# HCI4D Guideline Systematization: Creation, Documentation and Evaluation with Partners from Developing Countries

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## ABSTRACT

The distant gap of cultural characteristics between the development team and the target audience in developing countries poses significant challenges in the field of Human-Computer Interaction. Consequently, Fraunhofer AICOS, a Research and Development Institute, established a set of guidelines based on an extensive research and experimental fieldwork in order to answer more efficiently to a user-centered design approach, advocating user integration and enhancing user experience. The paper discusses the systematization of these guidelines, and its role in the development of mobile applications focusing on the mHealth, mGovernment, ICT solutions for Very Small Enterprises, and mAgriculture areas of activity. Furthermore, the process rooted the taxonomy and information architecture of a platform entitled TIQSI, whose mission is to assist design and Human-Computer Interaction teams by providing artistic, cultural and social ethnographic resources from developing countries.

**Keywords-** HCI4D, ICT4D, HCI guidelines, mobile applications, ethnography.

## 1. INTRODUCTION

The realization that cultural differences between developed and developing countries exist is fundamental. These differences have a substantial impact in design and technology approaches, namely in Information and Communication Technologies. Consequently, the role of Information and Communication Technologies varies in degree of importance between nations, and solutions for developing countries need to acknowledge certain challenges namely from technical, environmental and cultural perspectives [3].

Besides biology, culture is other dimension that is intrinsically natural to human beings, but cultural diversity poses challenges to designers and Human-Computer Interaction practitioners. Culture is at the core of the design process [34] and it is responsible for the variance in perception among individuals. An individual's childhood, upbringing, education and other social aspects influence the form people interact with the environment and shape the culture of an individual [33]. Furthermore, culture can act as a facilitator or inhibitor in the adoption and transferring of Information and Communication Technologies [7]. Therefore, an appropriate research about guidelines aimed for developing regions and their implementation in smartphones applications is necessary in order to create intuitive user interfaces and an adequate user experience.

### 1.1 ICT4D Competence Center

The second chapter discusses the role of Fraunhofer AICOS, a Research and Development Center, and their partners in the creation of smartphone solutions in the ICT4D context. Furthermore, the chapter clarifies the work that the ICT4D Competence Center, along with their partners, has been doing in order to create usable and engaging products for developing countries. In the past few years, ICT solutions have been growing and thriving in the majority of developing countries. Despite the large number of opportunities in the market, most products have been unsuccessful due to the cultural disparities between the developers of the product and the target users. Moreover, the divergence between the developers and the target users generates a number of misconceptions and misrepresentations that influence the usability and user experience of the product. Devising products for developing regions encompasses a series of additional challenges including, but not limited to, equipment and power failures, local purchases and manufacturing, the frequency of natural disasters, and cultural and social problems such as corruption and theft [3]. The ICT4D Competence Center collaborates with local African institutions and universities such as Nelson Mandela Metropolitan University, a South African university, and Eduardo Mondlane University, a Mozambican University, in order to develop products with a more user-centered approach. Therefore, since the developing team encompasses individuals from different nationalities, and the products are deployed to distinctive African nations, a strong knowledge of the cultures, values and customs of the regions is necessary.

### 1.2 Guidelines

The third chapter describes the process the research and development institute had in amassing and documenting guidelines specific for developing regions, and demonstrates the form these guidelines are implemented in the applications developed by the ICT4D Competence Center and the strategic partners. Moreover, the chapter demonstrates the relationship between the applications and

the guidelines developed at the ICT4D Competence Center. The guidelines are responsible for developing immersive applications able to ease the integration of the users and improve the user experience. The importance of the guidelines and their use in the application is due to a significant number of the users utilizing the applications display constraints that the developers must acknowledge, such as the degree of digital literacy, the level of written literacy and the prominence of oral-based cultures. Therefore, the utility of these guidelines is to facilitate the use of mobile devices in remote areas that often lack the contact with mobile devices and create usable products to improve the life of these individuals.

To summarize, the chapter describes the main areas of ICT4D on an individual basis, mentions the guidelines utilized, dissects the utilization of these guidelines in the application, announces the papers and methods of evaluation used, and draws conclusions about the relationships between guidelines and the solutions for the main areas. A significant number of these guidelines can be found in more than one area of ICT4D and consequently, the authors decided to mention only the most relevant ones for each application. Nonetheless, by recognizing the fundamental purposes of all the guidelines for future work, the authors made an entire list containing 211 guidelines specified for developing regions available online, which can be accessed through the link found in the appendix.

Two solutions pertaining to mHealth (MalariaScope and Epidemiologic Surveillance), two relating to mGovernment (IZIDoc and OurMoz), one in the area of ICT for very small enterprises (OurMoz), and one for mobile agriculture (Assistive Environment for Hydroponic Farming) are properly analysed and dissected in this chapter. These solutions were selected because they are supported by one year of research and fieldwork in the developing countries related to the ICT4D Competence Center.

### 1.3 TIQSI, an ethnographic platform

The fourth chapter discusses the role of TIQSI. This ethnographic platform was developed for internal use in the ICT4D Competence Center, and the objective of TIQSI is to recognize the existent cultural gap between the researchers and the target audience, and deliver solutions more appropriate for the target audience. Over time, the platform will also help in the creation of new guidelines particular to certain characteristics. Moreover, the chapter describes the process and the composition of the information architecture of the system.

## 2. ICT4D COMPETENCE CENTER

The conceptualization of the ICT4D Competence Center derives from the Interface Institutes Model. The Interface Institutes Model is used as a reference and it can be defined as a collaboration approach aimed to ease the establishment of innovative ecosystems as a method to promote the remote creation of ICT solutions whose mission is to answer the demands of local people and incentivize the acceptance of these solutions. Additionally, the Interface Institutes model consists in the joint collaboration of international organizations as a way to originate specific solutions able to address the needs of the local users. This model not only promotes the idea of knowledge transferring between local and distant teams developing the project, but also assists in the development of usable and useful products in environments where the research is scarce and the fieldwork is limited.

The ICT4D Competence Center thrives on the collaboration of international experts working with partners from scientific institutions in order to identify and develop ICT solutions with significant adhesion in developing countries. The symbiotic relationship between ICT4D Competence Center and the scientific institutions enhances the local relevance of the applications and problems considered as critical by the local population are targeted. The German Fraunhofer Fokus Institute, the Mozambican CIUEM, the South African NMMU, and the Portuguese Fraunhofer AICOS institute constitute the ICT4D Competence Center. The collaboration between partners has originated several sponsored projects that were deployed in developing countries by the ICT4D Competence Center, namely in Mozambique and South Africa. Furthermore, the communication with local partners in these nations has provided local resources and knowledge transfer optimal for different project tasks. Moreover, the fieldwork and evaluation performed by the ICT4D Competence Center has been shared through a number of papers.

At the moment, the ICT4D Competence Center is active in a number of projects in the Sub-Saharan region. MalariaScope is an mHealth solution able to perform automatic detections of the *P.falciparum* parasite through the use of a smartphones and image processing techniques. This ICT mobile solution is developed with the cooperation of the National Health Institute Doutor Ricardo Jorge and its main functions are to diagnose malaria in medically underserved areas, create a low cost alternative to current microscopes and provide a first triage framework able to supply the correct medication. Epidemiologic Surveillance is other mHealth application responsible for the collection of clinical data on remote locations in developing countries through the use of mobile devices and without the need of a continuous network connection. The application has been developed with Critical Software, a Portuguese information systems and Software Company, and the main objectives of the application consist in the correlation of the collected data with earth observation data as a form to predict outbreaks and epidemics, prevent the spread of infectious diseases such as Malaria and HIV/AIDS, and secure data storage of sensitive information.

The ICT4D Competence Center is also involved in the development of mobile agriculture solutions such as the Assistive Environment for Hydroponic Farming, a low cost mechanism for monitoring hydroponic farms in South Africa and Mozambique with a smartphone. This ICT

solution developed with the Nelson Mandela Metropolitan University in South Africa aims to improve farm management through the monitoring and control of environmental parameters, and the utilization of real time alarms, short monitoring cycles and automated reports that lead to an increased level of performance in the farms.

Furthermore, the ICT4D Competence Center is actively engaged in the areas of mobile for citizens and mGovernment, and ICT for Very Small Enterprises (VSE). One particular example of a solution in both areas is OurMoz, a citizen centered mobile platform able to supply real-time geotagged information about Mozambican cities. OurMoz combines the concept of social network with citizen reporting and the integration of E-Commerce. Another objective of the solution is to improve small commerce in Mozambique by enhancing the engagement between citizens and the stakeholders. Regarding solutions in the areas of mobile for citizens and mGovernment, the ICT4D Competence Center is also working on IZIDoc, a mobile solution with the intent of simplifying the administrative acts that require personal attendance at service provider's facilities, such as police stations and pharmacies. The objectives of the solution are to provide citizens with information about the status of requested goods or services, and optimize customer service. OurMoz and IZIDoc were both developed with Eduardo Mondlane University in Maputo, Mozambique.

Therefore, the ICT4D Competence Center has a specific mission and vision and is actively involved with local institutions as a form to supply solutions to particular problems in the African continent. The methodologies incorporated by the ICT4D Competence Center have originated interesting solutions to issues that affected African individuals on a daily basis.

## 3. GUIDELINES

The ICT4D Competence Center compiled a large amount of guidelines for developing countries. The guidelines provide recommendations to cope with cultural diversity, illiteracy, oral-based cultures, ergonomic factors, digital interface design, and social, environmental and environmental constraints. These guidelines also indicate the appropriate Human-Computer Interaction methods and methodologies for the people in developing regions.

The guidelines were collected with a specific motivation and methodology, which lead to the incentive of using certain keywords. The compilation of the guidelines is correlated to the growth and development of the ICT4D Competence Center and certain concerns became the pivots for the research of these guidelines. Therefore, the compilation of these guidelines derives from a number of reasons, including the needs and concerns of the countries the ICT4D Competence Center is currently working on. The number of countries might be expanded later and the guidelines must match the needs and concerns of the new countries. The guidelines amassed also aim to answer to problems and constraints in the ICT4D areas, cope with high illiteracy rates, support the prominence of oral based traditions, assist the percentage of disabled users that were victims of civil wars, lack of medical access and transportation issues in South Africa and Mozambique. The inequalities of women in the Sub-Saharan region, the differences in lifestyle between rural and urban areas, and the presence of multilingualism in the countries of study, along with the importance of official and local languages and the prominence of English and Portuguese, were also fundamental concerns depicted in these guidelines.

| mHealth | | mGovernment | VSEs & mGovernment | mAgriculture |
|---|---|---|---|---|
| MS | SS | IZI | OUR | HYDRO |
| 2 | 2 | 2 | 25 | 17 (*) |
| 5 | 5 | 17 (*) | 46 | 19 (*) |
| 17 (*) | 17 (*) | 19 (*) | 75 | 112 |
| 19 (*) | 19 (*) | 34 | 116 | 121 |
| 36 | 35 | 41 | 126 (*) | 122 |
| 41 | 41 | 42 | 131 | 126 (*) |
| 43 | 43 | 43 | 145 | 136 |
| 49 | 51 | 48 | 189 | 139 |
| 74 | 78 | 66 | 191 | 142 |
| 78 | 79 | 78 | 205 | 196 |
| 79 | 80 | 79 | 209 (*) | 207 |
| 80 | 114 | 80 | 210 (*) | 209 (*) |
| 114 | 115 | 114 | | 210 (*) |
| 118 | 118 | 115 | | |
| 121 | 121 | 117 | | |
| 122 | 122 | 118 | | |
| 123 | 123 | 121 | | |
| 124 | 124 | 122 | | |
| 126 (*) | 126 (*) | 123 | | |
| 132 | 138 | 126 (*) | | |
| 185 | 143 | 189 | | |
| 187 | 145 | 191 | | |
| 188 | 160 | 192 | | |
| 189 | 187 | 197 | | |
| 191 | 188 | 209 (*) | | |
| 193 | 189 | 210 (*) | | |
| 209 (*) | 191 | 211 | | |
| 210 (*) | 193 | | | |
| 211 | 207 | | | |
| | 209 (*) | | | |
| | 210 (*) | | | |
| | 211 | | | |

| Key | |
|---|---|
| | Guideline specific to the solution |
| * | Transversal guideline |

Figure 1 Compilation of guidelines utilized in the solutions

As mentioned previously, the list enumerates 211 guidelines but only the most relevant and useful ones were mentioned in this chapter. The entire compilation of the guidelines can be accessed through the link located in the appendix, and they are categorized according to the problems they address. To determine which guidelines were more pertinent to each solution, a filtering process was performed, and five unique guidelines were selected for each application. Meanwhile, other five transversal guidelines were also singled out in order to demonstrate that regardless of the ICT4D area or the targeted developing region, certain guidelines share common values and can be utilized in a transversal fashion.

### 3.1. mHealth solutions

mHealth solutions rest on the fundamental aspect of supporting and provide equipment for healthcare professionals in developing nations with the use of smartphone based ICT solutions. These solutions allow the professionals to carry their work more efficiently and in an automatic manner specifically in the rural areas, where the medical services and facilities are scarce. The two mHealth solutions developed at the ICT4D Competence Center were developed with these goals in mind and a very specific set of guidelines was followed for each solution

MalariaScope is an mHealth solution aimed to provide malaria diagnoses in medically underserved areas through image processing techniques. The mobile solution is

intended to become a low cost alternative to microscopes and a good user experience is fundamental to comfort the users.

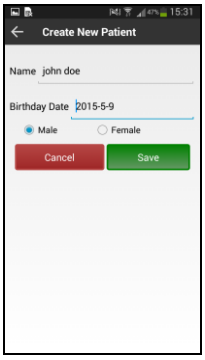


Figure 2 Create a new patient

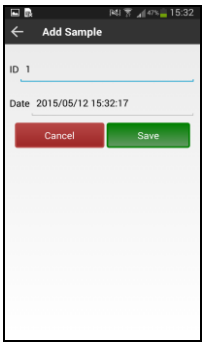


Figure 3 Add sample

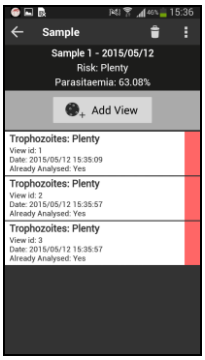


Figure 4 User samples

### 3.1.1 Additional motivation might be required to incentivize non-literate users

One of the guidelines followed by researchers for this particular solution consists in the acknowledgment that additional motivation might be required to incentivize non-literate users. Jan Chipchase [4] states that illiterate users are less motivated to spend additional time rote learning other features on the phone beside making and receiving calls, unless a group of people proactively demonstrates the value of the other features. The researchers should also spend a considerable amount of time instructing the illiterate users about the steps required to complete a task. These concerns are noted in the mHealth solution, and even though the application is currently not available on a national scale, the goal is for healthcare professionals to demonstrate and exemplify the importance that the functionalities provided by the solution have. The motivation of illiterate users is particularly important in nations of the Sub-Saharan region, namely Mozambique where the literacy rate is about 50.6%.

### 3.1.2 Orality provides different pathways to learn information

Oral based cultures store and share knowledge in different manners and this has a substantial impact in the learning form. Oral people learn from practical experience, "in situ" and in concrete situations, while literate based people use neutral, standalone objects containing abstract instructions applied across situations [29]. Furthermore, Walter Ong [25] states the learning methods acquired by oral-based people rely on forms of personal interaction and the knowledge is dispersed through speech. Adapting these methods to MalariaScope, once the application goes nationwide, the healthcare professionals and the researchers must deliver new forms of information aimed for oral based individuals. This signifies the professionals must create practical and concrete situations that explain the value of the solution to the individuals.

### 3.1.3 Oral people do not internalize new information the same way as literate people

There is a substantial discrepancy in the method how information is internalized between literate and oral people, and the HCI practitioners must recognize this dissimilarity. Oral based people cannot offload their memory requirements onto the technology of writing and therefore, they become more selective when choosing whether a piece of information should be internalized [29]. The same researchers describe that at times, even when the users understand each word in the content perfectly and a question about the same content is asked to oral based people, the user's response is based on prior knowledge. This action might result due to the lack of relevancy regarding formal content or the content is not organized in the linguistic style the users expect. Once MalariaScope goes nationwide, the researchers are assuring that the linguistic style in the application is compatible to the style used by the oral-based people in order for these individuals to internalize information in a more natural manner. Additionally, the formal content of the solution is not the focal point of the solution, but rather the applicability and ease of use.

### 3.1.4 Numbers might be ok

The idea that using numbers could pose usability and interaction issues due to the solution being used by literate and illiterate individuals is not empirical. Research focused in illiterate and semi-literate individuals has indicated that a significant portion of these people is numerate, and consequently, the use of numbers might be plausible [20] [21]. MalariaScope advocates the use of numbers with the belief that illiterate and literate individuals are being to understand the information conveyed by the numbers.

### 3.1.5 Numbers can be used to represent data but not actions

The use of numbers is optimal for data representation. However, numbers are not a good choice to represent actions. Parikh, Ghosh and Chavan [26] explain that numbers are well understood by many semi-literates and can assist the users in interface comprehension. On the other hand, the use of abstract numeric identifiers for navigation or action-based elements is not indicated [26]. Inspired from the conclusions of this guideline, MalariaScope only utilizes numbers to convey data such as identifiable numbers and navigation and action-based elements never employ numbers.

Epidemiologic Surveillance, the other mHealth solution, aims to predict outbreaks and epidemics through the correlation of collected data with earth observation data. Furthermore, the solution intends to prevent the spread of infectious diseases including Malaria and HIV/AIDS and secure data storage of sensitive information.


Figure 5 Page related to the located community


Figure 6 Pulverization page


Figure 7 Page related to Bodies of Water

### 3.1.6 Illiterate people detect invisible cues

On a daily basis, professionals need to interact with illiterate people. The solution equates this particular challenge and as Chipchase [4] indicates, certain cues are only visible if you know how to see it, and illiterate people are able to detect them. These invisible cues provide information regarding authenticity and value. During the initial stages of the solution, the visual elements were displayed to the professionals and they claimed that certain images were not understandable according to their reality. The professionals particularly reinforced the idea that the uniform used by them had a different colour in the application and this chromatic alteration could pose interpretation issues to the people unable to read or write.

### 3.1.7 Oral cultures prefer additive grammatical forms rather than subordinative forms

Walter Ong [25] affirms oral thought prefers additive forms while literate writing displays a preference for subordinative forms of grammar. Oral thought favours additive forms of grammar because it is more pragmatic and is more indicated to join information. Epidemiologic Surveillance utilizes this concept specifically when the user is defining the locality. As exemplified in figure 5, the solution allows the users to indicate information pertaining to the terrain.

Once this option is selected, the user is able to provide information regarding bodies of water, the quantity of mosquitoes in the area, and the last time professionals pulverized the area. Additionally, the option pertaining to bodies of water allows the selection of multiple options, which enhances the additive grammatical form. Furthermore, once the three options are properly filled, the users are able to convey a message employing additive grammatical forms, such as “the area comprised of rice fields and lakes has a significant amount of mosquitoes and it was pulverized within the last 30 days”.

### 3.1.8 Identify actions through visual elements that indicate motion

The solution relies in the identification of actions and to provide a better level of comprehension to the user, visual elements indicating motion were used. Research indicates that illiterate and semi-literate users associate drawings

with objects or locations (e.g. kitchen), rather than the action (e.g. cooking) [20]. Therefore, researchers state that visual elements should indicate motion, such as water running from a faucet, in order to provide better user comprehension [20]. The mHealth solution uses images indicative of motion, namely the act of pulverization, in order to ease user comprehension.

#### 3.1.9 Icons are used as landmarks

Knoche and Huang [16] display that illiterate users often use icons to orient themselves on the interface, through shape recognition, length of the text, along with other forms of perception. This concept was utilized in Epidemiologic Surveillance, and the extensive use of illustrations and icons derives from this approach. Additionally, the metaphors implemented in certain icons come from actual objects and they also act as landmarks for user recognition.

#### 3.1.10 Input modality (voice or touch-tone) performance and preference varies

Over time, Epidemiologic Surveillance will contain different forms of input modality. Research indicates that the performance levels and preference about input modalities varies between touch-tone navigation and voice input. For instance, certain research studies indicate that touch-tone navigation is preferred compared to voice input due to the error propensity of the latter [27]. On the other hand, low literacy users present higher task success when using a speech input compared to touch-tone input [30]. Therefore, the optimal approach is to provide both voice input and touch-tone input, and let the user chose the option according to context [30]. The current version of Epidemiologic Surveillance only provides touch-tone input, but once the solution spreads to a nationwide area, voice input will be added to the application.

The two mHealth solutions are targeted to different individuals and present distinct functionalities, even though they belong to the same area of ICT4D. The characteristics surrounding each solution were noted, and answers were encountered to current and future problems. Other guidelines were used during the development of these solutions but these are the more relevant ones.

Moreover, many interaction behaviours and user experience problems have been responded through the use of these guidelines. For instance, usability studies about one solution were conducted and the results were written in "MalariaScope's User Interface Usability Tests: Results Comparison Between European and African Users". Giesteira et al. [10] described the experimental procedure and compared the results from usability tests between European and African participants. Furthermore, questionnaires using a Likert scale have been conducted in Maputo, the capital of Mozambique. The questionnaires were performed in order to collect feedback from Mozambican users regarding the integration of guidelines in Epidemiologic Surveillance.

### 3.2. Mobile for citizens and mGovernment solutions

The Mobile for Citizens and mGovernment area explores specific user requirements for the successful development and implementation of eGovernment applications and services, investigates success factors and user requirements that could provide information for the development of mobile government user interfaces able to simplify, and streamlines the interaction between citizens and national authorities, with a particular focus on citizens residing in rural or remote areas. These characteristics are embedded in the mGovernment solution developed at the ICT4D Competence Center.

IZIDoc is an mGovernment solution specially designed to make citizens' life easier by enabling them to access information about every kind of document, receive real-time updates about the status of requested documents, and save time by avoiding unnecessary visits to the service provider facilities.


Figure 8 User Profile


Figure 9 State of the student card

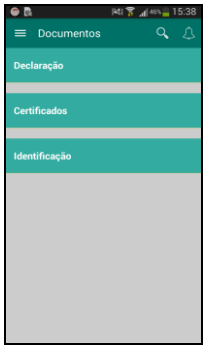


Figure 10 Document Selection

#### 3.2.1 Users with the inability to read take significantly longer to complete tasks that demand a degree of textual literacy

Individuals unable to read take significantly longer to complete certain tasks requiring a degree of textual literacy, such as filling a form. During a recruitment process in India, illiterate individuals took six times longer to recruit than literate people [3]. Furthermore, illiterate individuals are dependent on other individuals able to complete textual tasks with little to no effort. This dependency entitled "proximate literacy" is common in developing countries [4]. These behaviours were considered during the development of this mGovernment solution in order to assure a better user experience and an easier integration of the user.

#### 3.2.2 The involvement of illiterate users is particularly challenging compared with literate individuals

Illiterate users tend to display more challenges than literate ones, mostly due to having no faith in technology, presenting difficulties in understanding abstract questions, not being used to being tested, having little or no self-confidence, and feeling like they were not clever enough to use the technology and prefer to observe and learn [9] [17] [22] [28] [31]. Consequently, this guideline was an important indicator regarding the usability and user experience of the solution, and once the application is deployed on a national scale, this guideline has to improve in terms of scalability, reliability and practicality.

#### 3.2.3 Oral cultures organize and transmit information in a different manner compared to literate cultures

The knowledge derived from oral-based cultures is not stored but rather kept alive through continual verbal, extempore performance and as a consequence, knowledge becomes dynamic, fluid, and continuously evolving through creative channels [29]. The approach on knowledge by oral based cultures is rendered differently on distinct occasions and the socio-political characteristics influence the content of the information [29]. Since the solution will target oral based cultures in remote areas, the content in the application needs to be adapted to context, use dynamic language and convey the socio-political values of the population. Therefore, fieldwork prior to the implementation is a necessity as well.

#### 3.2.4 Information needs to be rooted in common experience with specific examples

Researchers must describe information in a familiar form to the cultural group. Abstract concepts and descriptions are not effective and ideally, new information should be conveyed in terms of cultural memes and preferably using the oral formula of the culture [29]. The oral formula of the culture should be left to the local members of the culture such as local storytellers [29]. Once again, fieldwork prior to implementation is fundamental and the collaboration with local individuals is intrinsic. The solution in question attempts to eliminate abstract concepts and descriptions in order to ease the comprehension of oral based people.

#### 3.2.5 Involve local undergraduates in fieldwork during research

The involvement of local undergraduates in the fieldwork research is optimal due to providing familiarity with the local languages, cultural norms and systems. Additionally, the involvement of undergraduates builds rapport with community partners, overcomes barriers and increases the comfort in the learning process of the users [15]. Prior to IZIDoc being deployed on a national scale, the use of local undergraduates in the fieldwork is being equated due to providing the benefits mentioned above. Besides the use of these guidelines to enhance user experience and ease the interaction of the user with the solution, System Usability Scale questionnaires will be handed in Mozambique in order to evaluate the usability of the system.

### 3.3. ICT Solutions for Very Small Enterprises (VSEs)

The ICT4D Competence Center is also concerned with ICT for Very Small Enterprises. This research area focuses on increasing productivity and efficiency levels for very small enterprises, mainly through the development of mobile ICT solutions addressed to the needs of workers and entrepreneurs, namely by helping them to manage their resources, finances and customer relations more efficiently.

OurMoz is a solution whose mission is to provide an opportunity as a crowdsourcing platform to gather and share contributions from a large local community in real-time. Additionally, registered users can provide and comment geotagged facts and occurrences, while unregistered citizens can see information about what happens in the neighbourhood. Even though the referred solution in included in the area of Very Small Enterprises, the application also has characteristics associated with the mGovernment area.


Figure 11 List of occurrences


Figure 12 Page specific to an occurrence


Figure 13 Add a new occurrence

#### 3.3.1 Illiterate users are subjected to major barriers in mobile usage

A significant number of researchers have stated the major barriers that illiterate users encounter when interacting with mobile devices. Illiterate users have difficulties in features requiring text edit, creating text messages, saving and creating text messages, and using the address book [4] [9] [12]. Additionally, largely textual interfaces present psychological and literary barriers to semi-literate users [1]. During the development stages of OurMoz, these difficulties were equated and the solution aims to decrease the amount of barriers telated to mobile usage.

#### 3.3.2 Researchers should realize orality includes linguistic and 'extra-linguistic' acts, such as gesture, movement, crafts and performance

Oral traditions are not just linguistic acts but also 'extra-linguistic' acts and African traditions clearly demonstrate the value of these 'extra-linguistic' acts through the use of their own narrative forms and functions for vocal imagery [2]. The solution is intended to spread into a national scale and once it does, research about the 'extra-linguistic' acts associated with the oral traditions must be performed. It is important for researchers to know that oral based traditional hold cultural material and therefore, the acts associates with these traditions, including gestures and movement, should be properly studied.

#### 3.3.3 Oral people give more importance to the source of information than literate people

Individuals from oral societies perceive information as social and traceable to one person and therefore, it is common for them to question social characteristics of the people involved in a narrative because oral based people are interested in understanding the characters in contextual value [29]. Furthermore, the source of information has a greater level of emphasis in oral societies. When the solution reaches the entirety of the nation, it needs to evaluate the value that the source of information holds in the areas where oral traditions thrive.

#### 3.3.4 Illiterates and semi-literates have different requirements

Regarding the interface design of an ICT solution, a substantial amount of research has been conducted pertaining to the requirements necessary according to the literacy level of the user. For instance, text-based user interfaces can cause anxiety on low literacy users [21] and if the application is targeted for fully illiterate users, minimal text should appear in the interface [8]. Researchers should also be careful not to treat every user as illiterate because of the negative impact on the potential benefits of text for semi-literate users [32]. Furthermore, audio or graphical augmentation accompanied by text has been shown to reinforce the reading skills of semi-literates [8] [32], assist the literate helpers helping the low-literate individuals [16], and improve literacy [14]. Since the solution ranges a wide array of users with different levels of literacy, requirements such as the ones above mentioned must be followed. Regarding OurMoz, the users of the solutions can be separated into three groups, namely the common citizen, the fiscal agent and the supervisor of the fiscal agent. For each group, different requirements have been assessed and followed.

#### 3.3.5 Participatory Design should act as an instrument towards social change

The participation of the users in the design process is fundamental for the sustainability of the project but also to promote social change, particularly in the developing regions. Consequently, the users in the design projects can utilize the ICT solution as a form to promote change through communication and language channels [18]. In other words, besides the practical value, reliability and sustainability the solution must support, it should also advocate for social, political and economical change. Once the solution reaches a significant amount of the population, our intent is for the solution and the users interacting with the application to promote and advocate for better quality of life.

The guidelines chosen for this solution intended to incorporate the different types of users interacting with it, but also promote better standards of life in developing regions. There was also a concern regarding whether the system was usable or unusable, and therefore, System Usability Scale questionnaires where conducted in Mozambique.

### 3.4. mAgriculture Solutions

mAgriculture is the research area concerned with the improvement of the economic environment related to agricultural production. The research area aims to enhance efficiency, optimize production and boost the economic

development of a region. The ICT4D Competence Center has been developing a mAgriculture solution able to create a low cost mechanism for mobile monitoring of hydroponic environment. The system permits farmers to receive notification on any deviations from the parameters desired for optimal plant growth.


Figure 14 Select a Zone

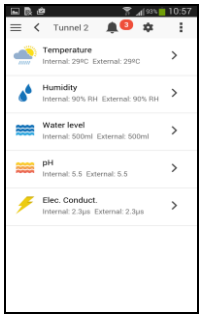


Figure 15 Select element(s) the solution is able to control

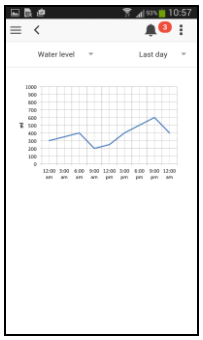


Figure 16 Visualize activity of an element

### 3.4.1 A large portion of the applications created for developing regions are likely to be used in distracting environments

It is not uncommon for ICT solutions in developing nations to be used in public and noisy locations, which presents difficulties to the concentration of the user. Therefore, researchers have to pay attention to contextual cues in the navigation, such as providing contextual information to remind the users where they are once they get distracted. The Assistive Environment for Hydroponic Farming (AE4HF) solution is going to be used in distracting environments and consequently, the researchers must devise techniques able to assist the user once distraction ensues.

### 3.4.2 Graphics are good for information output

Graphics are able to communicate across languages due to the ability to understand the content of pictures. Visual comprehension requires minimal active learning and is acquired since childhood due to everyday interactions with the outside world [24]. Despite the danger of ambiguity and confusion about what the images convey, the graphical symbols hold large amounts of non-linguistic information [5]. The solution replaces textual cues with graphical symbols due to being able to communicate across languages. Since the application is targeted for South African nationals, which has 11 official languages, the use of graphical symbols appeared to be optimal.

### 3.4.3 Do not use icons on their own

Icons should be accompanied by textual descriptions in order to be more comprehensible [4] [17]. An icon should never be used to express meaning by itself, and the ideal format consists in a visual/ audio text captioning [19]. Additionally, graphical icons with voice feedback appear to be the most effective solution to enhance the comprehensibility of users [32]. The solution does not employ the use of icons with voice feedback, but this form of communication is being pondered for future developments. The current version only utilizes graphical icons accompanied by textual descriptions because no comprehension issues were encountered so far.

### 3.4.4 Indicate that icons can be selected

At times, users unfamiliar with computers do not know that icons are selectable and consequently, the aesthetics and behaviour of the icon must be altered when selected or hovered over to assist the users [32]. The icons used in Assistive Environment for Hydroponic Farming (AE4HF) were based in this guideline, and when certain icons are selected, the appearance of the same changes as a form to notify the user that the icon was pressed.

### 3.4.5 Designing appropriate and relevant solutions to local problems should consist in leveraging the stakeholder's inherent expertise

The researchers should always listen to the participants' thoughts and opinions [30]. Interviews were conducted with the owners of Hydroponic farms in South Africa as a way to determine the functionalities that the solution should have, as well as the preferred method for displaying information. The thoughts and opinions of the participants are intrinsic for designing relevant solutions for the target users.

Despite being the only mAgriculture solution in development at the ICT4D Competence Center, the application has been subjected to an intensive evaluation. Interviews with the owners were conducted on numerous occasions, hydroponic farms have been visited a couple of times, and on that purpose, Giesteira et al. wrote an article entitled "ICT4D HCI Guidelines: A study for Developing Countries". Even though the article provides an overview of the ICT4D Competence Center, the mAgriculture solution is described and the results regarding the usability of the system were registered [9].

## 3.5. Transversal Guidelines

Despite the substantial differences between the solutions and the ICT areas associated, a certain number of guidelines are transversal and should always be equated when devising solutions for nations in developing nations. This section demonstrates five guidelines that must always be respected when developing ICT4D solutions.

### 3.5.1 Learning about the community in advance

One guideline evident in the five solutions developed by the ICT4D Competence Center elaborates on the importance of learning about the community in advance. As Dearden [6] states, proper homework and groundwork needs to be done prior to entering the field, meaning the researcher is obligated to have a fair knowledge of the area and the work of the community. The existence of previous research demonstrates that the researchers were concerned about the effects of the solutions and they cared about the community, which promotes trust. Furthermore, this guideline promotes the sustainability since the beginning of the project. For instance, prior to developing Assistive Environment for Hydroponic Farming (AE4HF), interviews were conducted with the farmers in order to understand certain methods, behaviours and processes involved in hydroponic farming.

### 3.5.2 Usefulness and relevance is essential to the acceptance and adoption of interactive systems in developing countries

Other guideline encountered in every ICT4D solution is the notion that usefulness and relevance are essential factors to the acceptance and adoption of interactive systems in developing countries. An example from literary review comes from StoryBank, a project where Matt Jones and other researchers [13] describe the relevance and usefulness that the system has in impoverished communities, because it allows people from those areas to participate in the user-generated content revolution. OurMoz provides the same functions depict by Jones and the other researchers to the users of Mozambique. The use of the application allows them to become integral members of the community and improves the quality of life.

### 3.5.3 Demonstrate the benefits of using the technology to the users

A third guideline shared in common between the five solutions is the need to demonstrate to the user the benefits of using the technology. In “Full-Context Videos for First Time, Non-Literate PC Users”, Medhi and Toyama [23] depict a scenario in which India illiterates saw no motivation to interact with computers because they believed the devices had no relevant information. The authors claim mistrust and lack of motivation is a classic example of the gap between the familiar route to acquire information and the unfamiliar high-technological solution. Therefore, researchers have to demonstrate the benefits of technological solutions. Regarding the solutions devised in the ICT4D Competence Center, both mHealth solutions, MalariaScope and Epidemiologic Surveillance, provide advantages to the users such as the presence of medical access in remote areas and the fact that rural individuals do not need to travel to large urban areas, and these must be demonstrated to the users in order to develop a trusting bond between the users and the applications.

### 3.5.4 Devise solutions inspired by the users

Devising solutions inspired by the users is another guideline evidenced in the entirety of the solutions developed at the ICT4D Competence Center. The guideline derives from the work made by Lalji and Good [17], where they document that the user’s mobile experience can be improved by withdrawing inspirations from the abilities, everyday practices and workarounds of the user. The mGovernment solution IZIDoc is the epitome of this guideline because the creation of the application originated from the need to simplify administrative acts that require personal attendance at the facilities of service providers, including administrative centres and police stations, and the concern of optimizing customer service in Mozambican territory.

### 3.5.5 Plan for everything to take longer than expected

Additionally, the researchers have to plan for everything to take longer than expected regardless of the ICT4D area or the developing country. Brewer and other researchers [3] indicate that time dilation is expected which often causes frustrations given the limited time. Despite the fact that the authors refer to time in the field, the same can be said for the development of the application. The solutions at the ICT4D Competence Center are subjected to constant delays and time extensions due to cultural discrepancies including different notion of time, but also communication problems, inexperience regarding technical and experimental approaches, and difficulties with the programming languages utilized, namely Java, XML and PHP.

## 4. TIQSI, AN ETHNOGRAPHIC PLATFORM

Documenting and systematizing guidelines is important in order to deliver usable interfaces to the users, but the usability of a system cannot be supported only by previous research. As a form to extract new guidelines, an ethnographic platform for internal use was developed at the ICT4D Competence Center. The need to discover new guidelines appeared because culture and human nature are constantly changing and consequently, certain guidelines will become obsolete while others will have a more prominent role.

TIQSI, an ethnographic platform, attempts to solve common issues discovered at the ICT4D Competence Center, including the cultural misconceptions developed by the researchers and the aesthetic values associated with a culture. On short, the platform aims to inspire, contextualize researchers and generate new guidelines by allowing the research to interact with cultural material from different region.

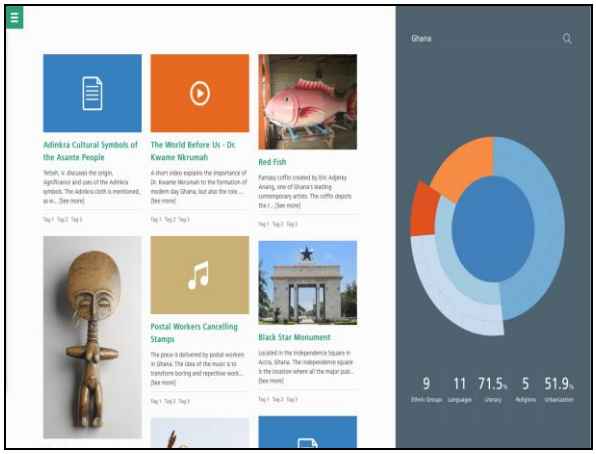


Figure 17 TIQSI with the interactive navigation menu

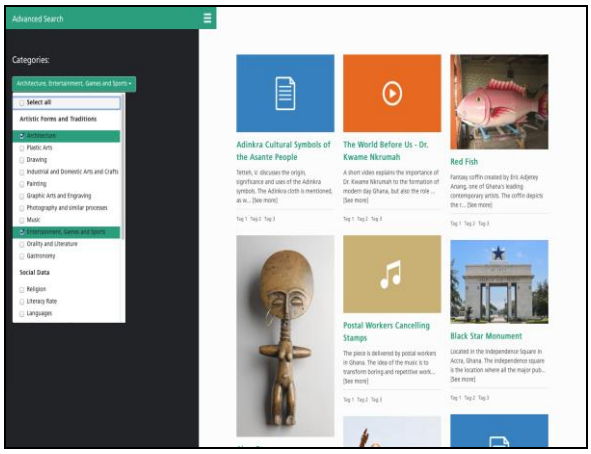


Figure 18 TIQSI with the traditional navigation menu

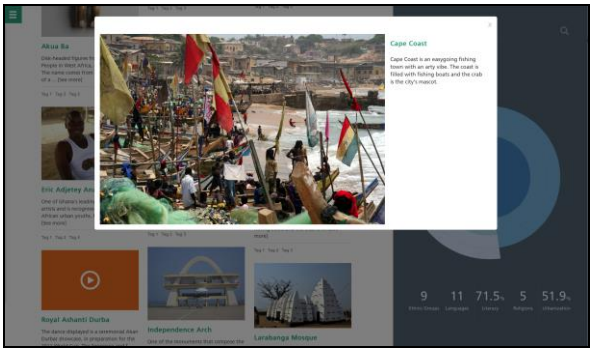


Figure 19 Close-up of a cultural artefact

The conceptualization of the platform originated from a noticeable cultural misconnection between the researchers and the users. At times, researchers were not able to create usable and easy to use solutions due to cultural differences in terms of values, customs and habits. The mission of the platform is to enhance the competences involved in the HCI4D area and the fields of Design, Development and Human-Computer Interaction by articulating different sensibilities and skills that consolidate innovation, creative spirit and collective emotional intelligence in the ICT4D context.

The development of the platform was not an easy task considering the amount of cultural material available to inform the researchers. A refinement process preceded the development of the platform. The first step was to create a taxonomic system for the platform. The taxonomic system derived from a significant amount of references, namely books, museum websites and research papers, and curators were consulted. Two of the most important resources to create the taxonomic system and the subsequent Information Architecture were the Universal Decimal Classification, a faceted classification conceived by Paul Otlet and Henri La Fontaine, and the Art & Life in Africa website from the University of Iowa Museum of Art. Culture is difficult to define and even more complicated to classify. Consequently, the taxonomic system was subjected to numerous iterations and alterations. The taxonomic system derived from extensive research of documentation aimed to categorize cultural and artistic forms. A holistic point of view and multidisciplinary approach were fundamental for the creation of the taxonomic system.

After developing a taxonomic system, the information architecture of the platform was designed. The three main areas of the Information Architecture are the protocols, the FAQs and the country. The information was organized in a geographical manner and the identifiable element was the country. The country was composed by three categories entitled *Artistic Forms and Traditions*, *Social Data* and *Shared Values*. The *Artistic Forms and Traditions* categorized the artistic content of a country within eleven fields:

- 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.

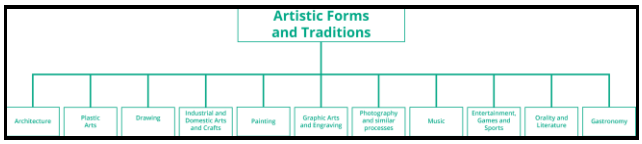


Figure 20 Information Architecture pertaining to Artistic Forms and Traditions

Tags were created for each one of the fields inside the *Artistic Forms and Traditions*. These are intended to further specify the type of artistic form. For example, the following tags subdivide the architecture field:

- Buildings and architecture in general,
- Secular architecture,
- Sacred Architecture,
- Buildings for Educational, Scientific and Cultural purposes,
- Residential Architecture

The *Social Data* field is concerned with significant statistical and visual data regarding demographic and socio-economical aspects of a country. Demographic aspects such as religion, education, language, urbanization rate, immigration rate and ethnic distribution have a significant impact in the population and the platform aims to provide an overview of the demographic aspects of a country to the researchers. The socio-economical aspects focus on characteristics referent to the population, including active population, unemployment rate and sector distribution. The socio-economical aspects field also covers the role of entertainment, games and sports within a country. For instance, Nollywood and cinema in general is the dominant form of Nigerian popular culture. For researchers, this information is particular important because new guidelines regarding the use of video in user interfaces for Nigerian users can derive from these cultural artefacts.

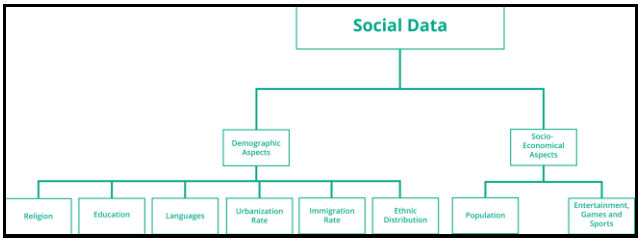


Figure 21 Information Architecture of the Social Data field

The third field categorizing the country is *Shared Values*, which is divided by rural life, urban life, prominent people, and legends and mythology. This field was developed as a form to identify unique elements shared between individuals in the country. For example, the political boundaries of the Sub-Saharan nations are not delimited according to cultural identity and therefore, the cultural disparity inside a country can be high. The cultural differences originate distinct points of view, which generate conflict between cultural groups, social classes and even religious organizations. This field aims to discover similarities across a country, rather than focusing on the differences.

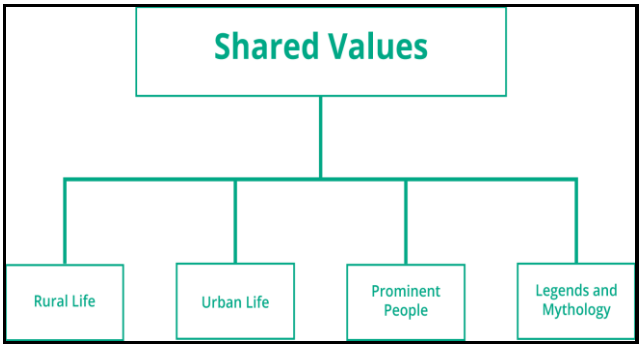


Figure 22 Information Architecture of the Shared Values field

The current version of TIQSI only provides information pertaining to African countries but the concept is to display information about any country in the world. Additionally, a data collection application developed at the ICT4D Competence Center that utilizes an ethnographic gamification process will be integrated into the platform, resulting in the creation of new guidelines specified to a particular country.

## 5. CONCLUSIONS

The ICT4D Competence Center permits the researchers to work in the field within different areas of mobile solutions. The work performed at the center has assisted researchers in specifying which guidelines are indicated for which area of research. The systematization of guidelines is intrinsic for the development of usable and intuitive solutions for developing countries and the aggregation of guidelines help researchers to design solutions faster and in a more efficient manner. More importantly, the work derives from partnerships with institutions located in developing countries, which assists in certain tasks such as fieldwork evaluation.

Equally as important as the documentation of guidelines is the generation of new ones, because culture is constantly changing and the guidelines must adapt to these changes. Therefore, TIQSI, an ethnographic platform was conceived in order to familiarize researchers with the context of the users, but also to inspire them to answer common problems with new solutions. In the near future, the platform will integrate Okavango, a data collection application utilizing a gamification approach, and the results extracted from the application will be incorporated into the ethnographic platform. This symbiotic process will enable the generation of new guidelines, but also prove or refute certain guidelines considered valid at the moment.

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## APPENDIX: HCI GUIDELINES FOR DEVELOPING COUNTRIES

The document compiled by the researchers at Fraunhofer AICOS can be found online in the following link: http://ict4dcc.fraunhofer.pt/papers/ANNEX_HCI_Guidelines_for_Developing_Countries.pdf .

In order to access the document "HCI Guidelines for Developing Countries", the following information is required for login purposes:

**Password**: IJMU_HCI4D_Guidelines