ICT4D HCI Guidelines: A study for Developing Countries

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Abstract

This paper presents a set of research-based Human-Computer Interaction (HCI) guidelines for developing countries. The proposed guidelines were developed under the umbrella of the Fraunhofer AICOS (FhP) ICT4D Competence Center (ICT4DCC). The ICT4DCC follows a collaborative model known as 'Interface Institute' and aims to develop ICT solutions through partnerships between scientific and industry institutions from Europe and developing African countries. By exploiting this collaborative environment, we aim to validate and refine the guidelines by applying them in products targeted at developing countries users. To this end, two of the ICT4DCC partners, the Nelson Mandela MetropolitanUniversity (NMMU) and Eduardo Mondlane University Informatics (CIUEM) are collaborating on the design and development of a mobile application for hydroponic farming following a User-Centered Design (UCD) approach. Insights from a usability evaluation of a functional prototype conducted with the intended users in South Africa were used to validated the guidelines. Further more, highlights on how the model implemented by the ICT4DCC can be a privileged medium to better serve the potential users through the implementation of these guidelines.

Keywords
ICT4D, ICT, HCI, HCI4D, Guidelines, Developing Countries, Interface Institutes

Steyn, J., Van Greunen, D. (Eds). (2014). ICTs for inclusive communities in developing societies. Proceedings of the 8th International Development Informatics Association Conference, held in Port Elizabeth, South Africa.
ISBN: 978-0-620-63498-4 Pages 189-205

Introduction

Designers and developers from the developed world tasked with creating products for developing countries users face multiple challenges. One of the major hurdles is the difficulty for people living in the developed world to gain an accurate understanding about the user profiles of the people from developing countries, due to a gap between mental model frames of reference and experience with technology (Toyama, 2010) (Smith et al., 2004).

The lack of adequate knowledge about the needs of the users and the context of use can result in detrimental outcomes, such as the lack of acceptance of the product by the intended audience (Toyama, 2010) (Lalji and Good, 2008) (Poole, 2013).

The use of guidelines to inform and inspect design decisions can help close the gap when access to the end users is not possible (Scandurra et al., 2013). In this regard, the guidelines act as design directions serving to inform the designing of the products in order to delivery products that are useful, usable and providing a positive user experience. However, literature is scarce regarding guidelines specific for the development of products meant for use in developing countries in the scope of Human-Computer Interaction for Development (HCI4D).

While the use of guidelines might be adequate when there is an ample research about the target population, the literature is scarce regarding guidelines specific for the development of products meant for use in developing countries. Moreover, even if such guidelines are developed, the lack of access to the users makes it difficult to properly assess their validity.

In this paper, we aim to contribute to solving these problems, firstly, by presenting a set of research-based Human-Computer Interaction (HCI) guidelines for designing products meant for use in developing countries and, secondly, by describing the theoretical Interface Institute collaborative model of the ICT4D Competence Center, through which European and African academic and industry institutions partner to develop technological products that serve local demands.

Regarding the structure of this paper, the first section lists a set of research-based HCI guidelines for developing countries. The following section describes the 'Interface Institutes' model and how it is being applied in the ICT4D Competence Center. In section 3, we present the insights from a usability evaluation of a mobile application prototype conducted on-site by South African researchers that illustrates the UCD approach followed by the ICT4DCC interface institute model on the HCI and User Experience (UX) research areas. Finally, section 4 presents the conclusions and plans for future work.

Research-based HCI Guidelines for developing countries

In this section we present a set of research-based HCI guidelines for developing countries with the goal to inform designers and developers in order to achieve suitable, usable and preferred products for audiences in developing countries, and therefore increase their acceptance and a long-term positive UX.

The guidelines were developed after an extensive literature review on the fields of ICT4D, HCI4D and UX. Each guideline was derived from at least one published piece of literature.

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The literature and studies that support the guidelines were conducted in multiple countries, mainly from Africa and Asia and focus on the main barrier that can be found in those regions, including illiteracy or low literacy (both textual and technological), lack of adequate mental models and understanding of established interaction metaphors, and language and dialect barriers. Therefore, most of the guidelines are aimed at helping illetrate and semi-literate users in the developing countires.

The guidelines are classified under four major areas: Interface Design (Text, Graphics, and Voice and Audio), Device Manipulation, Navigation and Information Architecture, and Content.

Due to space constraints, we'll only present an abbreviated set. The full set of guidelines can be obtained from the authors.

Interface design

Text

- **Minimize reliance on text**

For illiterate users, minimal text should appear in the interface (Findlater et al., 2009). Full operation of the system should be possible without text (e.g., voice input and output) (Huenerfauth, 2002).

- **Do not remove all text from the interface**

The interface should not be completely text-free. Even when not understood, textual content in the interface can be memorized and recognized as visual patterns by illiterate users (Joshi et al., 2008). Moreover, text in the interface is helpful for the more literate users that often assist the illiterate in tasks that require reading or writing skills (Knoche and Huang, 2012).

- **Complement text with other modalities**

Text has been shown to be beneficial to semi-literate users, for example, by reinforcing their reading skills, motivate learning and improve literacy. Thus, augmenting text with other modalities is recommended (Cuendet et al., 2013). A multimodal interface might cater for users of all literacy levels (Gavaza, 2012).

Graphics

- **Use culturally relevant icons**

Effective icons should relate to the culture and common experience of the user base, referencing concepts in their lives. Icons should be memorable, nameable, and concrete so that users can discuss them with each other (Huenerfauth, 2002).

- **Prefer realistic cartoons for representing pictorial content**

Semi-abstract, realistic, cartoon representations are preferred and understood more accurately by illiterate and semi-literate users than abstract simple graphics (Medhi et al., 2007a). Hand-drawn cartoons also better than photorealistic representations (Medhi et al., 2007b).

- **Use motion to visually identify actions**

When used to identify actions, visual elements should indicate motion (e.g., water running from a faucet, steam puffing out of a kettle). Otherwise, illiterate and semi-literate users associate

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the drawings with objects or locations (e.g., kitchen), instead of the action (e.g., cooking) (Medhi et al., 2007a).

- **Icon should be accompanied by captions**

Icons should not be used on their own, so a form of visual/audio text captioning should always be available (Huenerfauth, 2002). Graphical icons with voice annotation generally help users in speed of comprehension (Medhi et al., 2006).

Voice and audio

- **Voice content should be provided in the local language and accent**

Providing the content in the local language and accent is a critical success factor in the developing world (Botha et al., 2012). If the user group encompasses multiple languages and dialects, a multi-lingual system might be needed (Sherwani et al., 2009a).

- **Help should be always available**

In addition to providing training on using the voice interface, which can make a significant difference in regard to its usability (Sherwani et al., 2009a), help (e.g., an audio assistant) should be continuously available (Lalji and Good, 2008).

- **Oral information should be short and simple**

Information presented orally needs to be short. Low literate and literate users find it hard to hear long passages of text with the purpose of extracting small nuggets of information. The speech content can be made more conducive for hearing by simplifying sentence structures and replacing difficult words with easier phrases (Sherwani et al., 2009a).

- **Audio feedback should be provided on-demand**

The user should be able to request (e.g., through a button) that the entire contents of the screen, as well as any specific screen element, piece of text, or item, be read aloud (Huenerfauth, 2002).

- **High speech recognition is crucial**

High recognition accuracy is a necessary condition for the success of a speech system (Sherwani et al., 2009a). The voice user interface design and the capability and readiness of the speech technology are the differentiating factors for UX in any mobile speech application (Botha et al., 2012).

Device manipulation

- **Avoid complex interaction styles**

Multi-function buttons, soft keys, over-cluttered buttons and double-tap interaction have been shown to cause problems to low-literacy users.

Navigation and Information Architecture

- **Use linear navigation**

Linear navigation structures are quicker to understand than branched, hierarchical structures for low-literacy users (Medhi et al., 2010).

- **Encourage interface exploration**

Interface exploration should be encouraged to allow users to familiarize themselves with the system's capabilities and overcome technophobia. Some strategies to achieve this include

providing reassuring and encouraging feedback, provide a 'undo' function and always asking for confirmation before fatal operations (Huenerfauth, 2002).

- **Keep the screens simple and limit the number of tasks**

The screens of the application should be kept simple and the number of tasks possible at one time (and the ways to accomplish them) should be minimal (Medhi et al., 2006) (Prasad et al., 2008).

- **Avoid scrollbars**

Scrollbars should be avoided, as it has been shown that they are not well understood by low-literate users (Prasad et al., 2008) (Medhi et al., 2011).

- **Use real-life metaphors to explain foreign concepts**

The lack of textual literacy is often accompanied by low or inexistent technology literacy. Explaining foreign concepts to low-literacy users might be achieved by using real-life metaphors relevant to their context (Medhi et al., 2006).

Content

- **Use familiar language**

The language and terminology used by the system must be one with which users are comfortable with. The choice of words and phrasing must be given as much thought as the development of the visual interface (Lalji and Good, 2008). Even when users cannot fully read the text displayed, using their local language gives them a greater sense of familiarity.

The ICT4DCC Model

Despite the booming of mobile ICT market in most developing countries, there have been few success inthe development and adoption of ICT products especially in those. The reason for such high failures has been mainly because the developers of the products meant for use in the developing countries lack an understanding of the target users. In this regard the ICT4DCC proposes a theoretical Interface Institutes model.

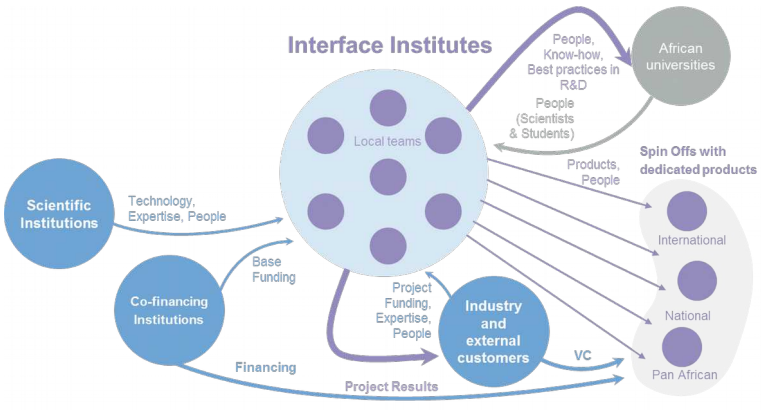

Figure 1 - Interface Institutes Operational Model

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The Interface institutes model is a collaboration approach that aim to facilitate the establishment of innovation ecosystems in order to promote the remote creation of ICT products that serve the demands of the local people and fosters the acceptance of products by the target users.

The Interface Institutes is a model that foresees teams from international organizations working together in order to create specific solutions that are address the needs of local users. The operational model of Interface Institutes aims to promote joint knowledge sharing between the remote and local teams working on a project in order to develop products that will have a positive impact contributing to socio-economic growth of the local regions where the outcomes of the project are deployed. This model promises to be a relevant approach towards the development of usable and useful products in scenarios where there is scarsity of literature to provide guidelines on the profiles and requirements of the target users.

Having the Interface Institute model as a reference, the ICT4DCC,gathers a team of international experts working with international partners from scientific institutions and industry to identify and develop pre-commercial ICT solutions with local relevance for developing countries.The ICT4DCC partners include the German Fraunhofer Fokus Institute, the Portuguese FhP AICOS Institute, the Mozambican CIUEM, and the South African NMMU.

Several projects have already been selected to be sponsored and executed under the ICT4DCC and deployed in developing countries. Both in Mozambique and South Africa, local partners have been providing local resources and expertise to different projects tasks.

In Mozambique, partners from the CIUEM recently conducted an usability evaluation for a mHealth application, MalariaScope (Rosado et al., 2014). The results from the evaluation indicated that the application was found to be usable and satisfactory by a sample representative of the intended audience.

After a successful experience with the MalariaScope project in Mozambique, the ICT4DCC is now working in the same collaboration model with NMMU.

Researchers from the NMMU are collaborating with counterparts from ICT4DCC to develop a mobile application for hydroponic farming. The *Assistive Environment for Hydroponic Farming* (AEHF) system was selected as an opportunity to validate the proposed guidelines. The hydroponic system is considered to offer socio-economic growth in the South African context and overly in developing countries. The following section presents a description of the *Assistive Environment for Hydroponic Farming* and results from a usability evaluation of a prototype of the application.

Assistive Environment for Hydroponic Farming - AEHF

The *Assistive Environment for Hydroponic Farming* is a product developed by ICT4DCC that consists of an Android app. The primary goal of the AEHF app is to create a low cost mechanism for mobile monitoring of hydroponic farms. Hydroponic farming is a mean of precision agriculture where plants are grown in mineral nutrient solution instead of soil.

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The proposed AEHF app makes it possible for farmers to get to know the conditions in the hydroponic farm without physically visiting the farm, thus saving time and reducing labour intensity while collecting accurate data. The app was design according to the mental models of the users, where a number of greenhouses are grouped into zones and those greenhouses are refered to as tunnels. In the app Greenhouses are refered to as tunnels in order to match the terminology and mental models of the users. Those tunnels were further grouped into zones. The AEHF app is intended to be used by people with precision farming background from developing countries in multiple contexts.

The AEHF app was developed based on the proposed HCI guidelines for developing countries presented earlier. In terms of HCI methods and methodologies, the ICT4DCC follows the recommendations and best practices from the literature and industry. As such, products are developed according a User-Centred Design (UCD) approach. UCD is a broad term that encompasses several design methods sharing the same goal: bringing users into the design process to ensure the product developed meet their needs, demands and desires (Putnam, Kolko, Rose, and Walton, 2009). This involvement of the users in design has been shown to lead to more usable and satisfying products (Abras et al., 2004). While UCD methods are also often used in the developed world, they have added importance when designing for users in developing countries, as their life experiences are likely to be markedly different from those of the designers (Lalji and Good, 2008).

In accordance with the ICT4DCC, a prototype of the AEHF was developed as a collaborative work between FhP AICOS in partnership with a team of researchers based in South Africa, NMMU. The first step in designing AEHF involved an research into the context of hydroponic farming in South Africa. The context of hydroponic farming was examined through a context inquiry study where researchers from NMMU visited two hydroponic farms in Port Elizabeth. The objective of the visit was to gather the requirements for developing the AEHF app. As mentioned earlier, the AEHF is a project under ICT4DCC, thus FhP AICOS and the farm owners contributed with the business requirements of the system. The user requirements were gathered as the researchers interacted with the target users of the AEHF app. The requirements were then consolidated and presented in a user requirements specification document that was shared between the teams. Furthermore, these requirements were prioritised based on the needs of the users and objectives of the ICT4DCC. Thus the objective of the first version of the prototype was to provide the minimal functionality to illustrate the potential usefulness and usability of the app.

The researchers at NMMU went on to design low fidelity prototypes of the app based on the HCI guidelines for developing countries. The low fidelity prototypes were shared with the FhP AICOS team who went on to design high fidelity interactive prototype of the app. The interactive prototype was tested on its potential usefulness and usability by users in the hydroponic farms in South Africa. The evaluation was conducted in South Africa, by local researchers from the NMMU. The use of local researchers can help quickly establish a climate of trust with the users and provide clear feedback to the research team, as well as overcome possible reactions towards foreign researchers, such as hostility, scepticism, indifference, or eagerness to please due to differences in perceived status (Sherwani et al., 2009b) (Toyama, 2010) (Anokwa et al., 2009).

Early involvement of local partners in the usability testing stage allows the results to be incorporated before the product is released (Russo and Boor, 1993) and ensure that the user interface is culturally appropriate, thus enhancing the user experience and increasing its chances of acceptance (Shen et al., 2006).

The usability test of the app is discussed next.

AEHF App usability evaluation

This section describes the usability evaluation of the functional prototype of a mobile application for hydroponic farming. The purpose of this usability evaluation is validate the proposed HCI guidelines for developing ICT products that are meant to be used in developing countries. Through the evaluation we aimed at determining if the app that was developed based on the proposed guidelines will be appealing for the acceptance of the product with a positive user experience. Thus the formative evaluation serves to provide basis on finding the user interface design elements that work well for the users, the appropriate navigation and interaction style also to determine the barriers to a positive user experience of the people through the use of the AEHF app. Throughout the test we seek to observe any errors that occur as the users interact with the application so as identify opportunities to enhance the user interface design and user experience. This way the guidelines will be refined.

The following guidelines were validated of their applicability in this paper: Text; Graphics; Device Manipulation; Navigation and Information Architecture; Content. Guideline Voice and audio and its sub components, have not been considered in the scope of this paper. The reason behind the alienation of validating Voice and audio guidelines is based on the level of the fidelity of the prototype.The AEHF app is a high fidelity prototype to illustrate the visual aspects and expected funtionalty of the proposed system. Secondly, the prototyping tool that was used had limitations of incorporating voice and audio elements.

Methodology

The usability / user experience evaluation for AEHF app was conducted in the real context of use of hydroponic farming. A context inquiry based type of test was conducted. The users were visited in the respective farms and were asked to use the app as they would do on their typical day routine. The aim is to make the testing as real as possible and maintain naturalness of the context of using the app. Also, this way, it was aimed that the sample of users recruited were a true representation of the actual users of the AEHF app. To start the test, the app was launched and the participants were asked to explore the app and make unguided comments on what they think about it. Following this, the participants were asked to complete the four tasks (albeit in a different order), which included common use cases such as general exploration of the app, viewing real data for a specific tunnel, changing the values of parameters in a zone and setting custom preferences. After the test, a System Usability Scale (SUS) survey was administered..

The AEHF app was tested using the following techniques:

- The thinking aloud protocol;
- User observation;
- Video recording;

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- Subjective user comments on the impression of the app;
- Task completion.

Recruitment of the participants

The app is targeted at African users. The screening criteria for the participants was based on the fact that the participant should be knowledgeable about hydroponic farming and also a entry level background knowledge on how to use mobile phones or similar smartphone devices or touch screens. Secondly, the participants had to consent that they are willing and able to undergo a 45 - 60 minutes hands-on evaluation of the AEHF app, during which they will be asked of their qualitative subjective feelings on their interaction with the app.

For this evaluation 6 participants were recruited, comprising of farm managers, supervisors and operators of hydroponic farm equipment. The skills of the users may vary as some farms are highly technologized while others are still operating manually.

Selection of devices

The system was evaluated using Sony Xperia smartphones with the 4.3” WXGA (1280 x 800) screen, in standard colour mode and automatic brightness.. The device was selected specifically because it is both water resistant and dust proof which makes it ideal for the context of use. Smartphone device has been chosen as it has been observed during the farm visit that most of the farmer will be carrying their phones while they are doing other tasks around the farm. Thus a Smartphone will be convenient compared to tablet devices because of its size and portability.

Presentation of Results

The performance varied among the six participants. All the participants managed to complete Task 1 without any error. Three participants completed Task 2 successfully; one completed the task with assistance while two failed to complete the task. The average error rate for Task 2 was 0.8 (SD=1.2). The minimum number of errors committed was zero while maximum number of errors was three.

Task 3 was completed by three participants while two participants failed to complete the task and one participant completed with assistance. The average error rate for Task 3 was 2.3 (SD=2.5). The minimum number of error in Task 3 was zero while maximum number of errors was six. In Task 4, three participants completed the tasks successfully while the other three failed. The task had an average error rate of 2.2 (SD=2.2). The minimum number of errors was zero with a maximum of five errors.

The global average satisfaction measured with the SUS scale was 74.2 (SD=16.1). This represents a good, and above the average, score (Bangor et al., 2009).

Participants were probed to comment on the app as they were observed performing the tasks. These tasks were aligned to validate the proposed guidelines. This section presents the findings from user testing based on the qualitative descriptive data that was obtained (Think Aloud Protocol).

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Table 1 presents the comments on the AEHF app from the participiants.

Participant	Comments
P1	The participant managed to identify and relate to zones and tunnels also to explore the tunnels to view the parameters. The three vertical dots for menu was not easily understood by the user. The icon for settings confused the user instead the user suggested the use of spanner icon clearly labelled settings. The layout of the app was found to be “clean, clear and easy to navigate”. It was difficult for the participant to identify the option for configuring parameters both in the tunnel and at zone level. The participant easily noticed the notification icon and commented that it was easy to identify because of the red colour used, it is familiar with other applications that he knows also the number near it makes it easy to know the count of notifications. The term “landing page” was not easily understood but the participant noted that it is important to be able to customise the app to meet their preferences.
P2	The participant commented that grouping of Zones makes it easy to navigate to the various tunnels. The notification “alarm” icon was easily noticed and the participant commented that the colour is good and the number “3” close to the icon shows how many notifications are there. The settings icon was not found to be familiar to this participant. Liked the graphical representation, though the numbers on the horizontal axis are vague and do not mean anything to the participant. The participant found it easy to navigate within the app. The participant commented that colours are not important, what matters most is the functionality of the app. Participant expected to be able to make rectifications to the notifications from the app. What does “water and Electric. Conduct” mean? Participant noted that there is no feedback after changing the settings. It was easy for the participant to navigate from one screen to another. Did not understand “Min and Max” in the configurations screen, the participant interpreted that the screen is showing the maximum and minimum recordings. It was difficult to for the participant to input min and max values on the configurations screen.
P3	Initially the participant assumed that the purpose of the app is to teach him how to farm. The participant managed to identify and understand the groupings of tunnels into zones. Navigation within the app was done with ease by this participant. The participant was familiar with the hamburger menu and there three vertical dots for menus. Participant expected to find an option to save the configurations after making changes to the configurations screen and setting the landing page.

	Elect. Conduct was not understood by the participant. The participant inquired what “water” meant.
P4	The participant kept on looking for menus at the bottom of the app and he kept on swiping from left to right hoping to flip between the various screens in the app. The participant easily noticed the notification icon and on notification listing, the participant liked the confirmation before deleting the notification. The delete icon was well understood by this participant. Liked the hamburger menu and did not struggle to use this feature. The participant failed to change the values on the configurations screen. Initially the participant thought that the feature was to display the minimum and maximum values for the parameters. The term “Landing page” was not understood. The participant indicated that they would want an option that allows then to configure the app and customise their preferences.
P5	The participant suggested that the letters A, B, C, D should indicate irrigation controllers and zones will be assigned to irrigation controllers while tunnels will be assigned to the zones. Water level does not make sense on what it means. Graphical presentation showing the fluctuations in parameters makes it easy to read, however the intervals on the graphs are not labeled and can be hardly understood, there is need of clear labelling of the horizontal axis The use of green colour is good and is associated with vegetation, however the app is inconsistent regarding the use of colour. The colour is only used on the landing page and the rest of the pages look blunt. The participant indicated that he would like to be able to change the names used on the zone names to suit what he wants.
P6	The participant understood the zones and grouping of tunnels with their respective parameters. Setting preferences to desired “Landing page” confused the user, the term landing page was not easily understood. The user did not understand what “Electro. Conduct” means. On the configurations menu, the user misunderstood “Min and Max” to mean the minimum and maximum values recorded by the system After changing configurations the participant expected to find an option to save at the bottom and a confirmation message to say that the setting have been successfully saved. The parameter “water” was found to be confusing and not clear of what it mean. The participant understood the red icon for alerts to mean that there is a warning and the number “3” indicates the number of warnings. Red colour made it easy to notice that something was wrong. The participant easily picked the settings icon and said it similar to other applications that he has used. The placement of the settings icon close to the three dot menu made the screen cluttered.

Table 1. Subjective user comments

Overall, AEHF app was well received by the sampled users. The participants indicated to be happy with the information architecture and the overall layout of the app. The app received good ratings on its perceived ease of use and usefulness and was found to be easy to navigate.

There were, however, some issues that the users' qualitative feedback allowed to unearth. It was found that some users interpreted colour codes differently, did not noticed that some interface elements (such as textual list items) were clickable or failed to understand the meaning of some icons meant. One recurring case was the "Gear" icon, which was not associated with changing configurations. Some users suggested using a spanner icon instead.

There were also problems with lack of feedback after changing some settings. Terms such as "Landing page" and "Elect. Cond." (abbreviation for Electrical Conductivity) were not promptly understood by all users. Some participants suggested the addition of new parameters, while indicating that others - "Water level" – did not make sense. The labelling of the graphical visualizations, the interval used and the lack of readability of the values were subject of some negative feedback.

The participants were observed as they performed the tasks and some observation notes were recorded during the test. Also, video recordings were consulted to further analyse how the participants interacted with the app. Thus, the think aloud comments of the users, task performance observations and video recordings where triangulated and analysed using In vivo coding technique (King, 2009). The guidelines have been used as codes for data analysis. A validation of the guidelines based on the results from the user testing is presented next.

Interface design

Text

- **Minimize reliance on text**
  The AEHF app had very minimal text and the participants commnented that they found the app to be easy and clean to interact with it. Colour differentiation between zones,use of icons made it easy for the users to interact with the app with minimal text.

- **Do not remove all text from the interface**
  The app contained text in form of lables like names of zone, tunnels and parameters and these were well understood by the participants.

- **Complement text with other modalities**
  The use of text was complemented with icons and use of colour. Alerts and notifications were presented with red colour. Colour differentiation between zones that have plants and those without were easily interpreted by the participants. The use of different colours made it possible to get the attention of users even without reading the text. Also, icons that are familiar to the users like, the "bell" for alerts, were easily recognised by the participants without reading text.

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Graphics

- **Use culturally relevant icons**
  Icons like the “delete” and “bell” for alarms were easily understood by the participants. The items are familiar to the users. The use of “gear” icon to represent settings did not match to the mental models of the participants, intead some of those suggested that they are more familiar with the use of “spanner” icon for settings.

- **Prefer realistic cartoons for representing pictorial content**
  This guideline was not implemented in the functional prototype.

- **Use motion to visually identify actions**
  This guideline was not implemented in the functional prototype.

- **Icon should be accompanied by captions**
  The icon for alerts had some texts close to it and it was easily noticed and understood while the “gear” for settings and three dots for menu did not have any captions and some participants failed to recognise them.

Voice and audio

- **Voice content should be provided in the local language and accent**
  This guideline was not implemented in the functional prototype.

- **Help should be always available**
  The guideline was not implemented in the functional prototype. However, the participants would ask to the moderator whenever they got stuck while performing the tasks. This validated the need to have availability of Help as a guideline.

- **Oral information should be short and simple**
  This guideline was not implemented in the functional prototype.

- **Audio feedback should be provided on-demand**
  This guideline was not implemented in the functional prototype.

- **High speech recognition is crucial**
  This guideline was not implemented in the functional prototype.

Device manipulation

- **Avoid complex interaction styles**
  The AEHF app interaction style consist of single tap and sliding the main menu. All the participants found it easy to interact with the app and the mentioned that the app was easy to navigate. Only one participant managed to discover that the menu can be swiped to expand and collapse it. This validated that complex interaction styles should be avoided.

Navigation and Information Architecture

- **Use linear navigation**
  The users found the app to be easy to navigate and it was easy for them to return to previous screen or home screen whenever they felt that they were lost.

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- **Encourage interface exploration**
  The app lacked feedback when the users completed certain tasks like customising the landing page. This left the users wondering if they had done the correct execution. Most users welcomed the confirmation message when they were about to delete notifications. This gave them assurance that the app would prevent them from making mistakes. Lack of feedback and confirmation messages discourages the users from exploring the app with confidence.

- **Keep the screens simple and limit the number of tasks**
  The AEHF app was designed in a way that each screen represented a single task. Other tasks related to the respective screen were provided as links from the active screen. This contributed to the users finding the app to be easy to understand and use with minimal memory load.

- **Avoid scrollbars**
  The participant struggled with the use of scrollbars when they were scrolling down the configurations screen. It was difficult for the participants not to activate the touch areas while they were trying to scroll down the screen.

- **Use real-life metaphors to explain foreign concepts**
  The native “bin” and “bell” icons were used to delete and denote notifications. These were easily associated with the participants as they related to common real life metaphors that are familiar to the participants.

Content

- **Use familiar language**
  Most of the terminology used by the AEHF prototype matched the expectations of the participants. The terms like pH, Temp, Humidity were well understood by the participants. Terms such as “Landing page” and “Elect. Cond.” (Abbreviation for Electrical Conductivity) were not promptly understood by all users while most users found “water” did not make sense. The labelling of the graphical visualizations, the interval used and the lack of readability of the values were subject of some negative feedback. This confirms that the terminology used should be common in the domain in which the application is targeted to be used.

In addition to the proposed guidelines the following have been found to be important to be included:

- **Allow the users to customize and personalize the system**
- **Use of guided text entry**

While being the first iteration of a prototype, the insights about the users’ goals, expectations and mental models that can be extracted from this evaluation would be very difficult to achieve by conducting desktop research and relying on the intuition of designers and developers without access to a real context of use, hence the need for guidelines based on field test with the target users.

Following the philosophy of UCD, these results will be taken into account in the next iteration of the AEHF app prototype, which will likewise be a joint collaborative effort between European and African researchers on the ICT4DCC context. The resulting

prototype will then be tested again with representative South African users in a real setting.

By constantly listening to the feedback from real users the guidelines will be validated and improved on. This expectantly leads to the development of products that are contextually relevant and providing a positive user experience to the target audience.

Conclusions and future work

This paper reveals the challenges faced by designers and developers of ICT products that are meant to be used in geographically remote locations, precisely in the developing countries community. The challenges include a lack of understanding of the profiles of the users, the context in which the ICT products are to be used and the requirements for developing the products that are meant for use in the remote locations. Such challenges can result in the users rejeting the products. The success and acceptance of the products is dependent on how they appeal to the needs and context of the target users.

The paper proposes guidelines that were disseminated from literature. The guidelines serve as design directions to be followed in order to develop products that are meant for use in developing countries.
An interactive prototype of the AEHF app was developed following the proposed guidelines. This prototype was tested with the target users of the app in order to foster the validation of the guidelines.

Future work is focused on further validation of the proposed guidelines in the context of ICT4DCC. The following aspects build avenues for further researching the applicability of the guidelines:

- Application of the guidelines in order to develop ICT products for use in a real-life context;
- A study on impact assessment on the acceptance of products as a result from implementation of the guidelines;
- Conducting multiple case studies in different contexts, using different products and users so as to evaluate the extent to which the guidelines can be generalized;
- Work on the Interface Institutes concept in stages within a longitudinal research projects, so as to evaluate how the model can be implemented;
- Increasing the number of participants for user testing.

Acknowledgments

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

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ISBN: 978-0-620-63498-4 Pages 189-205