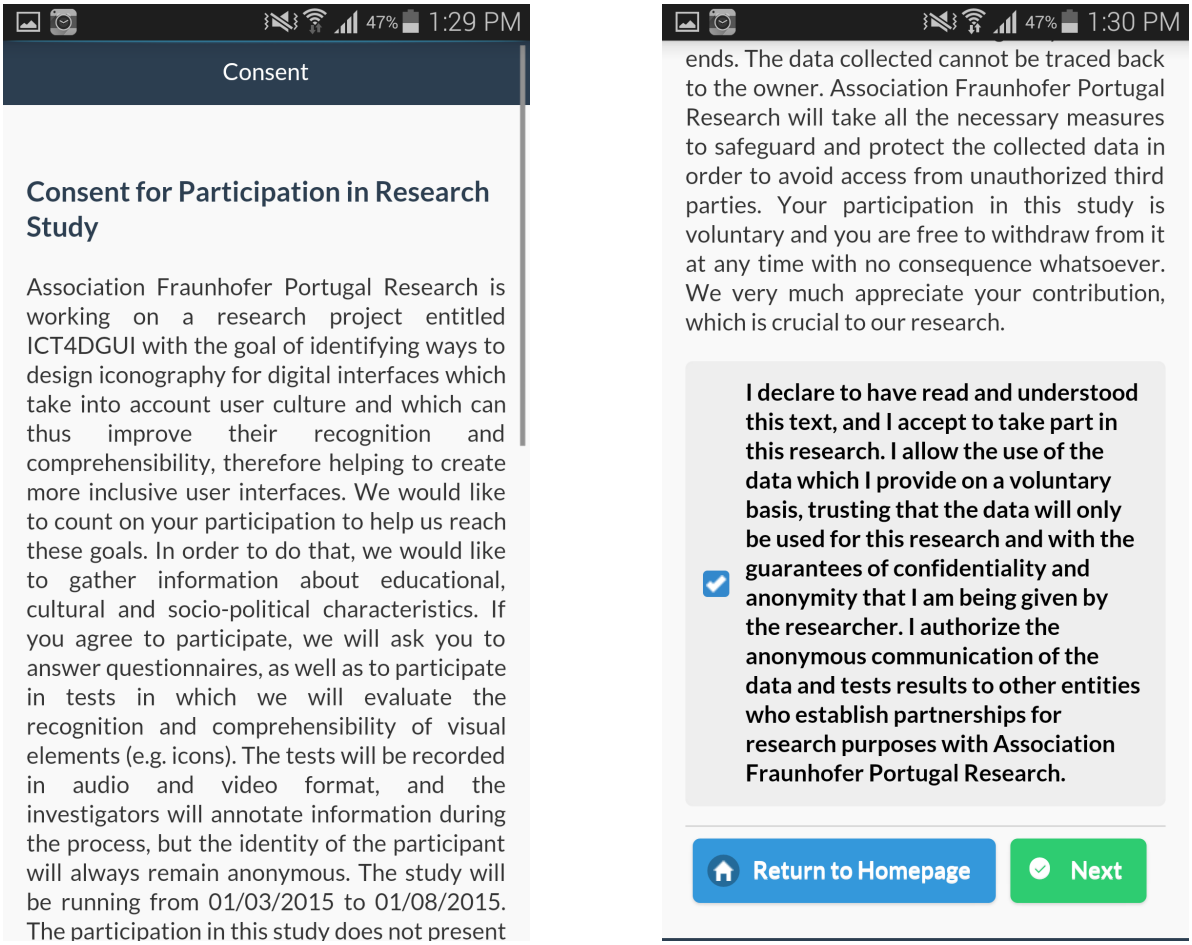


Figure 3 – Consent Page

Questionnaire

- In order to advance to the next pages, you must fill the following fields:
    - Sex
    - Age
    - Nationality
    - Native languages
    - Ability to read and write
    - The ability to use smartphones
- Participants below 18 years cannot participate.
- The native languages should indicate not only the “official” language, but also the local languages.

Example:

For instance, in the Northern Cape, the official languages are Afrikaans, Tswana, Xhosa and English. Nonetheless, several people speak native languages such as Nama and Khwe.

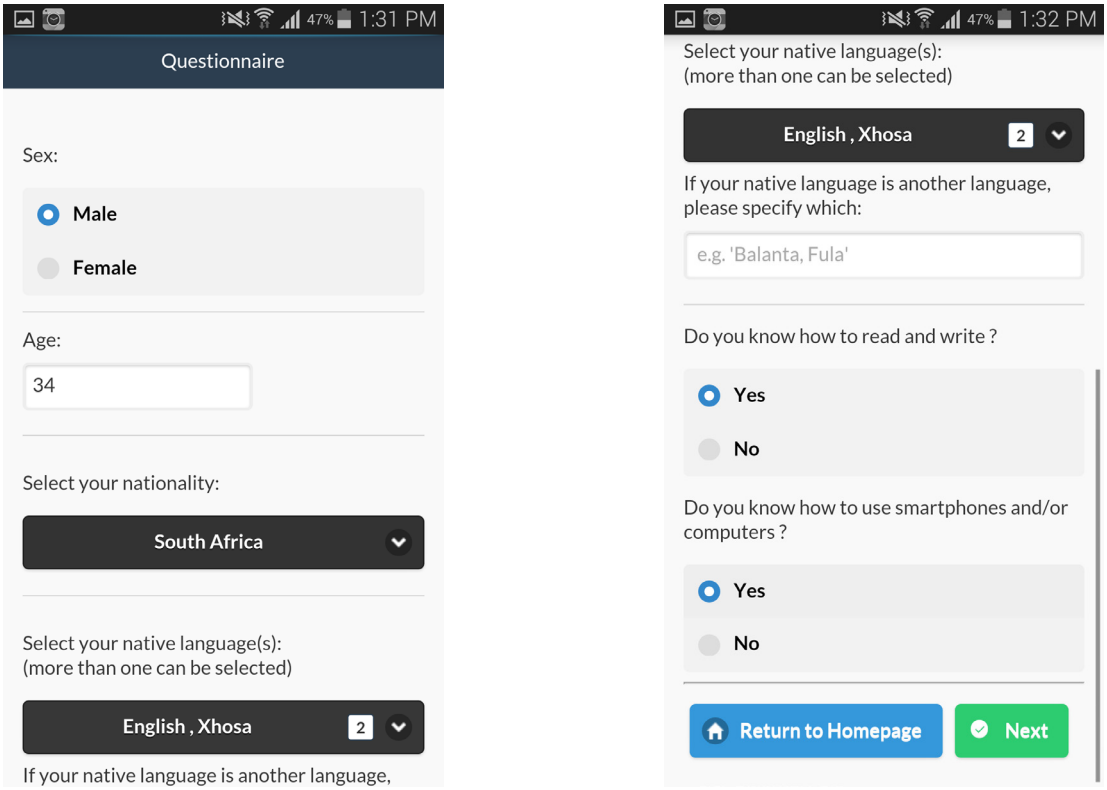


Figure 4 – Questionnaire Page

Level 1 – Icon Recognition

The first level, entitled “Icon Recognition” contains 16 questions.

- Each question displays five icons, a list of options and a text field.
- The goal is to associate the five icons with a meaning from the list of options or insert a new meaning in the text field.
- The list contains 57 options related to actions and functions in a smartphone.
- If the participant thinks the icons do not represent any of the 57 options, the participant is able to write what the icon represents in the text field.
- In case the participant really does not know the meaning of the icons, the option named “I do not know the meaning of this icon” can be selected.
- After the participant selects **Next Question**, the answer cannot be changed.
- A reference page with the elements of the list is provided in this document ("Reference Sheet Level 1 – Icon Recognition ”) and it should be used during the process to assist both the participant and/or the supervisor.

The final question is succeeded with a conclusion page indicating the amount of points the user obtained in the game.

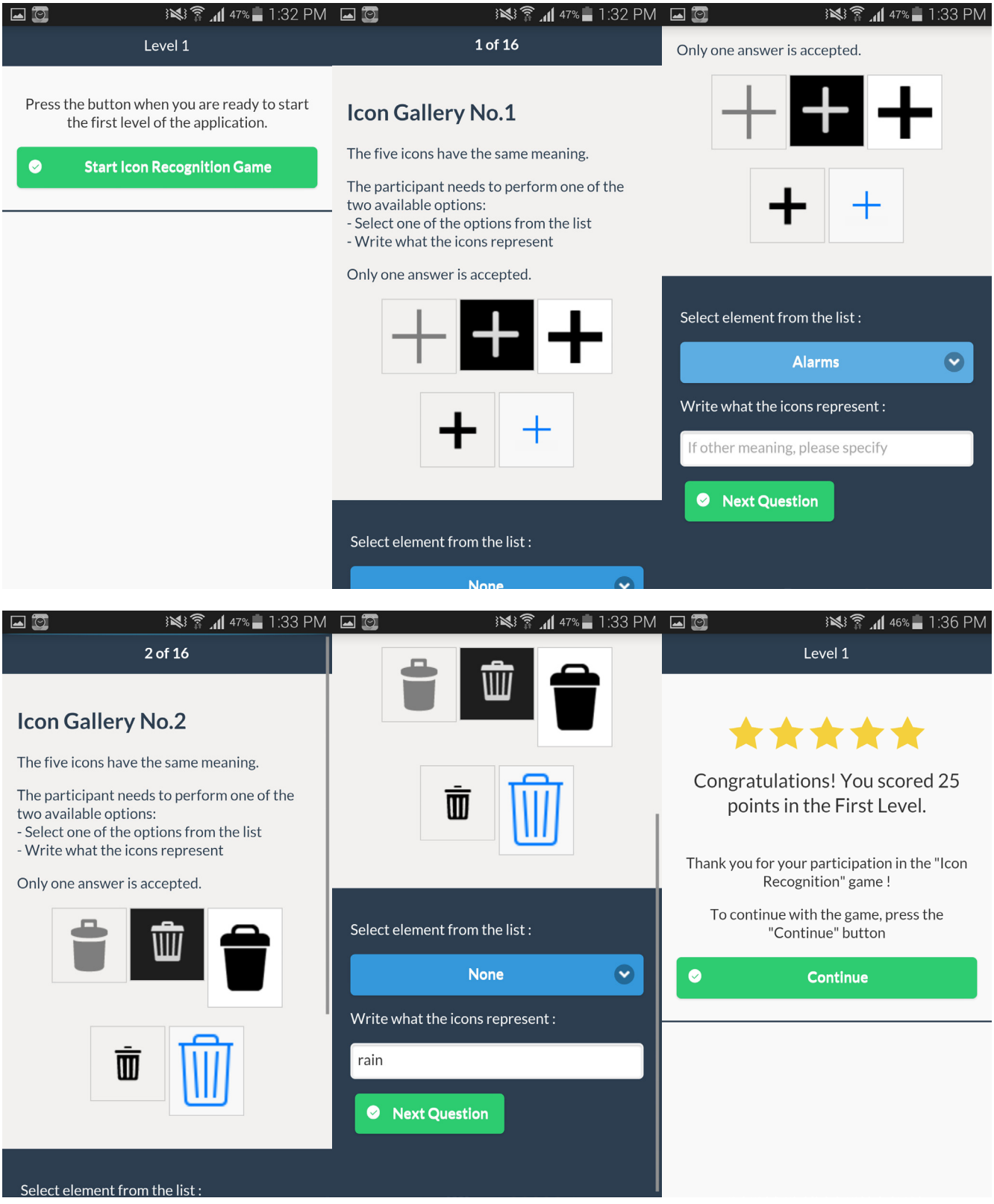


Figure 5 – First Level

Level 2 – Icon Preference

The second level, entitled “Icon Preference” contains 16 questions.

- Each question displays five icons, followed by the same five icons aligned vertically.
- The objective of the level is to select the **Best** and **Worst** icon from the set.
- Only one icon can be selected as the best and another one as the worst.

The final question is succeeded with a conclusion page indicating the amount of points the user obtained in the game.

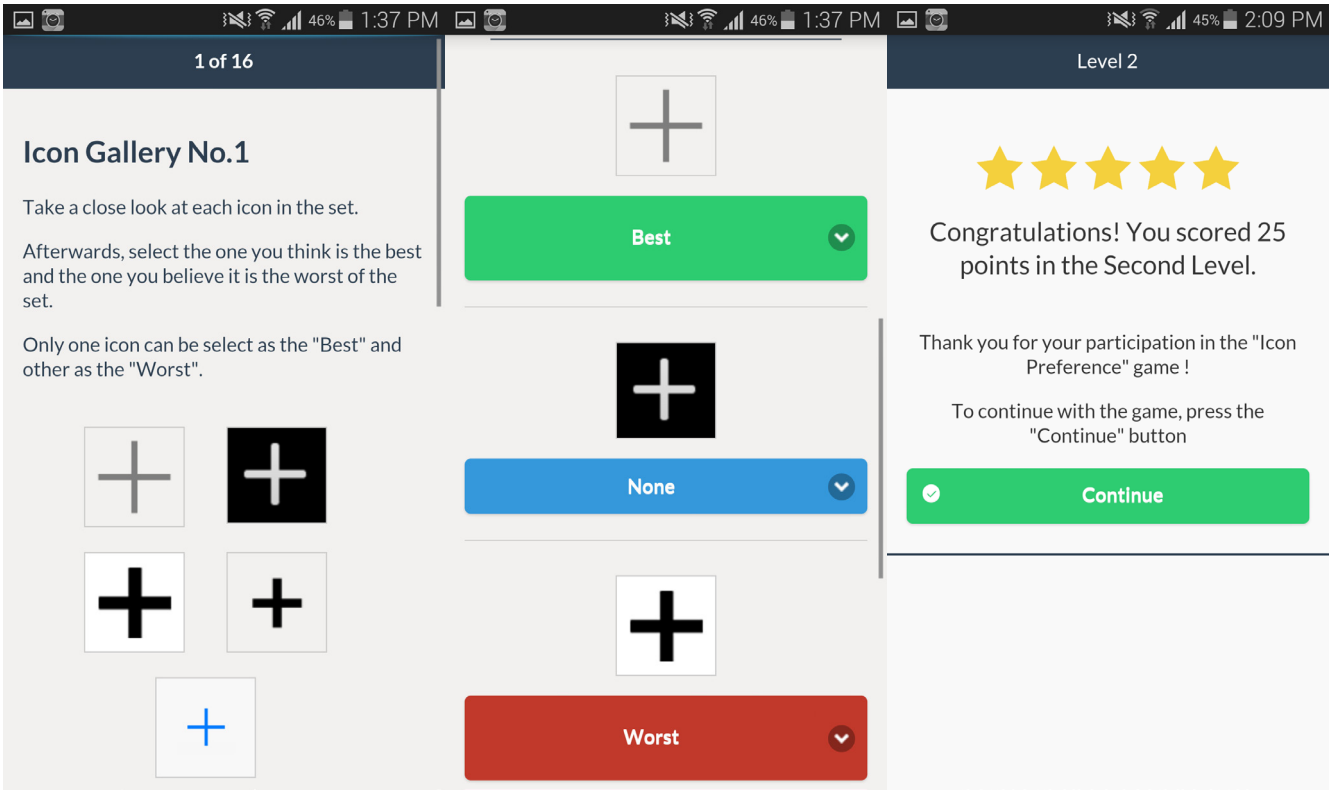
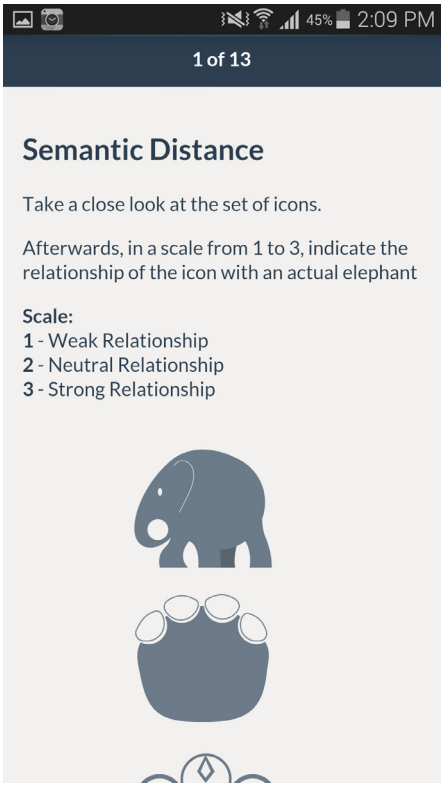


Figure 6 – Second Level

Level 3 – Preference of Elements

- The last level denominated “Preference of Elements” is divided in 14 pages.



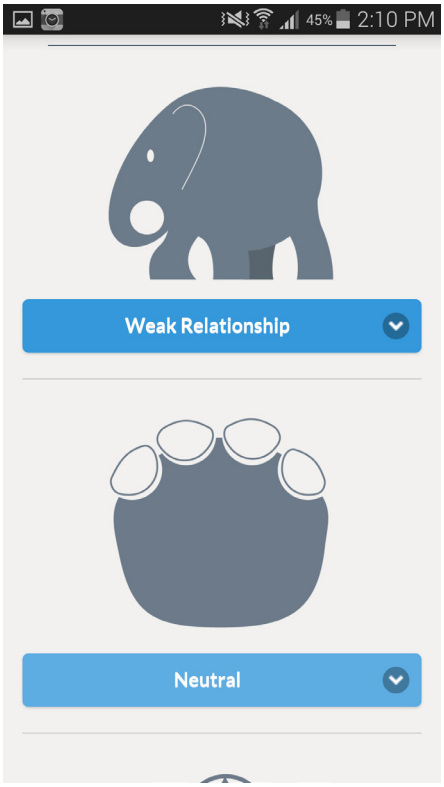


Figure 7 – First Page of Level 3

- The first page contains three icons and the participant must associate the icons with the representation of an elephant.
- The three icons must have a relationship associated with them,
- All the three icons can have the same type of relationship.

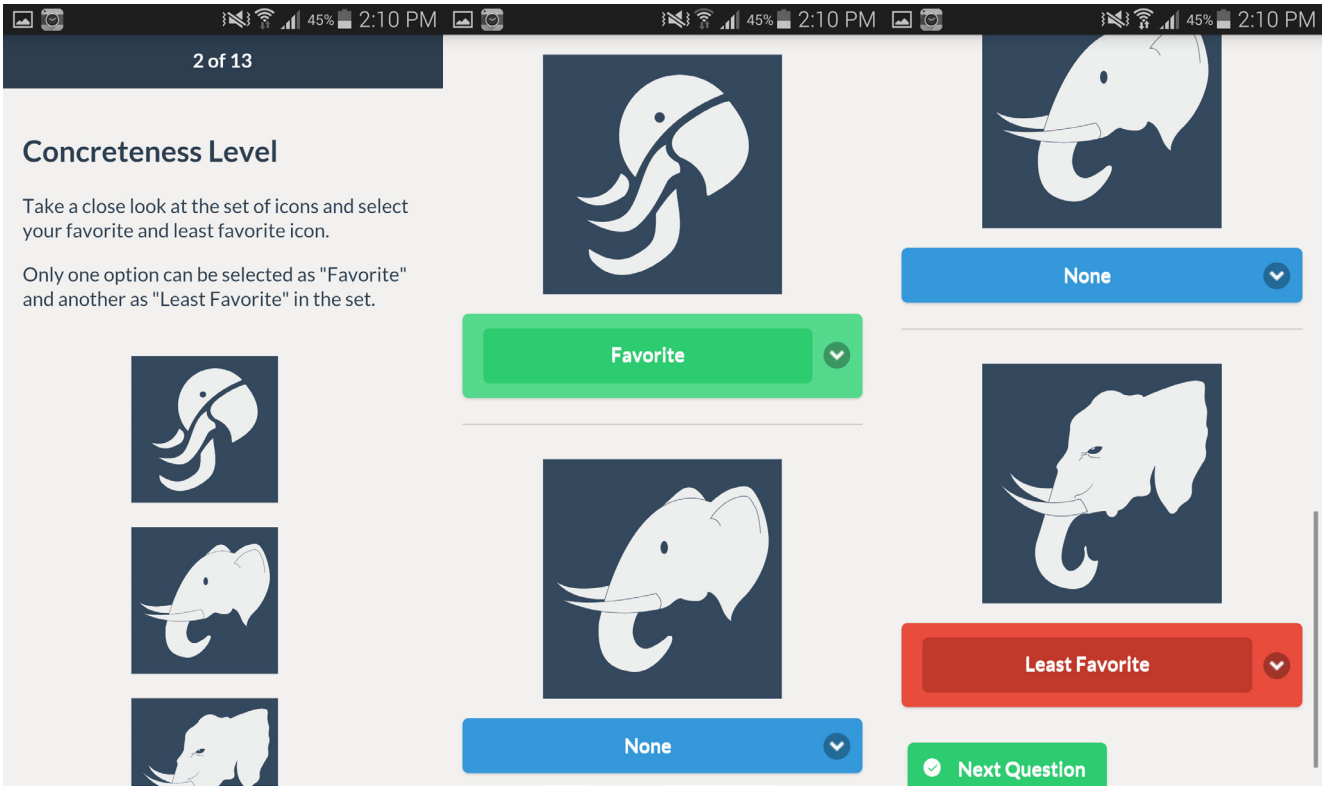


Figure 8 – Format of pages 2 to 9 in level 3

- From page 2 to page 9, the participant must select the **Favorite** and the **Least Favorite** icon.
- The page displays a number of icons together, followed by the same icons aligned vertically.
- Only one icon can be the favorite and another one as the least favorite.

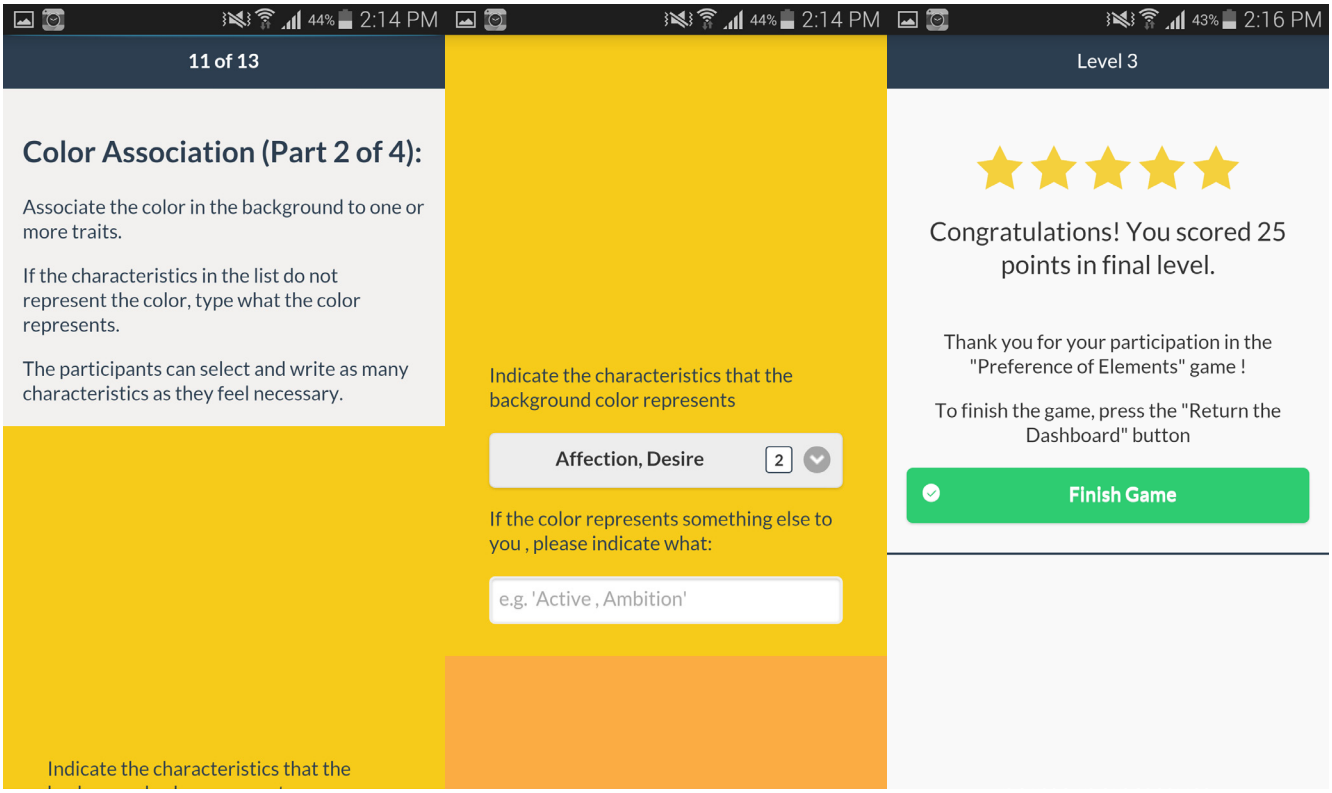


Figure 9 – Format of pages 10 to 13 of level 3

From page 10 to 13, the participant has to associate characteristics to a color.

- This part of the level contains 4 pages with 4 colors each.
- The list has 38 characteristics and the participants can select several options from the list, as they can also write other characteristics associated with the color.

  Example:

  The color “white” might represent purity and calm, two options in the list, but it can also signify tranquility and peace, characteristics that need to be written in the text field.

- One color can be associated to several emotions or traits.

- A reference page with the elements of the list is provided in this document (“Reference Page Level 3 – Color Association”) and it should be used during the process to assist both the participant and/or the supervisor.

- Another reference page (“Reference Page 2 Level 3 - Colors”) contains the colors used in this level and should be utilized in case the participants need additional help in associating the colors to characteristics. The page should be cut into 16 pieces and each piece contains one color. The pieces are shown one at a time to ease the comprehension of the user.

The final question is succeeded with a conclusion page indicating the amount of points the user obtained in the game.

Sending the results

- Once the participant ends all the three levels, the application returns to the introduction page.

- If an Internet connection is available, press the **Send Results** button in the Introduction page.

- The application might display several email applications and the supervisor must select one of the options. Out of all the options, the supervisor must select **Gmail**.

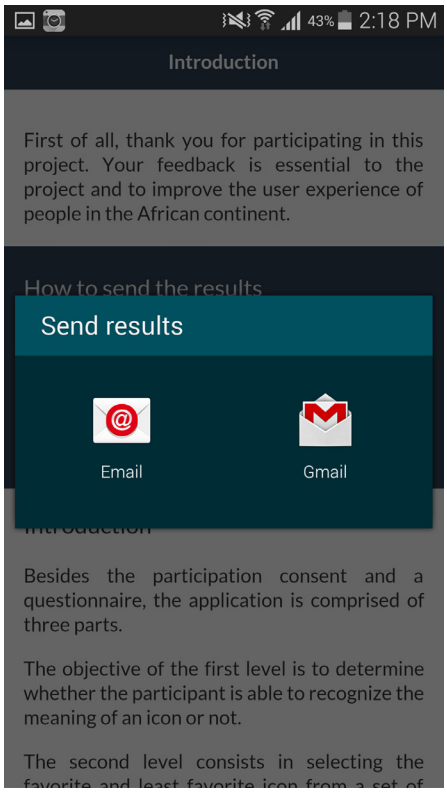


Figure 10 – Sending the Results

- In case the supervisor does not have a Gmail account or does not want to send the results from a personal email account, the following public account can be used:

Public Account for the Project:

Account Name: okavango.send.info@gmail.com
Password: sendResults2015

- When sending the email, type the location or locations where the games where the application was used and indicate the amount of days the application was utilized.

- Whenever possible, add photographs and notes regarding the location, the participants and the interaction of the participants with the application.

  Example:

  The application was used in the Northern Cape region, specifically in the [Name of the Location], near the capital of the province, Kimberley. The application was utilized during a week and about 30 people interacted with the application.
  The users were eager to use the application despite their lack of experience with smartphones. Photos were attached regarding the participants and a couple of notes were taken regarding the interaction of the participants with the application:

  - Subject X had never seen a smartphone before.
  - A person said X was a nice addition to see in mobile applications
  - Some people suggested the use of local languages.

Reference Page 1

Level 1 – Icon Recognition

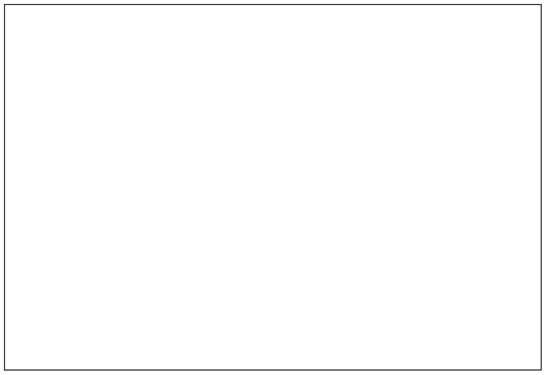
About
Accept
Add
Add Alarm
Alarms
Attachment
Back
Backspace
Battery
Bluetooth
Brightness
Calendar
Cancel
Contacts
Copy
Cut
Data Usage
Delete
Dial Pad
Download
Edit
Email
End Call
Error
Expand
Forward
Help
Import / Export
Messages
Merge
Network Signal
New
New Account
New Attachment
New Email
New Event
New Picture
Next Item
Not Secure
Overflow
Paste
Phone
Picture
Previous Item
Refresh
Remove
Ring Volume
Save
Search
Select All
Settings
Share
Split
Undo
Unread
Warning
Wi-Fi

Level 3 – Color Association

Active
Affection
Anger
Calm
Cold
Courage
Death
Desire
Disgust
Energetic
Envy
Expectation
Faithful
Fear
Happiness
Hate
Hope
Joy
Lively
Love
Modern
Nervousness
Neutral
Offensive
Optimism
Passion
Passive
Pleasant
Pleasure
Pride
Sadness
Shame
Suffering
Surprise
Sympathy
Traditional
Unpleasant
Warmth

Reference Page 2

Level 3 - Colors















Appendix I

Usability Test Protocol for TIQSI

Disclosure

The purpose of this document is to support the usability testing conducted to the TIQSI platform, a project research conducted at Fraunhofer, Portugal. The usability testing and the report were performed by Marcos Soares at Fraunhofer AICOS for the ICT4D Competence Center.

Acknowledgements

We would like to acknowledge the financial support obtained from North Portugal Regional Operational Programme (ON.2 - O Novo Norte), Portuguese National Strategic Reference Framework (NSRF) and the European Regional Development Fund (ERDF) from European Union through the project ICT4DCC (ICT4D Competence Center) NORTE-07- 0124-FEDER-000042.

Fraunhofer
PORTUGAL

RESEARCH CENTER FOR ASSISTIVE INFORMATION AND COMMUNICATION SOLUTIONS

ISO/IEC 25062 Usability Test Protocol – Tiqsi

2015

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Users

For the usability testing the researcher expect to recruit at least 10 participants with experience in the fields of mobile development, web development, user interface design, user experience design and Human-Computer Interaction. The users were selected due to emulating the type of users the system was developed for.

Context of product use in the test

1.1. Test facility

The evaluation will take place in one setting at the Fraunhofer AICOS's research center. The location was selected due to convenience but also because it simulates the environment the platform will be utilized. Tiqsi is an internal platform to assist and support the needs of the researchers developing for regions with different cultures, and therefore, the setting where the usability testing will take place is ideal.

1.2. Display devices

The usability testing requires a laptop computer and consequently, a 15-inch Macbook Pro from Mid-2010 will be used for the evaluation.

Test procedure

1.3. Participant general instructions

The participants should receive the following general information regarding the project:

"Tiqsi is an ethnographic platform and its objective is to gather cultural information from developing nations. The platform aims to systematize cultural content as a form to contextualize the researchers and help them in the creation of user-centered solutions. The solution was idealized due to several reasons, such as:

- *The absence of a database able to store projects and cultural heritage,*
- *The cultural and physical distance between the end users and the researchers,*
- *The lack of a single shared internal system*
- *The fact that anthropological and cultural content is not gathered in a sole location.*

Therefore, the platform seeks to enhance the competences of professionals involved in the ICT4D area as well as provide a procedural and projectable scientific support in the HCI4D area. The ICT4D field aims to create solutions for developing countries."

Regarding the prototypes the participants should be given the following information:

"It is worth noting that this is only a beta version of the platform and certain functionalities are not available yet. The usability study aims to analyze and determine the functionality of the platform."

"Also, during the rest of the session, I'll be working from a script to ensure the instructions are provided the same form to every participant of the study"

"Do you have any questions before we begin?"
[Answer any questions]

[Write start time of the test]

Regarding the pre-questionnaire:

"I would like to ask for your permission to film the test under the compromise that these images are for research purposes only and will not be shown to anyone other than the researchers working on the results of this test. I would also like to ask you to read and please sign this informed consent form. "

"Before the test session begins, I will ask you to complete a short background questionnaire and answer a few questions "
[The participant completes the background questionnaire]

"Now, I would like to ask you the following questions:

- When someone mentions an ethnographic platform, what do you expect?

  [If an answer is provided, proceed to the second question]
  [If no answer is provided, advance to the last question]

- Do you believe an ethnographic platform is able to assist professionals in the development of solutions for different cultures?

- Which type of data would you like to see in the platform? "

Regarding the test:

"As mentioned before, I am here to learn how professionals in the fields of Mobile Development, Design and Human-Computer Interaction cope with the problems associated with the creation of ICT solutions for developing regions"

"During the session, I will ask you how to use the platform to do a variety of tasks and I will observe and record you while you do these tasks. As you do these tasks, please try to do whatever you would normally do. A paper with one task will be handed to you and once that task is completed, another paper with a new task will be provided."

" Please know I am not testing you, and there is not such thing as wrong answer. Your feedback is valuable in order to help us understand what works and what does not work in the platform".

After the test and questionnaire:

" Do you have any questions or comments?
To conclude the study, I will provide a SUS questionnaire and ask a couple questions afterwards. Thank you very much for your participation in this test, you opinion is very valuable to us."

1.4. Participant task instructions

For the test the participants will be asked to perform the following tasks:

1. Search for Ghana and open the file entitled "Mausoleum of Kwame Nkrumah"
2. Close the modal window, search for Liberia and indicate the values of the following social data indicators: Ethnic Groups, Languages, Literacy, Religious and Urbanization.
3. Search for Cameroon, filter the results by "Architecture" and open the file named "Bandjoun Chefferie".
4. Return all results in Cameroon, and filter the results with the alternative navigation method. Filter the results by "Architecture" and open the file entitled "Yaoundé Centre"
5. Search for Ghana, and play the sound file "Postal Workers Cancelling Stamps". Afterwards, close the modal window.
6. Search for Liberia, open the text file named "International Human Rights, Gender-Based Violence, and Local Discourses of Abuses in Postconflict Liberia: A Problem of "Culture"? ".

Prior to the tasks, a background questionnaire will be handed to the participants (see appendices). After the tasks, the SUS questionnaire must be handed to the participants (see appendices).

Performance and satisfaction metrics

1.5. Criteria and measurements

Only one facilitator will participate in the evaluation of the platform. Since the test includes several tasks the researchers will encourage participants to use the think aloud method. Additionally, each evaluation will be recorded (video and sound) to better analyze the data after the test.
To evaluate the usability of the system we will measure effectiveness (via task completion) and satisfaction.

1.6. Metrics for effectiveness, efficiency and satisfaction

To measure the effectiveness of the system we will measure task completion rate, deviations, errors and assistances.

Each task will be divided into several steps that form the ideal flow to completion (see Participant task instructions). The accomplishment of these tasks will allow the calculation of task completion rate. The tasks related with the prototype will have a binary completion tasks, and other information will be collected through observation and the think-aloud method.

Deviations are defined as alternative flows to the completion of the task, that, while not being the ideal flow, still enable the participant to achieve task completion.

An error will be counted every time the participant performs an action that does not contribute to task completion.

An assistance is considered every time the participant requests the assistance of the facilitator in order to perform the task. If the assistance is required because the task was not well explained it should not be considered as assistance in task completion; if the participant forgot the following step of a task that should be noted, since it may not be a problem with the system's usability but instead with the formulation of the task.

The efficiency metric will not be considered for this evaluation due to the lack of metrics for comparison. This metric would be of better use on the evaluation of a following iteration. Nevertheless, the facilitators will take into account the overall time spent using the application and the time spent in each task, and clear deviations from an appropriate time should be noted.

Satisfaction will be measured through the use of the SUS questionnaire (see appendices). In addition, we will encourage participants to use the think aloud method, which can also give us some data regarding their satisfaction with the system.

Appendices

Background Questionnaire

1. What is your age?

2. What is your gender?

3. How many years of experience do you have with ICT4D solutions?

4. What is your level of experience regarding Mobile and Web Development?

5. What is your level of experience regarding User Interface / User Experience Design?

6. What is your level of experience regarding Human-Computer Interaction?

Pre-session Questionnaire

1. When someone mentions an ethnographic platform, what do you expect?

2. Do you believe an ethnographic platform is able to assist professionals in the development of solutions for different cultures?

3. Which type of data would you like to see in the platform?

Post-Session Questionnaire

1. Can an ethnographic platform act as a viable repository for cultural material? If yes, why is that?

2. Can the platform assist in the creation of user-centered solutions for culturally different audiences?

3. Do you believe this platform can be used on a regular basis for inspiration and consultation purposes?

4. Do you think the platform is easy to use?
   Is the navigation within the platform intuitive?
   Which navigation method out of the two is the easiest to understand and use?
   What can be done to improve the least intuitive method of navigation?

5. Is the amount of information in the description adequate?
   If not, do you believe there is too much or too little information?

6. Is the information placed in a consistent manner?

7. Is the information presented in an explicit and consistent manner?

8. Is the content of the platform easy to read?

9. Is the use of titles per cultural material appropriate?

10. Are the titles and text helpful?

11. Do you believe the presence of external links with curated material is a good addition to the platform?

12. What is your overall opinion about the platform?

Participant general instructions – Portuguese Translation

Os participantes devem receber a seguir informação sobre o projeto:

" A Tiqsi é uma plataforma etnográfica cujo objetivo consiste em reunir informação cultural de países em desenvolvimento. A plataforma tem como missão sistematizar conteúdo cultural de modo a contextualizar os investigadores e ajudar na criação de soluções centradas no utilizador. A plataforma foi idealizada devido a quatro razões, sendo estas:

- *A falta de uma base de dados capaz de armazenar projetos e material cultural,*
- *A distancia física e cultural existente entre os utilizadores e os investigadores,*
- *A falta de um único sistema interno de partilha de informação,*
- *E o facto do material cultural e antropológico não estar organizado numa única localização.*

Por isso mesmo, a plataforma procura aumentar as competências de profissionais envolvidos na área de ICT4D e também fornecer suporte científico na área de HCI4D. A área de ICT4D consiste em criar soluções para países em desenvolvimento."

Em relação aos protótipos os participantes devem receber a seguinte informação:

" É importante mencionar que esta é uma versão beta da plataforma e certas funcionalidades não se encontram disponíveis. O estudo de usabilidade foi criado com o intuito de analisar e determinar a funcionalidade da plataforma em contexto de uso diário."

"Também, durante o resto da sessão , eu vou seguir o guião de modo a assegurar que as instruções foram fornecidas da mesma forma a todos os participantes."

"Tem alguma questão antes de começar?"
[Responder às questões]

[Escrever a hora que a sessão começou]

Pré-questionário:
" Gostava de pedir a sua permissão para filmar o teste apenas para fins de investigação e vão ser visualizadas apenas pelos investigadores. Gostava também que lê-se e assinasse o consentimento."
[O participante assina o consentimento]

" Antes de começar a sessão, vou pedir que preencha um questionário"

[O participante completa o questionário]

"Agora, gostava de perguntar as seguintes questões :

- *Quando alguém menciona plataforma etnográfica, o que espera encontrar?*

  [Se sim, perguntar segunda questão]

  [Se não, perguntar última questão]

- *Acredita que uma plataforma etnográfica é capaz de assistir profissionais no desenvolvimento de soluções para culturas diferentes?*

- *Que tipo de informação espera encontrar na plataforma?"*

Em relação ao teste:

" Como foi mencionado antes, estou aqui para aprender com profissionais nas áreas de desenvolvimento Web e Mobile, Design e HCI que lidam com problemas associados à criação de soluções ICT para países em desenvolvimento."

" Durante a sessão, vou pedir que utilize a plataforma e efetue uma variedade de tarefas que eu vou observar e gravar. Enquanto efetua as tarefas, por favor tente simular aquilo que faria em condições normais. Um papel com uma tarefa vai ser entregue e após terminar essa tarefa, outro papel com uma nova tarefa vai ser entregue."

"Eu não estou a avaliar a si, mas sim a plataforma, e por isso mesmo, não existem respostas erradas. O seu feedback é importante de modo a perceber o que funciona e o que não funciona na plataforma."

Depois do teste:

" Tem alguma questão ou comentário?
Para terminar o estudo, eu vou fornecer um questionário SUS e vou pedir que responda a algumas questões.
Obrigado pela sua participação no teste. A sua opinião é muito valiosa para nós."

References

National Institute of Standards and Technology, *NISTIR 7432 – Common Industry Specification for Usability – Requirements*, 2007

Appendix J
Usability Test Report for TIQSI

Disclosure

The purpose of this document is to support the usability testing conducted to the TIQSI platform, a project research conducted at Fraunhofer, Portugal. The usability testing and the report were performed by Marcos Soares at Fraunhofer AICOS for the ICT4D Competence Center.

Acknowledgements

We would like to acknowledge the financial support obtained from North Portugal Regional Operational Programme (ON.2 - O Novo Norte), Portuguese National Strategic Reference Framework (NSRF) and the European Regional Development Fund (ERDF) from European Union through the project ICT4DCC (ICT4D Competence Center) NORTE-07- 0124-FEDER-000042.

Fraunhofer
PORTUGAL

RESEARCH CENTER FOR ASSISTIVE INFORMATION AND COMMUNICATION

ISO/IEC 25062 Common Industry Format for Usability Test Reports

Tiqsi

Tested by: Marcos Soares

2015

Date prepared: 21/05/2015

Prepared by: Marcos Soares

For:

Fraunhofer Portugal AICOS

Address inquiries to: Marcos Soares

Email: marcos.soares@fraunhofer.pt

This deliverable is in the framework of Project ICT4DCC (ICT4D Competence Center), with reference "Projeto n.º NORTE-07-0124-FEDER-000042", co-financed by the Regional Operational Program of the North (ON.2 – The New North) ["Programa Operacional Regional do Norte (ON.2 – O Novo Norte)"], in accordance with the National Strategic Reference Framework ["Quadro de Referência Estratégico Nacional (QREN)"], through the European Regional Development Fund ["Fundo Europeu de Desenvolvimento Regional (FEDER)"].

TABLE OF CONTENTS

1. Executive Summary

The Tiqsi platform aims to assist in the creation of user-centered solutions for developing nations. Cultural and physical disparities generate additional difficulties in the development of Information and Communication Technologies in developing nations. The objectives of the platform are to contextualize the development team about the cultural characteristics of a specific region, but also provide information about successful implementations and techniques.

Researchers have evaluated the web platform in an office setting with twelve participants. All participants were required to perform six tasks involving queries of cultural artifacts. Afterwards, questions regarding the navigation and content of the platform were conducted.

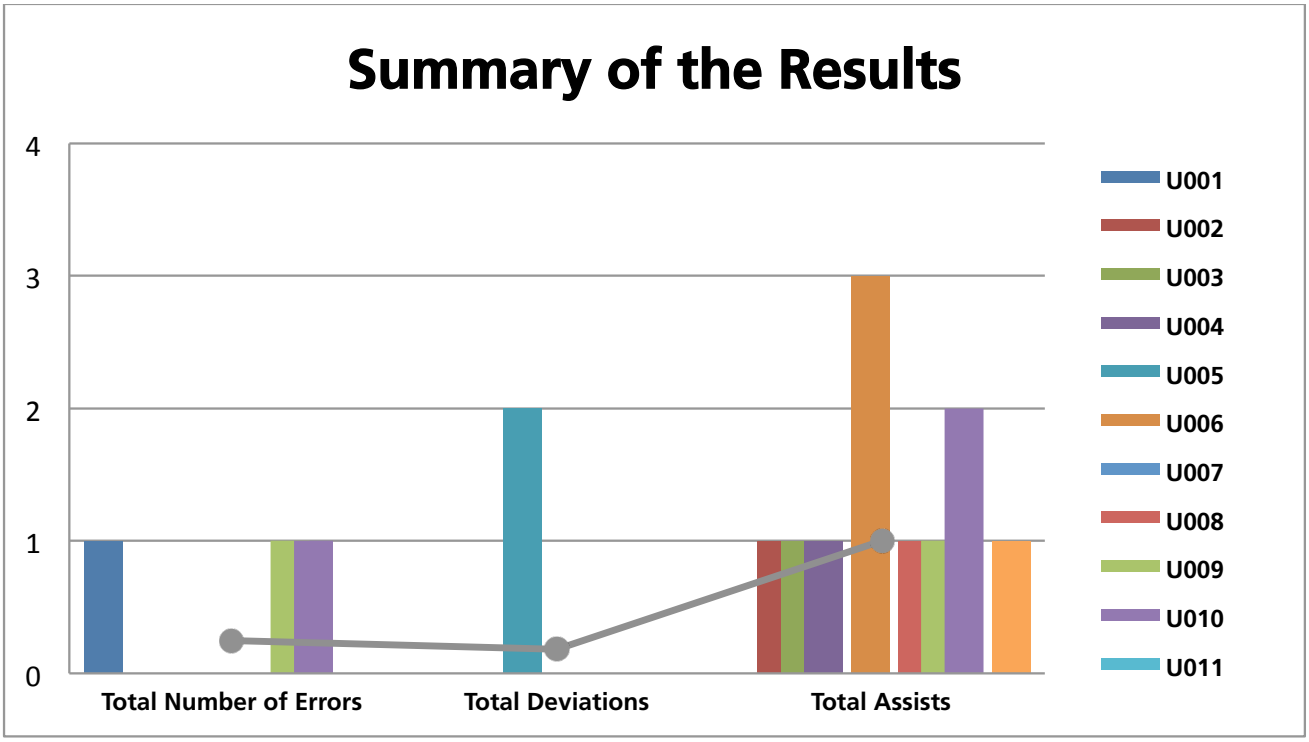
Results

Performance varied among the twelve users that participated in this evaluation process. Out of the twelve participants, only four were unable to complete the tasks without assistance. The average error rate was 0,25 (SD = 0,45). The minimum number of errors was 0 and the maximum was 1. Regarding assistance, the average assist rate was 1,00 (SD = 0,85). The minimum number of assists was 0 and the maximum was 3.

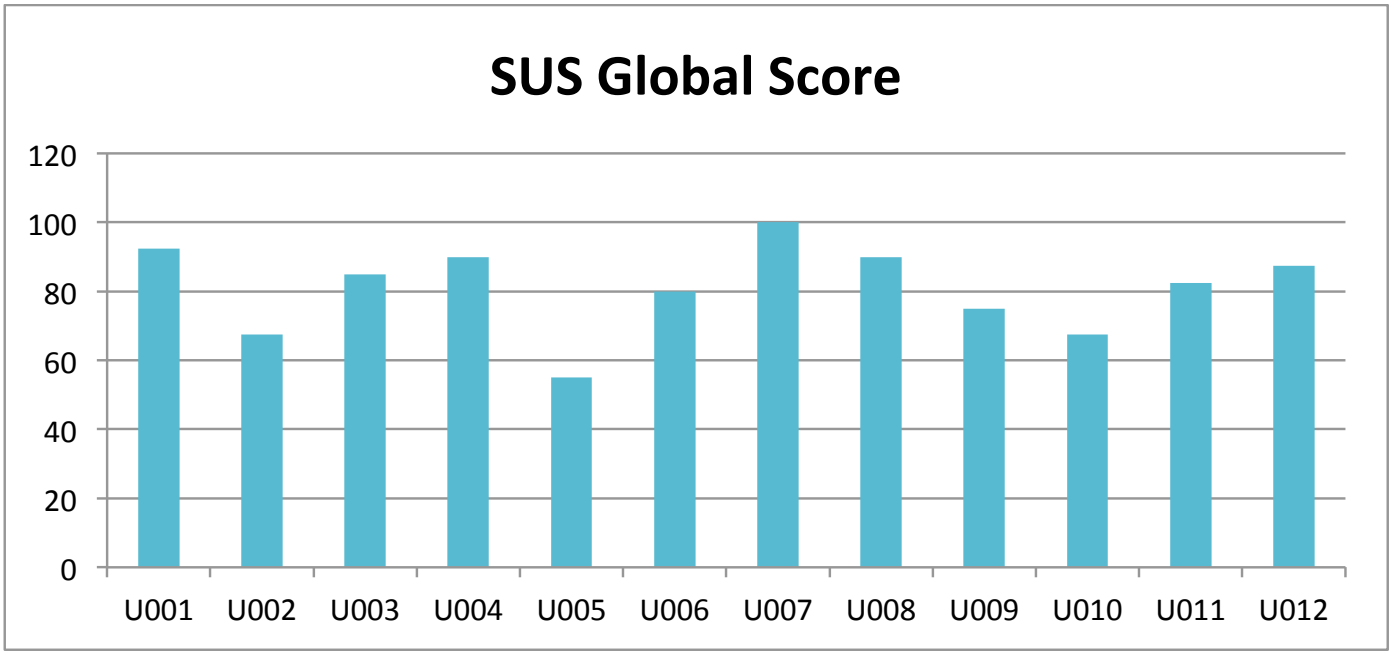
The global satisfaction measured with the SUS scale was 81,04 (SD = 12,77). This is well above the average 68 score calculated from the analysis of over 5000 users across 500 different evaluations[1].
Below we provide summary tables and charts of the results.

[1] http://www.measuringusability.com/sus.php

User	Total unassisted task effectiveness (%)	Total assisted task effectiveness (%)	Total Errors	Total Deviations	Total Assists
U001	100%	100%	1	0	1
U002	100%	100%	0	0	1
U003	100%	100%	0	0	1
U004	100%	100%	0	0	1
U005	100%	100%	0	2	0
U006	100%	100%	0	0	3
U007	100%	100%	0	0	0
U008	83,33%	100%	0	0	1
U009	83,33%	100%	1	0	1
U010	83,33%	100%	1	0	2
U011	100%	100%	0	0	0
U012	83,33%	100%	0	0	1
Mean	94%	100%	0,25	0,17	1,00
Standard Deviation	8,21%	0,00%	0,45	0,58	0,85
Minimum	83%	100%	0	0	0
Maximum	100%	100%	1	2	3



User	SUS Global Score
U001	92,5
U002	67,5
U003	85
U004	90
U005	55
U006	80
U007	100
U008	90
U009	75
U010	67,5
U011	82,5
U012	87,5
Mean	81,04
Standard Deviation	12,77
Minimum	55
Maximum	100



2. Introduction

Full product description

The Tiqsi platform aims to assist in the creation of user-centered solutions for developing nations. Cultural and physical disparities generate additional difficulties in the development of Information and Communication Technologies in developing nations. The objectives of the platform are to contextualize the development team about the cultural characteristics of a specific region, but also provide information about successful implementations and techniques.

The user is able to search information on a country basis, and gain access to several sources of information from images, videos, text files, sound and links. Quantitative and qualitative data regarding the country is supplied to the user in order to contextualize the development team and ease the process of creating user-centered design solutions.

The platform is intended for developers, designers, HCI professionals and other individuals involved in the creation of user-centered design solutions. The users are expected to be proficient with technological devices. Regarding the context of use, the platform is utilized in individual sessions or group occasions in an office setting.

Test objectives

The present usability evaluation pertained to the Tiqsi platform. The main goals of the usability testing were the following:

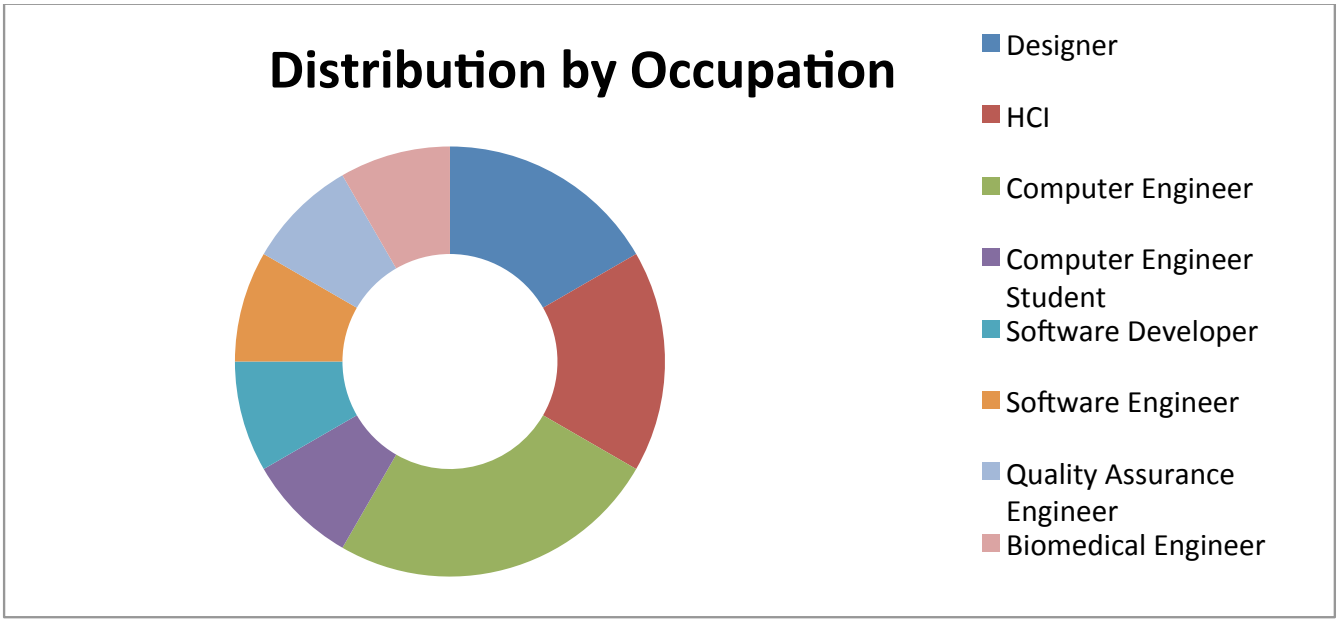
- Encounter and solve potential usability issues regarding the navigation within the platform,
- Determine the comprehensibility of different actions,
- Analyze the viability of the current information architecture,
- Detect terms and idiomatic expressions unknown to the target audience.

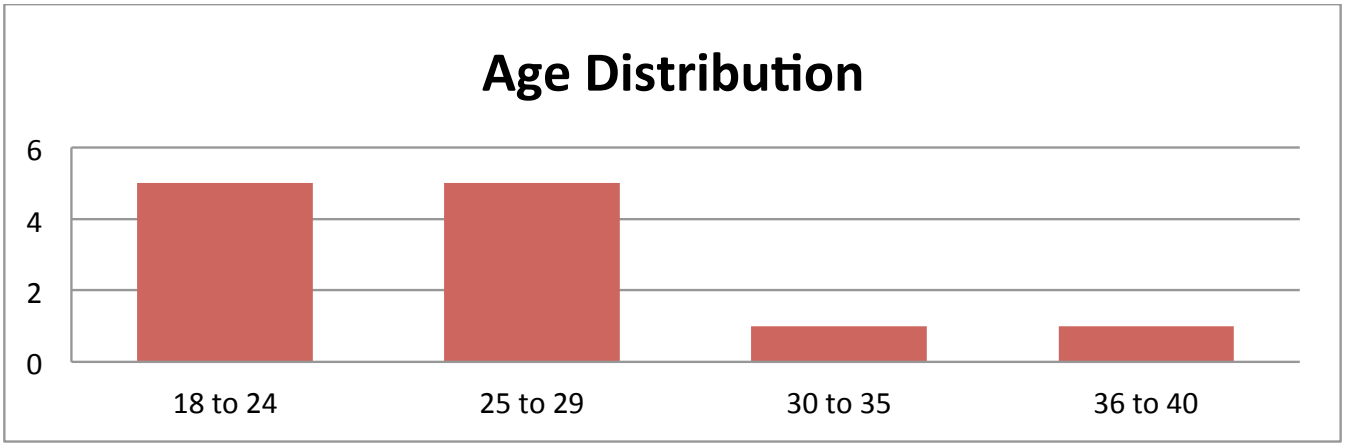
3. Method

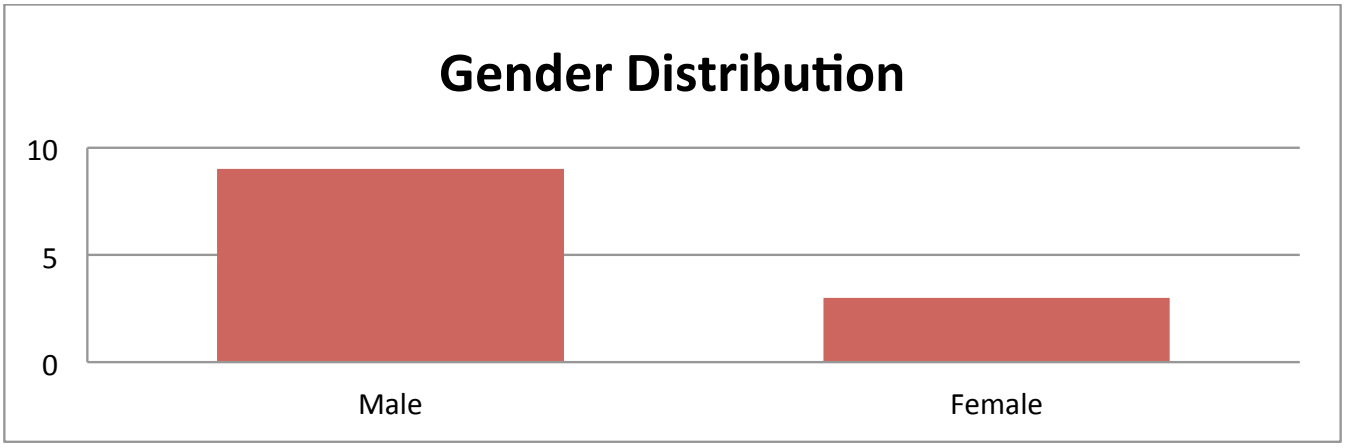
Participants

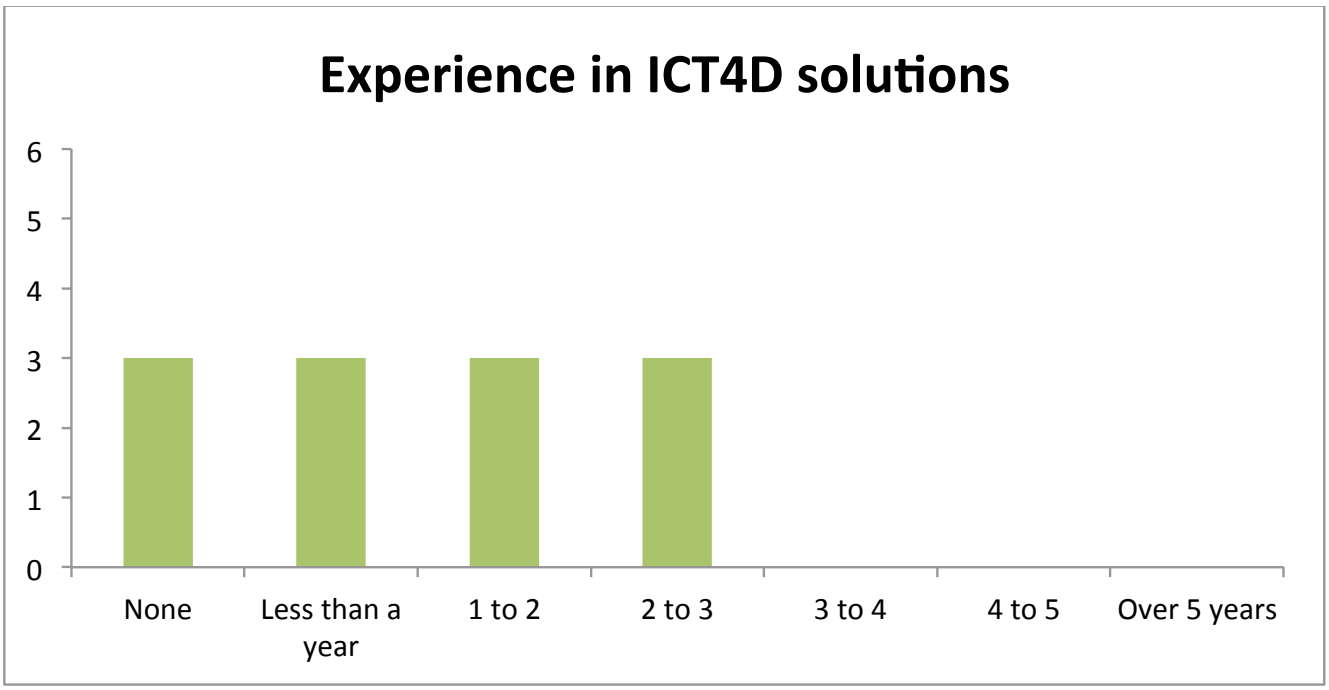
Twelve participants were recruited for the evaluation of the platform. Nine males were participants and the additional three were females. They were all between the 18 to 24 and the 36 to 40 age groups. The most common age groups among the participants were the 18 to 24 and the 25 to 29. Five individuals were between 18 and 24, another five were between 25 and 29, one was in the age group from 30 to 35, and another participant was between 36 and 40. Age groups were used because age was not a relevant factor in this study.

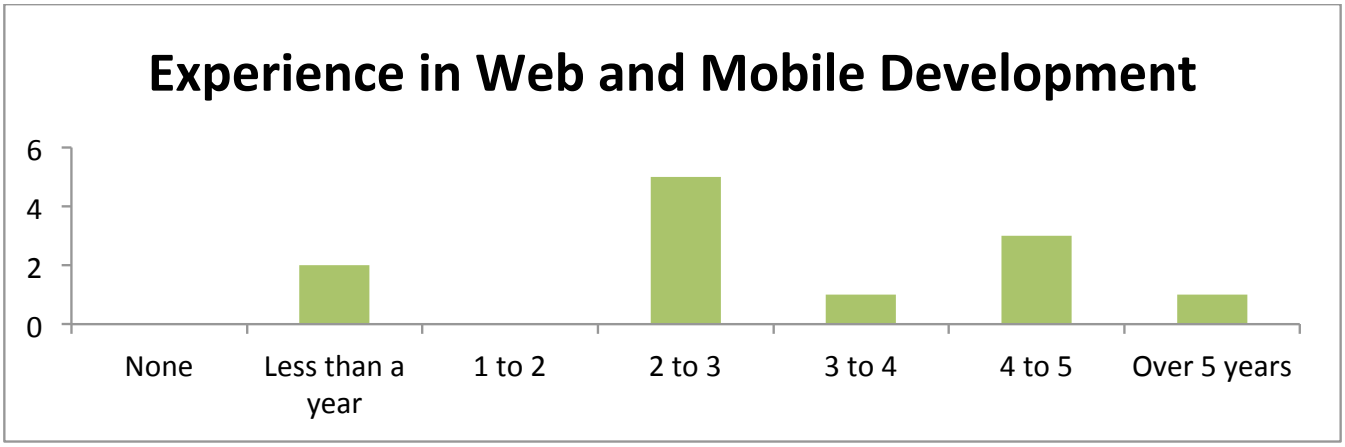
On the other hand, the participants were selected according to their occupation. Designers, Human Computer Interaction professionals, Computer Engineers, one Software Developer, one Software Engineer, a Quality Assurance Engineer, a Biomedical Engineer and one Computer Engineer Student participated in the evaluation process of the platform. These individuals were selected due to representing the target audience of the platform.

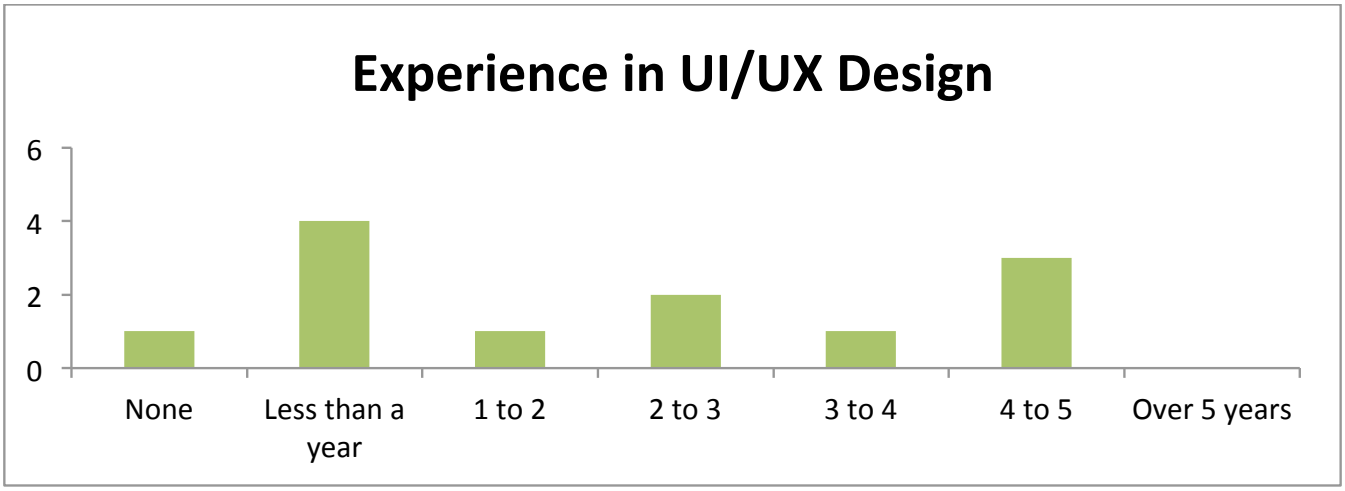


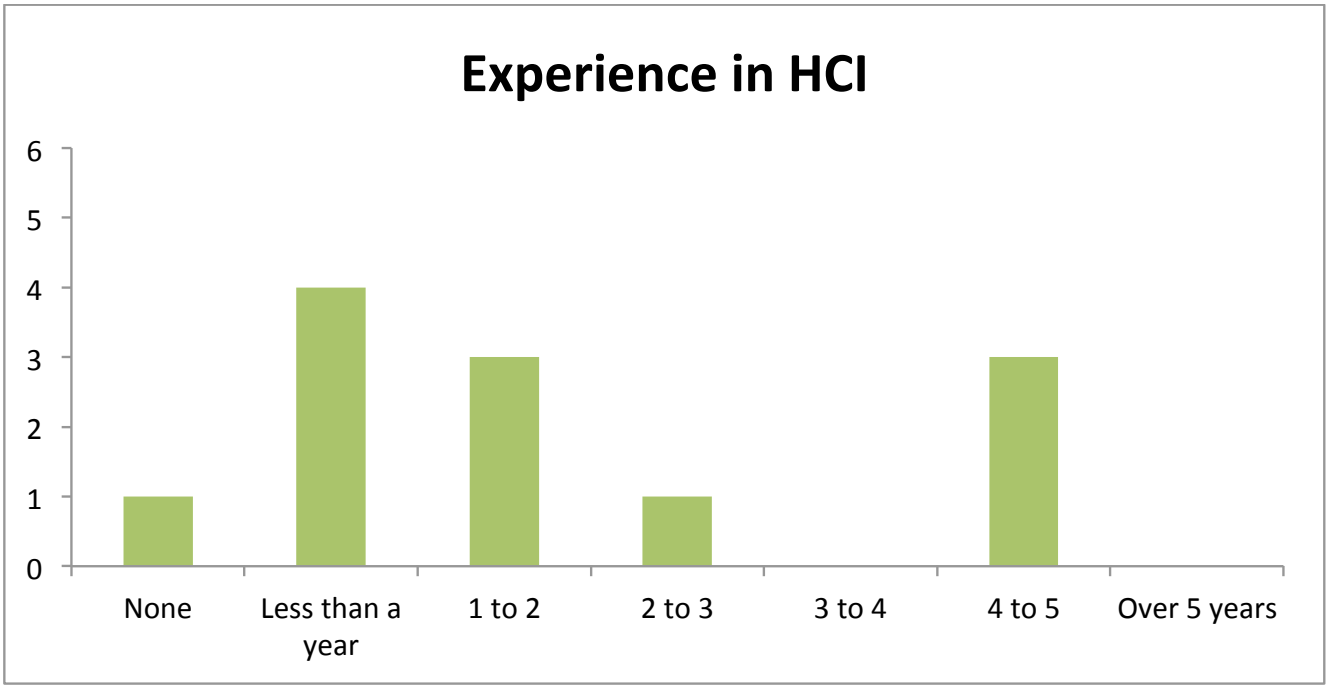

Age Distribution
6
4
2
0
18 to 24
25 to 29
30 to 35
36 to 40


Gender Distribution
10
5
0
Male
Female


Experience in ICT4D solutions
6
5
4
3
2
1
0
None
Less than a year
1 to 2
2 to 3
3 to 4
4 to 5
Over 5 years


Experience in Web and Mobile Development
6
4
2
0
None
Less than a year
1 to 2
2 to 3
3 to 4
4 to 5
Over 5 years


Experience in UI/UX Design
6
4
2
0
None
Less than a year
1 to 2
2 to 3
3 to 4
4 to 5
Over 5 years


Experience in HCI
6
5
4
3
2
1
0
None
Less than a year
1 to 2
2 to 3
3 to 4
4 to 5
Over 5 years

Context of product use in the test

3.1.1. Test Facility

The evaluation took place in at Fraunhofer AICOS's offices. The location was selected due to convenience but also because it simulates the environment where the platform will be used. Tiqsi is an internal platform to assist and support the needs of the researchers developing from regions with different cultures, and therefore, the setting where the usability took place is ideal.

3.1.2. Tasks

The participants were asked to perform the following tasks:

1. Search for Ghana and open the file entitled "Mausoleum of Kwame Nkrumah"

2. Close the modal window, search for Liberia and indicate the values of the following social data indicators: Ethnic Groups, Languages, Literacy, Religious and Urbanization.

3. Search for Cameroon, filter the results by "Architecture" and open the file named "Bandjoun Chefferie".

4. Return all results in Cameroon, and filter the results with the alternative navigation method. Filter the results by "Architecture" and open the file entitled "Yaoundé Centre".

5. Search for Ghana, and play the sound file "Postal Workers Cancelling Stamps". Afterwards, close the modal window.

6. Search for Liberia, open the text file named "International Human Rights, Gender-Based Violence, and Local Discourses of Abuses in Postconflict Liberia: A Problem of "Culture"? ".

3.1.3. Display devices

All the participants used the same device to test Tiqsi platform. The usability testing required a laptop computer and consequently, a 15-inch Macbook Pro from Mid-2010 was utilized.

3.1.4. Test administrator tools

Audio and video of the tests was captured using the Silverback 2.0 application. Prior to taking the test, the participant had to fill a background questionnaire. Additionally, once the test was finished, the participants were administrated a System Usability Scale (SUS) questionnaire (in Appendices).

Experimental design

3.1.5. Procedure

During the test, the test administrator collected certain metrics, namely errors, deviations and assists. The efficiency metric time per task was not registered because there wasn't a baseline to compare to. The sequence of events from greeting the participants until their dismissal was the following:

- Participants were greeted by the facilitator
- A brief contextualization of the platform was given to the participants.
- Afterwards, an informed consent was given to the participants.
- A background questionnaire was administered to the participants.
- A pre-test questionnaire about ethnographic platforms was conducted in order to understand the level of recognition of the participants with ethnography and its subsequent techniques.
- Afterwards, information about the test was read aloud from the script by the facilitator. This action aimed to provide general information regarding the project and explain the test procedure.
- The participants received the task instructions sequentially.
- The SUS questionnaire was supplied to the participants.
- A post-test questionnaire was conducted in order to gather qualitative feedback from the participants.
- The facilitator asked the participant if he/she had any additional question or comment.
- Lastly, the facilitator thanked and dismissed the participants.

Moreover, the participants were not compensated during the process.

3.1.6. Participant general instructions

Participants received the information below during the usability test.

The participants should receive the following general information regarding the project:

"Tiqsi is an ethnographic platform and its objective is to gather cultural information from developing nations. The platform aims to systematize cultural content as a form to contextualize the researchers and help them in the creation of user-centered solutions. The solution was idealized due to several reasons, such as:

- *The absence of a database able to store projects and cultural heritage,*
- *The cultural and physical distance between the end users and the researchers,*
- *The lack of a single shared internal system*
- *The fact that anthropological and cultural content is not gathered in a sole location.*

Therefore, the platform seeks to enhance the competences of professionals involved in the ICT4D area as well as provide a procedural and projectable scientific support in the HCI4D area. The ICT4D field aims to create solutions for developing countries."

Regarding the prototypes the participants should be given the following information:

"It is worth noting that this is only a beta version of the platform and certain functionalities are not available yet. The usability study aims to analyze and determine the functionality of the platform."

"Also, during the rest of the session, I'll be working from a script to ensure the instructions are provided the same form to every participant of the study"

"Do you have any questions before we begin?"
[Answer any questions]

[Write start time of the test]

Regarding the pre-questionnaire:

"I would like to ask for your permission to film the test under the compromise that these images are for research purposes only and will not be shown to anyone other than the researchers working on the results of this test. I would also like to ask you to read and please sign this informed consent form. "

"Before the test session begins, I will ask you to complete a short background questionnaire and answer a few questions "
[The participant completes the background questionnaire]

"Now, I would like to ask you the following questions:

- When someone mentions an ethnographic platform, what do you expect?

  [If an answer is provided, proceed to the second question]
  [If no answer is provided, advance to the last question]

- Do you believe an ethnographic platform is able to assist professionals in the development of solutions for different cultures?

- Which type of data would you like to see in the platform? *"*

Regarding the test:

"As mentioned before, I am here to learn how professionals in the fields of Mobile Development, Design and Human-Computer Interaction cope with the problems associated with the creation of ICT solutions for developing regions"

"During the session, I will ask you how to use the platform to do a variety of tasks and I will observe and record you while you do these tasks. As you do these tasks, please try to do whatever you would normally do. A paper with one task will be handed to you and once that task is completed, another paper with a new task will be provided."

" Please know I am not testing you, and there is not such thing as wrong answer. Your feedback is valuable in order to help us understand what works and what does not work in the platform".

After the test and questionnaire:

" Do you have any questions or comments?
To conclude the study, I will provide a SUS questionnaire and ask a couple questions afterwards.
Thank you very much for your participation in this test, you opinion is very valuable to us."

3.1.7. Participant task instructions

Participants were asked to try and complete the tasks as if the facilitators were not present. However, they were told that they could ask assistance from the facilitator at any time, if they were stuck or had any doubt regarding the task at hand.
They were also asked to voice any opinions, positive or negative, about any aspect of the mobile application while executing the tasks.

Usability metrics

3.1.8. Effectiveness

To measure the effectiveness of the system we will measure task completion rate, deviations, errors and assistances.

Task completion rate Each task will be divided into several steps that form the ideal flow to completion (see Participant task instructions). The accomplishment of these tasks will allow the calculation of task completion rate. The tasks related with the prototype will have a binary completion tasks, and other information will be collected through observation and the think-aloud method.

Deviations Deviations are defined as alternative flows to the completion of the task, that, while not being the ideal flow, still enable the participant to achieve task completion.

Errors An error will be counted every time the participant performs an action that does not contribute to task completion.

Assistances An assistance is considered every time the participant requests the assistance of the facilitator in order to perform the task. If the assistance is required because the task was not well explained it should not be considered as assistance in task completion; if the participant forgot the following step of a task, it should be noted, since it may not be a problem with the system's usability but instead with the formulation of the task.

3.1.9. Efficiency

The efficiency metric will not be considered for this evaluation due to the lack of metrics for comparison. This metric would be of better use on the evaluation of a following

iteration. Nevertheless, the facilitators will take into account the overall time spent using the application and the time spent in each task, and clear deviations from an appropriate time should be noted.

3.1.10. Satisfaction

Satisfaction was measured through the SUS questionnaire administered after the test. Additionally, all the comments made by the participants during the test as well as in the informal conversation that followed were registered.

4. Results

Data analysis

As mentioned before, all the testing sessions were recorded using Silverback 2.0. The recorded videos were exported from the application, visualized by the facilitator and document observations and comments unidentified during the usability test.

Each session was scheduled to take between 30 minutes and one hour. The average time of a session was around 50 minutes. The smallest usability test took 32 minutes and 54 seconds. On the other hand, the longest usability testing took 1 hour and 35 minutes.

An error was marked every time the participant performed an action that does not contribute to task completion. A deviation was marked every time the participant took an alternative path (i.e., different from the predefined ideal flow) to complete the task. An assistance was considered every time the facilitator intervened (at the participant's request or due to the facilitator's judgment) to help the participant in the completion of the task.

Presentation of the results

4.1.1. Performance results

User	Total unassisted task effectiveness (%)	Total assisted task effectiveness (%)	Total Errors	Total Deviations	Total Assists
U001	100%	100%	1	0	1
U002	100%	100%	0	0	1
U003	100%	100%	0	0	1
U004	100%	100%	0	0	1
U005	100%	100%	0	2	0
U006	100%	100%	0	0	3
U007	100%	100%	0	0	0
U008	83,33%	100%	0	0	1
U009	83,33%	100%	1	0	1
U010	83,33%	100%	1	0	2
U011	100%	100%	0	0	0
U012	83,33%	100%	0	0	1
Mean	94%	100%	0,25	0,17	1,00
Standard Deviation	8,21%	0,00%	0,45	0,58	0,85
Minimum	83%	100%	0	0	0
Maximum	100%	100%	1	2	3

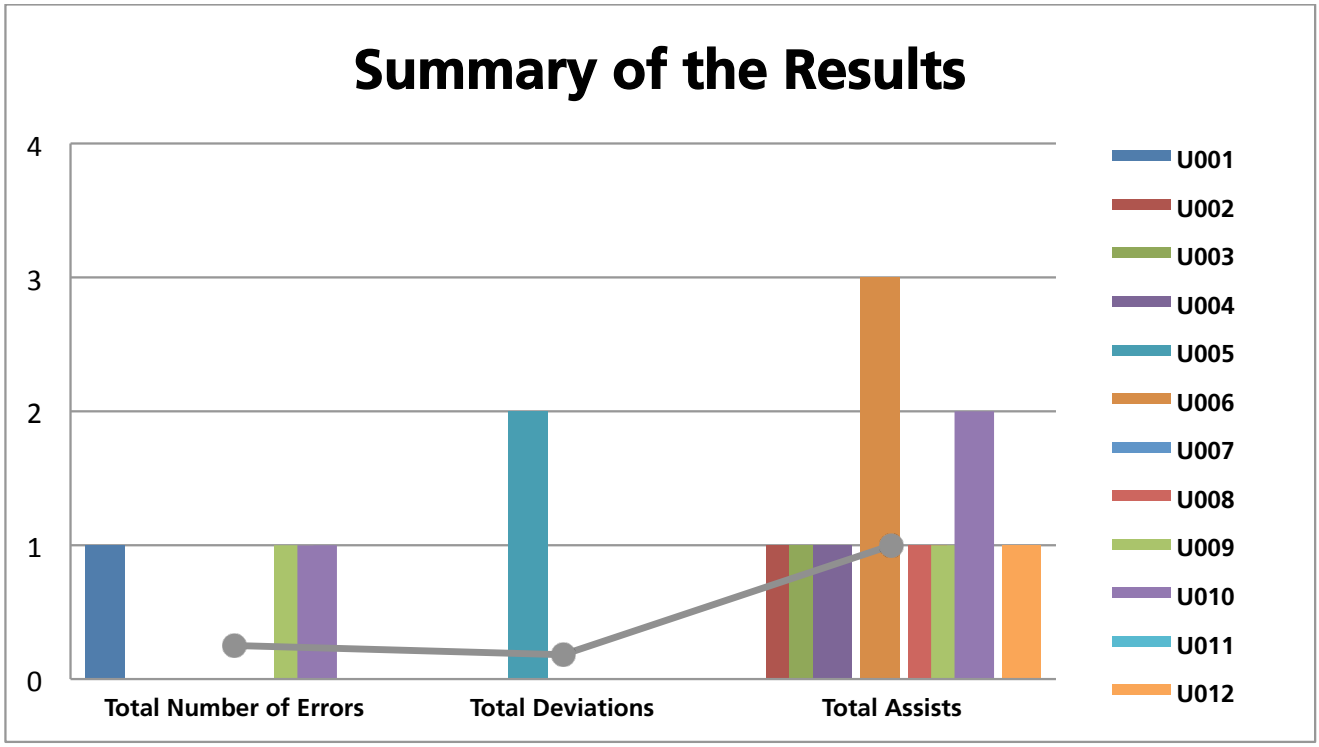
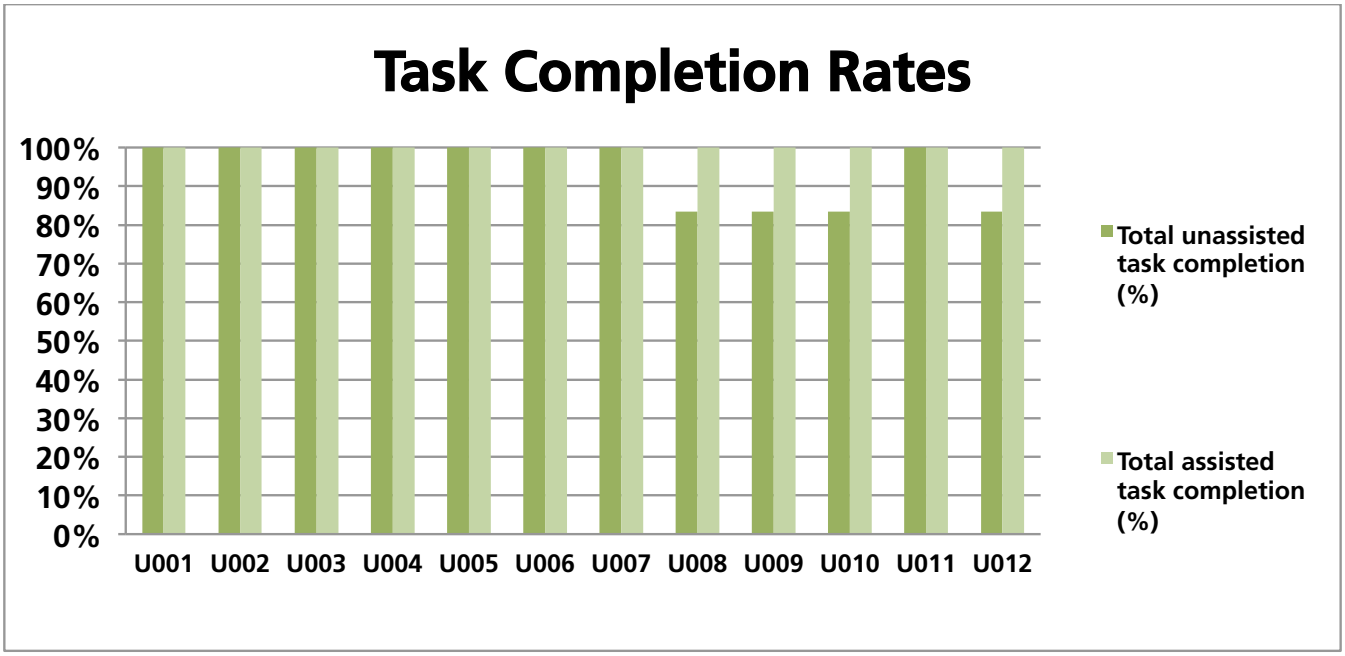
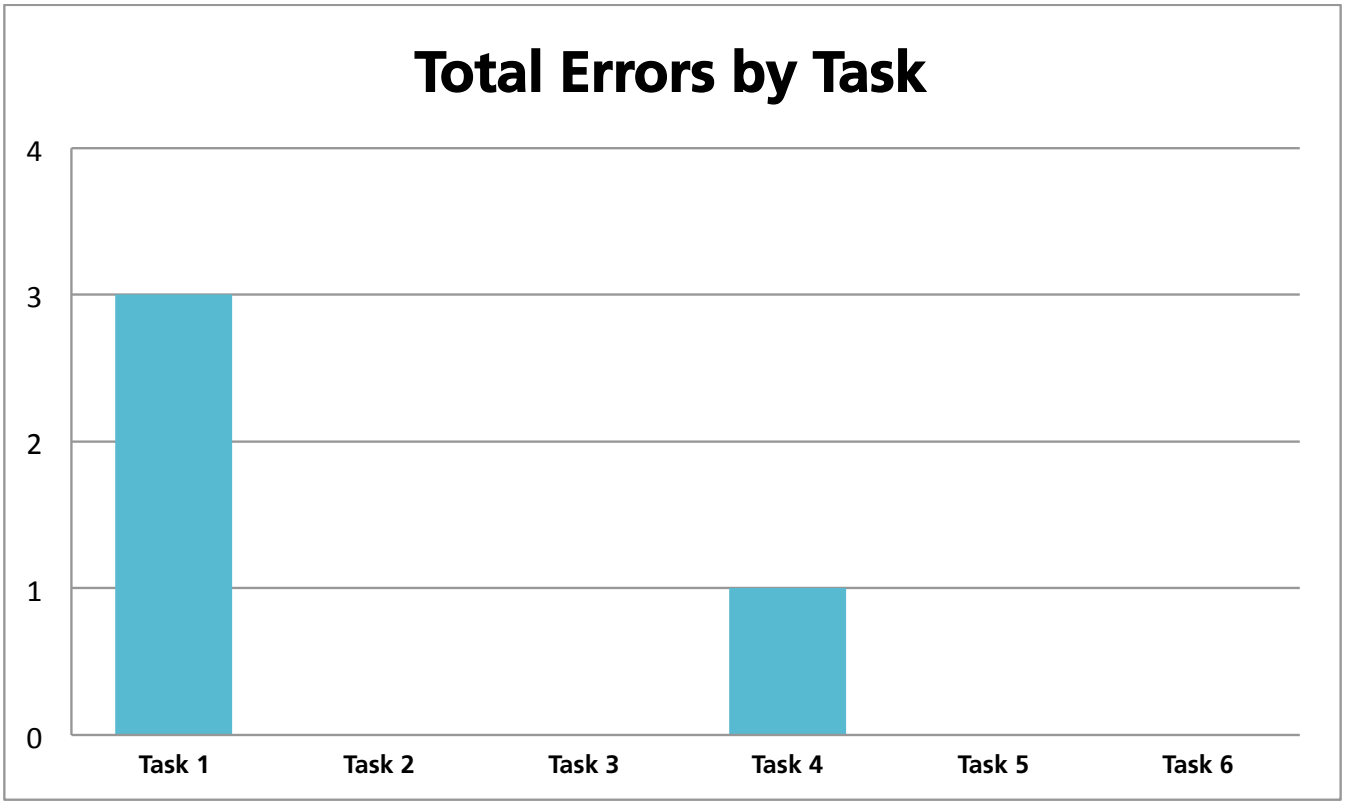
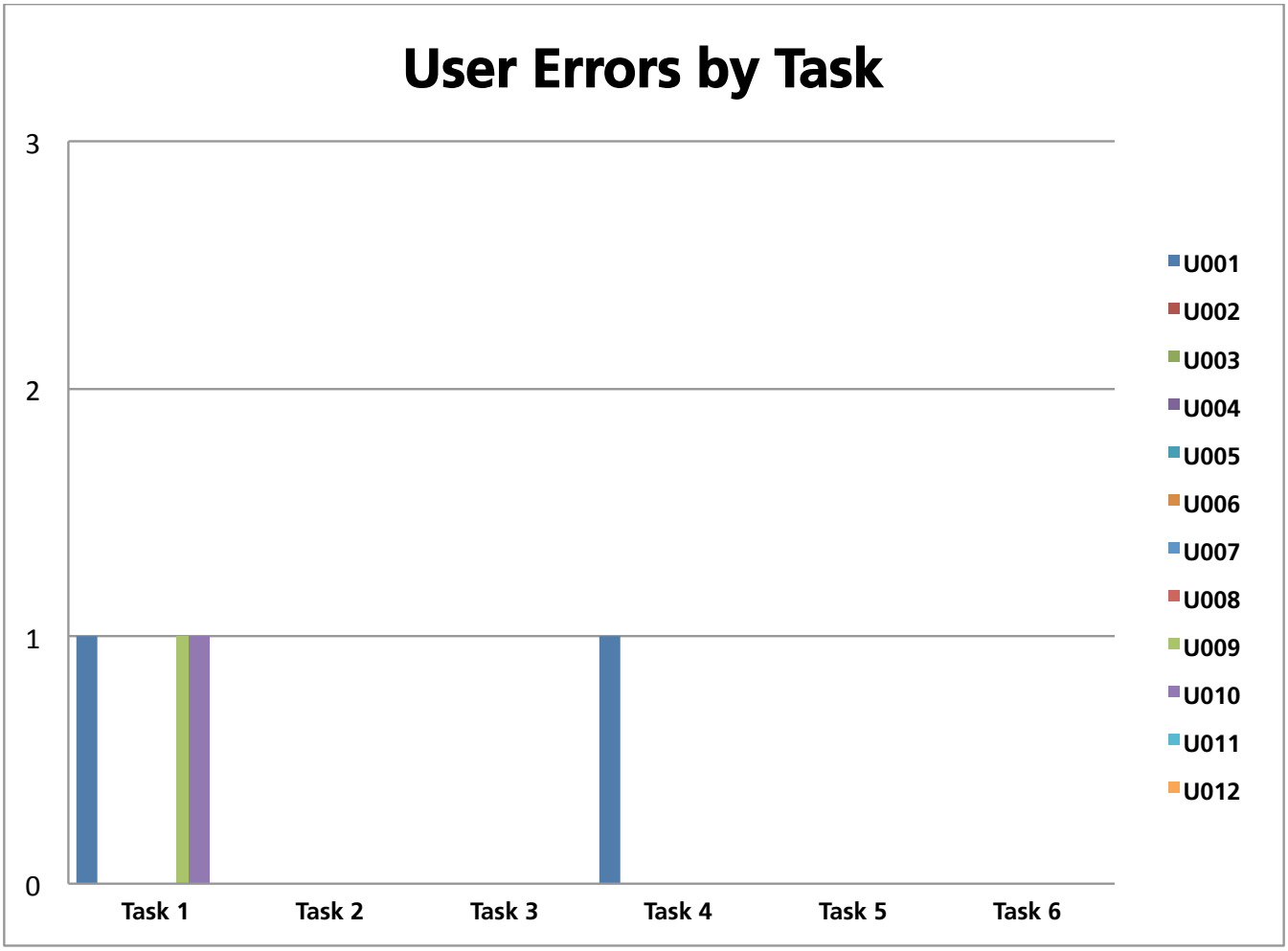


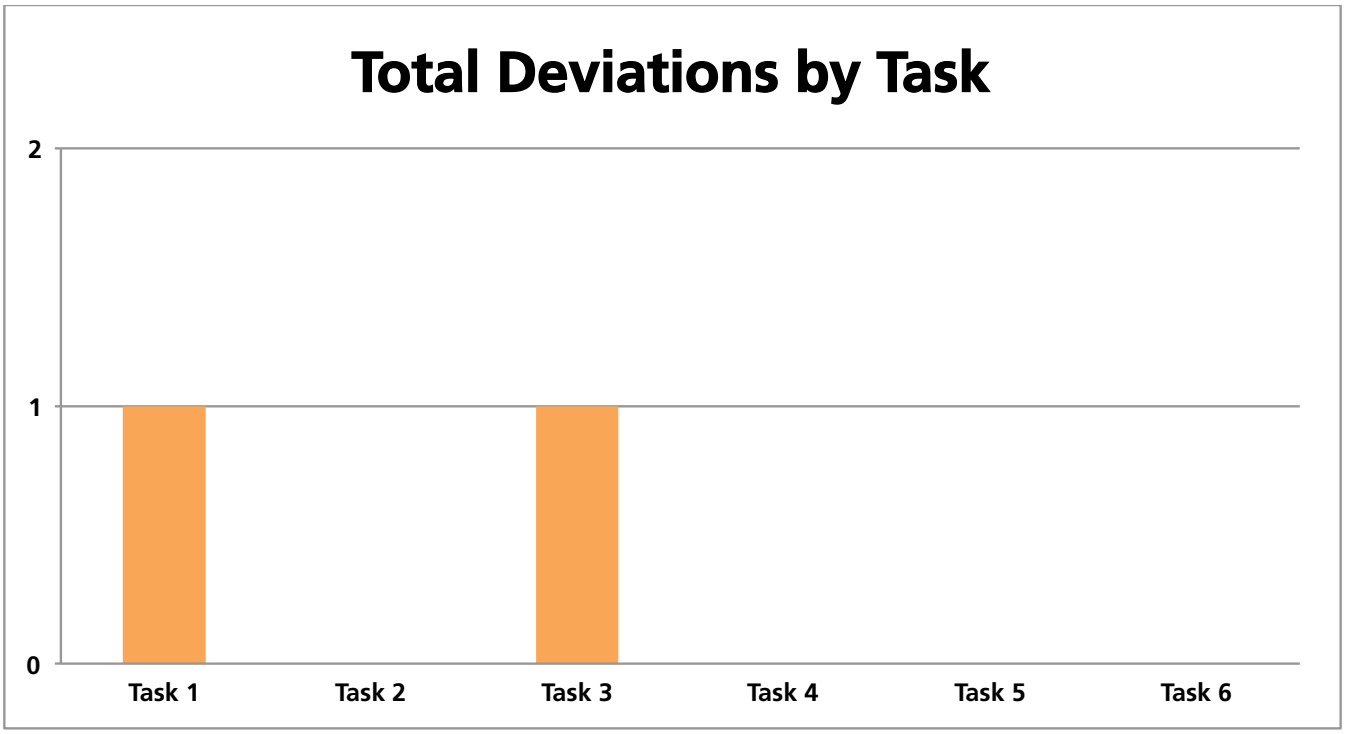
Figure 1 - Summary of the Results

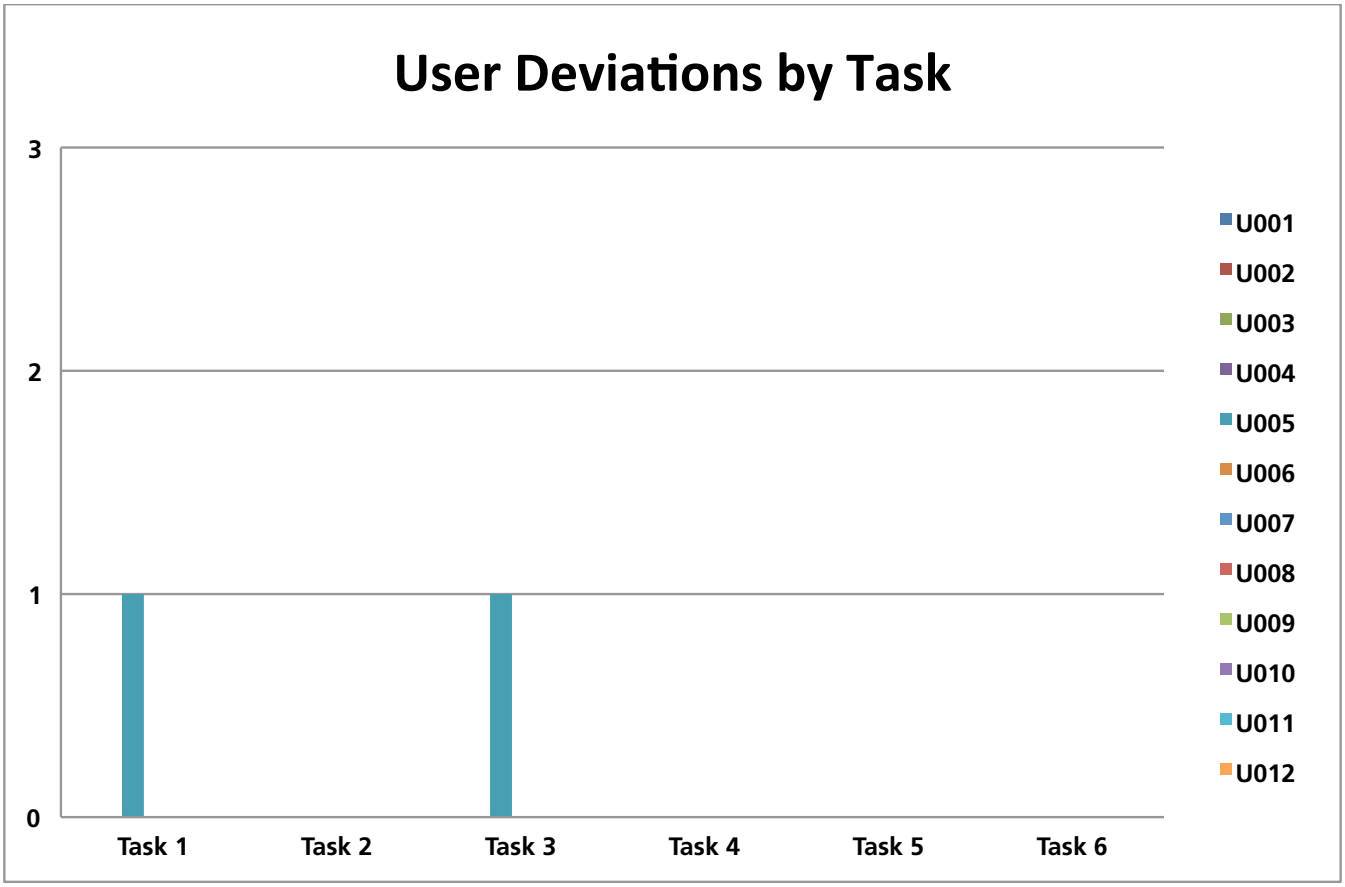
User	Total unassisted task effectiveness (%)	Total assisted task effectiveness (%)
U001	100%	100%
U002	100%	100%
U003	100%	100%
U004	100%	100%
U005	100%	100%
U006	100%	100%
U007	100%	100%
U008	83,33%	100%
U009	83,33%	100%
U010	83,33%	100%
U011	100%	100%
U012	83,33%	100%
Mean	94%	100%
Standard Deviation	8,21%	0,00%
Minimum	83%	100%
Maximum	100%	100%

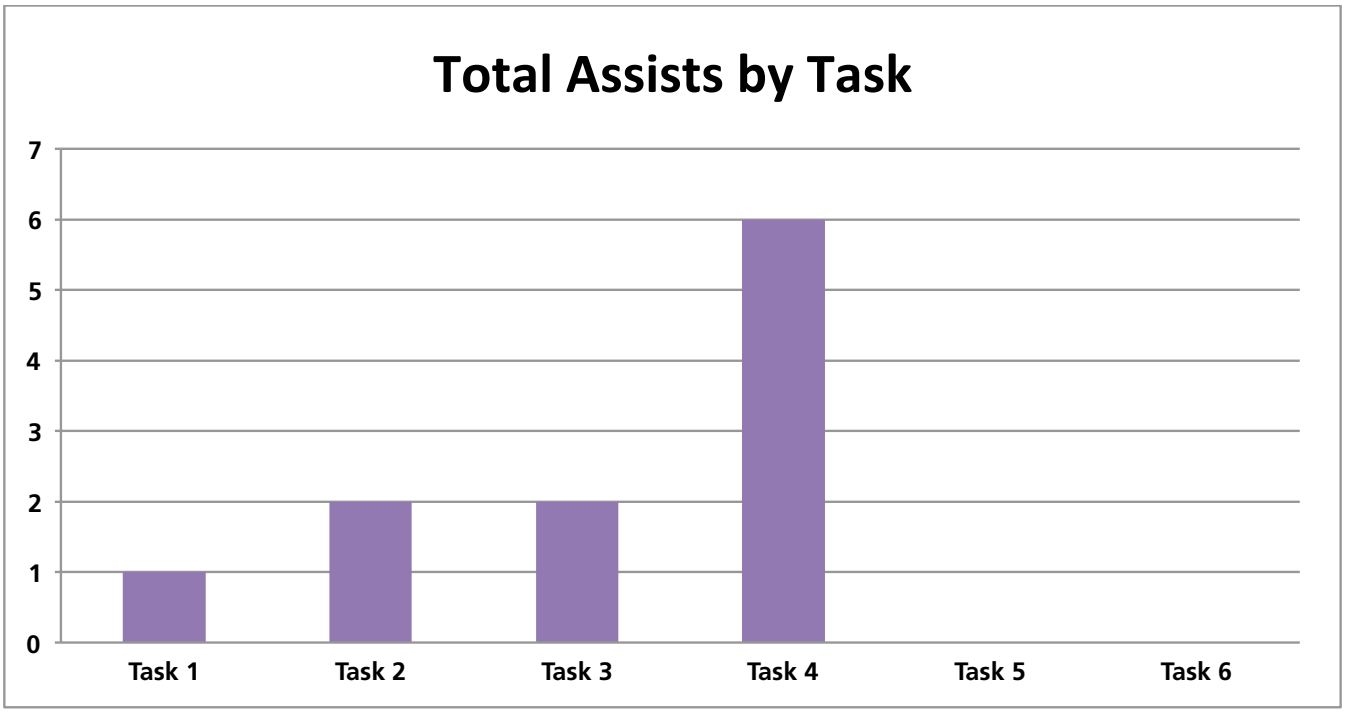

Task Completion Rates
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
U001
U002
U003
U004
U005
U006
U007
U008
U009
U010
U011
U012
Total unassisted task completion (%)
Total assisted task completion (%)

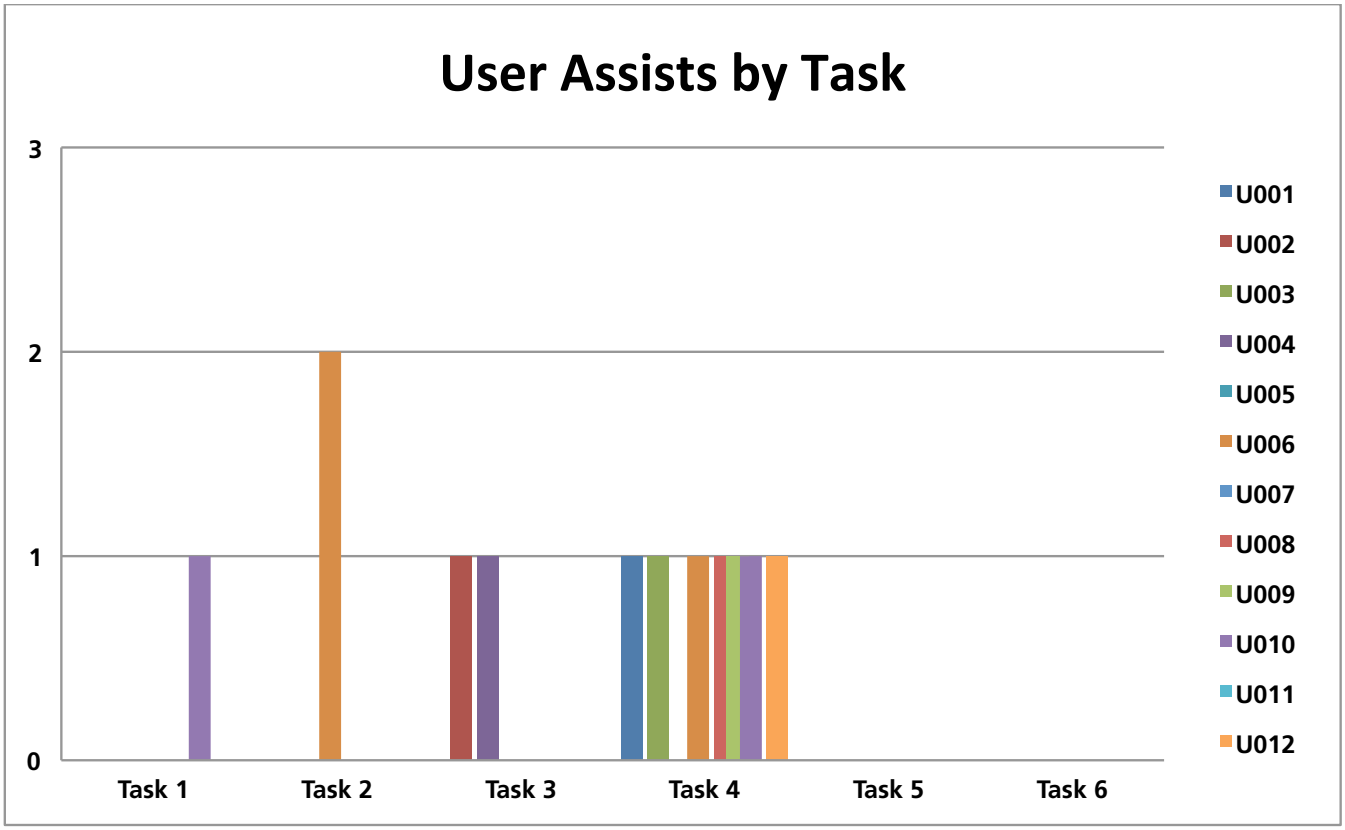

Total Errors by Task
4
3
2
1
0
Task 1
Task 2
Task 3
Task 4
Task 5
Task 6


User Errors by Task
3
2
1
0
Task 1
Task 2
Task 3
Task 4
Task 5
Task 6
U001
U002
U003
U004
U005
U006
U007
U008
U009
U010
U011
U012


Total Deviations by Task
2
1
0
Task 1
Task 2
Task 3
Task 4
Task 5
Task 6

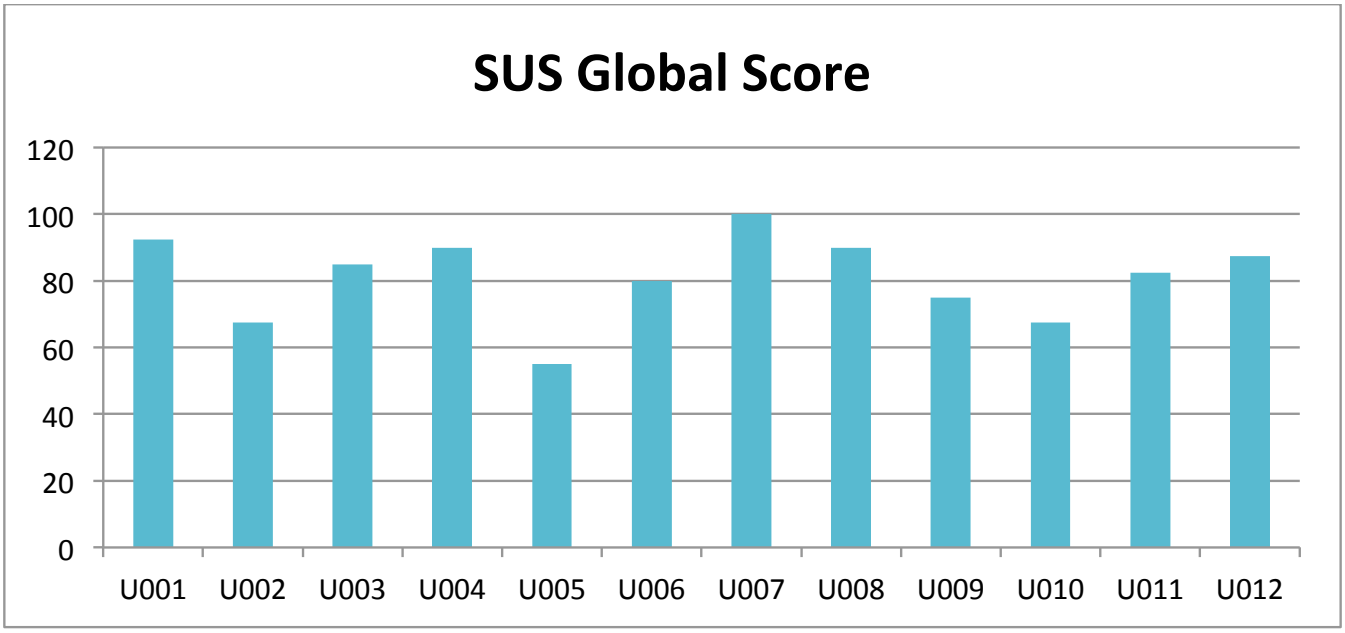

User Deviations by Task
3
2
1
0
Task 1
Task 2
Task 3
Task 4
Task 5
Task 6
U001
U002
U003
U004
U005
U006
U007
U008
U009
U010
U011
U012


Total Assists by Task
7
6
5
4
3
2
1
0
Task 1
Task 2
Task 3
Task 4
Task 5
Task 6



4.1.2. Satisfaction results

User	SUS Global Score
U001	92,5
U002	67,5
U003	85
U004	90
U005	55
U006	80
U007	100
U008	90
U009	75
U010	67,5
U011	82,5
U012	87,5
Mean	81,04
Standard Deviation	12,77
Minimum	55
Maximum	100



After finalizing the tasks, the participants filled a System Usability Scale questionnaire in order to assess the satisfaction. The average score of the SUS questionnaire was 81,04, with a standard deviation of 12,77. The lowest recorded score was 55 while the highest score was 100.

5. User comments

5.1. Task 1

Segment	Comments
Task 1	▪ All the users claimed the Enter button should be activate rather than forcing the user to press the search icon. ▪ U009 indicated auto-completion in the search bar could also be a good feature. ▪ U011 affirmed the search bar in the homepage and in the results page was not evident and easily depicted. ▪ U012 stated the results when searched should filter according to the order of the letters, and not by the presence of a letter in the word (e.g. When the user searches by the letter "g", only the countries starting with the letter "g" should be displayed). ▪ U001 and U009 stated the search should not only encompass countries, but also cultural artifacts and ethnic groups. An alternative provided by U009 consists in indicating that only countries can be searched. ▪ U001, U002, U003, U004, U007, U008, U010 and U011 suggested the modal window should fit the size of the screen and zoom tools should be available. ▪ U005 and U009 affirmed that not only should the modal window fit to page, but also the user should have the option of displaying a full screen version of the same cultural artifact.

	▪ U005 and U011 affirm if the cultural artifact has a Creative Commons License, the same artifact should be available to download and print. ▪ U003 and U012 pronounced that the modal window should always have the same consistent size. ▪ U001 and U006 claimed navigation controls in the modal window would be a nice addition. ▪ U002 said the modal window should close once the user presses outside the same modal window.

5.2. Task 2

Segment	Comments
Task 2	▪ U001, U002, U003, U004, U005 and U011 indicated that more social indicators should be available, namely: o GDP (Gross Domestic Product) o Population of the country o Major Urban Areas o Number of mobile phones in the country o Internet penetration rate o Mobile penetration rate o Population by age o Employment rate o Distribution by sectors o People in universities ▪ U001 stated a button should be added in order to access more social indicators. This approach signifies only five social data indicators would be readily available, but the user was able to select from a list of other indicators when this button was pressed. ▪ U001 affirmed it would be good to receive feed about new cultural artifacts in the page and/or by e-mail. ▪ U001, U002, U003, U008, U009, U010, U011 and U012 said the social data indicators should be clickable and display more detailed information. For instance, a nation has 10 ethnic groups and when this social data indicator is selected, the names of the ethnic groups are displayed. Other example is to present the percentage of the population that speaks a particular language.

	▪ U003 suggested the platform should provide links to more statistical data and other sources of information. ▪ U006 stated the social data indicators should be more noticeable. ▪ A personalized approach of the social data indicators was suggested by U007, U009, U010 and U011. The user stated that the customization of social data indicators would be a good feature. ▪ U012 affirmed the social data indicators should be grouped by category. ▪ U005 and U008 stated the search bar is not very noticeable. Furthermore, U012 suggested the search bar icon is more noticeable on the right side of the bar, rather than the left

5.3. Task 3

Segment	Comments
Task 3	▪ U001, U003, U005, U006, U007, U008, U009, U010 and U012 were more comfortable with using the filtering options associated with the hamburger icon and many times, could not recognize the fact that the graph acted as a navigation tool. ▪ U001 affirmed the hamburger icon was not easily noticeable. ▪ U009 states the user should be able to visualize all the categories at once in the dropdown list. In other words, scrolling should be avoided. ▪ U010 said the user should be able to search for the name of a specific item. ▪ U012 thought the hamburger icon was the menu for the entire website and stated that filter should not be located there. Moreover, U012 suggested the creation of another icon to represent all the filtering options located below the search bar. ▪ U012 was pleased with the idea of cross-referencing categories.

5.4 Task 4

Segment	Comments
Task 4	Navigational Graph: ▪ U001and U010 enjoyed the graph but had trouble discovering it. ▪ U003, U006 and U012 could not find the navigational graph without assistance. ▪ U007 affirmed the navigational graph is intuitive once the method is introduced. ▪ U004 suggested having the two navigational methods next to each other. ▪ U005 and U012 stated the back function in the navigational graph must be more noticeable. An icon to return all results right away was also thought off by U012. ▪ U002, U004, U008, U009 and U011 stated the divisions in the graph should display labels for identification purposes. ▪ U004 said the mouse over function for identification is not enough to recognize the categories. ▪ U002, U008 and U011 affirmed the differentiation of divisions by color tonality in the navigational graph would be important.

	▪ U002 claimed parents and children should be differentiated in the navigational graph. ▪ Additionally, U010 affirmed the platform should adopt a filtering system similar to photography websites such as 500px. ▪ The chart was confusing for U011. ▪ U012 suggested that titles should be associated to the social data indicators and the navigational graph. Video: ▪ The overall idea of the participants was to embed videos if these are available online. If the videos are not available online or belong to Fraunhofer, the video should be uploaded. ▪ The participants believe the video controls were sufficient for navigational purposes. ▪ U001 and U011 believe close captioning was a good feature to add to the video player. ▪ U001 and U006 claimed the video should display several resolution options. ▪ U005 and U011 suggested the videos should be available for download. ▪ U001 and U002 affirmed the user could navigate in the platform and a small video thumbnail with a cultural

	artifact could be running on the bottom right of the screen (e.g. Youtube application).

5.5. Task 5

Segment	Comments
Task 5	▪ **U001 was not pleased to the fact that the audio could not be controlled.** ▪ **U001, U003, U005, U006, U007, U008, U009 and U012 suggested if the sound was being played, an audio player should appear in the platform as a form to control the audio.** ▪ U010 enjoyed the idea of an external audio player, but the user should be confronted with a confirmation box regarding the sound of the cultural artifact once the modal window is closed. ▪ **U002, U004 and U005 believed the idea of continuous sound was distracting.** ▪ U003 and U011 stated the audio player if existent, should be able to be dragged across the screen. ▪ U004 suggested once the modal window of the cultural artifact containing a sound file is closed, the sound should also terminate. ▪ U007 and U008 affirmed the idea of sound being played once the modal window is closed and with the existence of a audio player is a good idea because this particular cultural type is not visual and might bore the user. ▪ U009 claimed that the sound could even be available once another search query is performed.

	▪ U010 suggested the audio player in the modal window should be located above or below the description. ▪ U012 stated the two main sections of the page should be controlled and resized according to the preference of the user. Nonetheless, a minimum size should be given to the results section of the page.

5.6. Task 6

Segment	Comments
Task 6	▪ The option to download the PDF file was an action demanded by every participant. The platform will only serve as a preview tool for the actual analysis of the PDF files. ▪ U001, U003, U011 and U012 suggested the size of the modal window could be larger and proportional. ▪ U003 claimed a search bar for the actual content of the PDF should be provided to the users. ▪ U006 and U012 stated that a Go to Page function would be useful to the users of the platform. ▪ U009 affirmed the ability to filter by media type in the query process would be extremely useful. ▪ U012 claimed a Full screen mode of visualizing the document would be a good addition to the platform.

6. Recommendations

The following table displays user's recommendations separated into three areas of importance. **Critical** recommendations are the ones that need to be implemented as soon as possible. The **medium** level recommendations are suggestions are recommendations important to implement, but not essential in terms of usability. At last, the **low** level recommendations are the suggestions nice to implement in future versions of the platform, but they are not necessary.

Critical	▪ Allow users to press the Enter key when a search is conducted must be resolved ▪ News feed about country or about the new content added to the platform ▪ Traditional navigation method must display all categories without scrolling. Therefore, this area needs to be resized. ▪ Close icon (X) in the modal window must be altered. Changing the hue should be sufficient to resolve this issue. ▪ Map with the ability to select several countries for comparison (for the next version of the platform)
Medium	▪ Auto-completion in the search bar ▪ Navigation controls, such as next and back, should be displayed in the modal window ▪ Search bar for the actual content in the PDF file ▪ Go to Page functionality in PDF files ▪ Modal window should fit the size of the screen ▪ Modal window should have a consistent size ▪ Modal window should close once the user presses outside the same modal window ▪ Titles should be associated to the interactive graph and the social data indicators ▪ Cataloging systematization for cultural artifacts instead of title and description. This is a method to make the platform more consistent.

	▪ Description of the platform in the homepage
Low	▪ Video upload for FhP videos and embedding for the other ones ▪ Social data indicators should be clickable and more information should be provided once the social indicators are clicked. ▪ Search bar in the results page is not very noticeable. Maybe the search icon is more noticeable on the right side of the search bar ▪ Make users realize the hamburger icon is clickable ▪ Icon for filtering options. Hamburger icon is seen as navigation for the whole menu ▪ A Back icon needs to be added to the interactive graph ▪ Labels are required for interactive graph ▪ Differentiation of categories in the interactive graph by color tonalities ▪ Parents and children should be differentiated in the navigational graph ▪ Confirmation box to keep audio playing once the user leaves the modal window of a sound file ▪ Filter by media type ▪ Present source and link of the file in the modal window ▪ Design an icon and for external links artifacts ▪ Infinite scroll is the method to display the results

7. Appendices

Participant general instructions – Portuguese Translation

Os participantes devem receber a seguir informação sobre o projeto:

" A Tiqsi é uma plataforma etnográfica cujo objetivo consiste em reunir informação cultural de países em desenvolvimento. A plataforma tem como missão sistematizar conteúdo cultural de modo a contextualizar os investigadores e ajudar na criação de soluções centradas no utilizador. A plataforma foi idealizada devido a quatro razões, sendo estas:

- *A falta de uma base de dados capaz de armazenar projetos e material cultural,*
- *A distancia física e cultural existente entre os utilizadores e os investigadores,*
- *A falta de um único sistema interno de partilha de informação,*
- *E o facto do material cultural e antropológico não estar organizado numa única localização.*

Por isso mesmo, a plataforma procura aumentar as competências de profissionais envolvidos na área de ICT4D e também fornecer suporte científico na área de HCI4D. A área de ICT4D consiste em criar soluções para países em desenvolvimento."

Em relação aos protótipos os participantes devem receber a seguinte informação:

" É importante mencionar que esta é uma versão beta da plataforma e certas funcionalidades não se encontram disponíveis. O estudo de usabilidade foi criado com o intuito de analisar e determinar a funcionalidade da plataforma em contexto de uso diário."

"Também, durante o resto da sessão , eu vou seguir o guião de modo a assegurar que as instruções foram fornecidas da mesma forma a todos os participantes."

"Tem alguma questão antes de começar?"
[Responder às questões]

[Escrever a hora que a sessão começou]

Pré-questionário:

" Gostava de pedir a sua permissão para filmar o teste apenas para fins de investigação e vão ser visualizadas apenas pelos investigadores. Gostava também que lê-se e assinasse o consentimento."

[O participante assina o consentimento]

" Antes de começar a sessão, vou pedir que preencha um questionário"

[O participante completa o questionário]

"Agora, gostava de perguntar as seguintes questões :

- *Quando alguém menciona plataforma etnográfica, o que espera encontrar?*

  [Se sim, perguntar segunda questão]

  [Se não, perguntar última questão]

- *Acredita que uma plataforma etnográfica é capaz de assistir profissionais no desenvolvimento de soluções para culturas diferentes?*

- *Que tipo de informação espera encontrar na plataforma?"*

Em relação ao teste:

" Como foi mencionado antes, estou aqui para aprender com profissionais nas áreas de desenvolvimento Web e Mobile, Design e HCI que lidam com problemas associados à criação de soluções ICT para países em desenvolvimento."

" Durante a sessão, vou pedir que utilize a plataforma e efetue uma variedade de tarefas que eu vou observar e gravar. Enquanto efetua as tarefas, por favor tente simular aquilo que faria em condições normais. Um papel com uma tarefa vai ser entregue e após terminar essa tarefa, outro papel com uma nova tarefa vai ser entregue."

"Eu não estou a avaliar a si, mas sim a plataforma, e por isso mesmo, não existem respostas erradas. O seu feedback é importante de modo a perceber o que funciona e o que não funciona na plataforma."

Depois do teste:

" Tem alguma questão ou comentário?

Para terminar o estudo, eu vou fornecer um questionário SUS e vou pedir que responda a algumas questões.

Obrigado pela sua participação no teste. A sua opinião é muito valiosa para nós."

Usability Testing - Tiqsi - Background Questionnaire

1. **Occupation**

.....

2. **What is your age?**
   Check all that apply.

   - [ ] 18-24
   - [ ] 25-29
   - [ ] 30-35
   - [ ] 36-40
   - [ ] Over 40

3. **What is your gender?**
   Check all that apply.

   - [ ] Male
   - [ ] Female

4. **How many years of experience do you have with ICT4D solutions?**
   Check all that apply.

   - [ ] Less than one year
   - [ ] 1-2 years
   - [ ] 2-3 years
   - [ ] 3-4 years
   - [ ] 4-5 years
   - [ ] Over 5 years

5. **What is your level of experience regarding Mobile and Web Development?**
   Check all that apply.

   - [ ] Less than one year
   - [ ] 1-2 years
   - [ ] 2-3 years
   - [ ] 3-4 years
   - [ ] 4-5 years
   - [ ] Over 5 years

6. **What is your level of experience regarding User Interface / User Experience Design?**
   Check all that apply.

   - [ ] Less than one year
   - [ ] 1-2 years
   - [ ] 2-3 years
   - [ ] 3-4 years
   - [ ] 4-5 years
   - [ ] Over 5 years

7. **What is your level of experience regarding Human-Computer Interaction?**
   Check all that apply.

   - [ ] Less than one year
   - [ ] 1-2 years
   - [ ] 2-3 years
   - [ ] 3-4 years
   - [ ] 4-5 years
   - [ ] Over 5 years

Informed Consent

Fraunhofer PORTUGAL

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4200-135 Porto, PORTUGAL

CONSENTIMENTO PARA PARTICIPAÇÃO EM INVESTIGAÇÃO

***A Associação Fraunhofer Portugal Research** faz trabalho de investigação destinado a encontrar soluções focadas na população sénior ou na população de países em desenvolvimento. A plataforma Tiqsi insere-se nesta última categoria, sendo um projeto que visa assistir nas práticas de design centrado no utilizador para países em desenvolvimento.*

A informação recolhida durante o teste realizado está relacionada com a usabilidade da plataforma. Esta informação será recolhida através da observação da interação, dados de vídeo e som, assim como um questionário e entrevista.

Estes dados são depois usados para criar soluções mais fáceis e eficazes que permitam melhorar aspectos do sistema.

Gostaríamos de contar com a sua participação. A participação não envolve qualquer prejuízo ou dano material e não haverá lugar a qualquer pagamento. Os dados recolhidos são confidenciais. A Associação Fraunhofer Portugal Research tomará todas as medidas necessárias à salvaguarda e proteção dos dados recolhidos por forma a evitar que venham a ser acedidos por terceiros não autorizados.

A sua participação é voluntária, podendo em qualquer altura cessá-la sem qualquer tipo de consequência.

Agradecemos muito o seu contributo, fundamental para a nossa investigação!

<u>O participante</u>:

Declaro ter lido e compreendido este documento, bem como as informações verbais fornecidas e aceito participar nesta investigação. Permito a utilização dos dados que forneço de forma voluntária, confiando em que apenas serão utilizados para investigação e com as garantias de confidencialidade e anonimato que me são dadas pelo investigador. Autorizo a comunicação de dados de forma anónima a outras entidades que estabeleçam parceria com a Associação Fraunhofer Portugal Research para fins académicos e de investigação científica.

Nome: _____

Assinatura: _____ ***Data*** ___ / ___ / _____

<u>Investigador responsável pela plataforma Tiqsi</u>:

Nome: Ana Correia de Barros

Telefone: 220 430 300

E-mail: ana.barros@fraunhofer.pt

ESTE DOCUMENTO É FEITO EM DUPLICADO: UM PARA O PARTICIPANTE E OUTRO PARA O INVESTIGADOR.

Tasks of the Usability Testing

1

Search for Ghana and open the file entitled “Mausoleum of Kwame Nkrumah”

2

Close the modal window, search for Liberia and indicate the values of the social data indicators: Ethnic Groups, Languages, Literacy, Religious and Urbanization.

3

Search for Cameroon, filter the results by “Architecture” and open the file named “Bandjoun Chefferie”.

4

Return all results in Cameroon, and filter the results with the alternative navigation method. Filter the results by “Architecture” and open the file entitled “Yaoundé Centre”

5

Search for Ghana, and play the sound file “Postal Workers Cancelling Stamps”. Afterwards, close the modal window.

6

Search for Liberia, open the text file named “International Human Rights, Gender-Based Violence, and Local Discourses of Abuses in Postconflict Liberia: A Problem of "Culture"? ”.

8. References

National Institute of Standards and Technology, *NISTIR 7432 – Common Industry Specification for Usability – Requirements*, 2007

Appendix K
Video Demonstration of the TIQSI platform

The video demonstration of the TIQSI platform can be visualized through the following link:

https://youtu.be/dVSWsvyVW6c

Appendix L

Video Demonstration of the Okavango Application

The video demonstration of the Okavango application can be visualized through the following link:

https://youtu.be/dwhCa9PZhKg

This is the Back Cover