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EXPLORING USER EXPERIENCE (UX) FACTORS FOR ICTD SERVICES

A Dissertation Submitted In Fulfilment of the Requirements for the Degree of

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IN

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By

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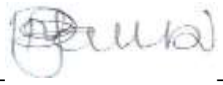
Declaration

I, Pride Bongiwe Nyambi hereby declare that the contents of this dissertation are my own work and that this dissertation has not previously been submitted for full or partial fulfilment of the requirements for an equivalent or higher qualification at any other educational institution. All sources referred to have been duly acknowledged. Furthermore, the contents of this dissertation represent my own opinions and not those of the University of Fort Hare and the sponsors.

Signed_____  _____

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Abstract

Consistent with global entities such as the United Nations- through the World Summit of the Information Society (WSIS), introduction of Information and Communication Technology (ICT) for human development has seen the introduction of ICT-based services aimed at facilitating socio-economic development of marginalized communities. The use of ICTs has always solicited the concept of Human Computer Interaction (HCI), which involves the methods which humans interact with technology. The types of User Interfaces (UIs) and interaction techniques that people use to interact with ICTs affects the way they perceive technology and eventually, their acceptance of the technology. Current ICT systems still haven't adopted the concept of placing the user at the core of the interaction. Users are still required to adapt themselves to the interface's characteristics; which limits the number of people who can use the system due to inabilities to adapt to the interface. As a result, the information embedded in these technologies is still inaccessible and useless to Marginalized Rural Area (MRA) users. Such usability challenges can be mitigated against and avoided by matching UI components with the users' mental models, language, preferences, needs and other socio-cultural artefacts.

In this research, literature in Human-Computer Interaction (HCI) is reviewed with emphasis on the usability and User Experience (UX) during user interaction with ICTs using various modes of interactions. HCI emphasizes the need for systems to take account of user's characteristics such as their abilities, needs, socio-cultural experiences, behaviours and interests. In efforts to meet the requirement of UX, the user, system and the context of use, need to be evaluated, taking into consideration that changing one entity modifies the UX. This will be achieved by persona profiling to determine the key characteristics of the user communities, clustered according to the key UX attributes. Subsequently, through detailed usability evaluations, including the use of System Usability Scale (SUS) to determine user satisfaction with various UI components/techniques per identified persona- thus providing and persona mapping for usability of Information and Communication Technology for Development (ICTD) services.

The results from this research are reflective of the importance of creating personas for usability testing. Some of the personas do not have a problem with interacting with most of the interfaces but their choice of interface comes from a preference point of view. For some personas, their skills and level of experience with ICTs motivates their choice of interface.

The common UI component that users from across the spectrum appreciate is UI consistency which makes interaction easier and more natural. Common obstacles with current User Interfaces (UIs) that inhibit users from MRAs include the hefty use of text in interfaces, unintuitive navigation structures and the use of a foreign language. Differences in UIs from different application developers present an inconsistency which challenges the users from rural areas. These differences include the layout, the text entry methods and the form of output produced. A solution to this has been identified from the usability test as the use of speech-enabled interfaces in a language that can be understood by the target audience. In addition, through literature study it has been found that UX of interfaces can be improved by the use of less textual or text-free interfaces. Based on literature, users from MRAs can benefit from using hand-writing based UIs for text-based entry which mimics pen and paper environment for literate users who have experience with writing. Finally, the use of numbered options can assist illiterate users in tasks that requires users to choose options and for navigation. Therefore, consistency in UIs designed to be used by MRA users can improve usability of these interfaces and thus, improving the overall UX.

Keywords: User Experience, User interface, Usability, ICTD, ICT, MRA, Persona, Interaction techniques, Human-Computer Interaction, Metaphors

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Dedication

With gratitude, I dedicate this dissertation to the three women of honour and beauty, my mother (Sinah Manzini), my aunt (Zodwa Phakedi) and my grandmother (Lizzy Mashele).

Acronyms

3D	3-Dimensional
AR	Action Research
ASR	Automatic Speech Recognition
DTMF	Dual Tone Multi-Frequency
EAR	Ethnographic Action Research
GUI	Graphical User Interface
HCI	Human-Computer Interaction
ICT	Information and Communication Technology
ICT4D /ICTD	Information and Communication Technology for Development
IDV	Individualism Index
IVR	Interactive Voice Response
MAS	Masculinity Index
MOPTAM	Mobile Technology Acceptance Model
MRA	Marginalized Rural Area
NFC	Near Field Communication
PD	Power Distance
RFID	Radio Frequency Identity
RuTAM	Rural Technology Acceptance Model
SD	Standard Deviation
SLL	Siyakhula Living Lab
SUS	System Usability Scale
TAM	Technology Acceptance Model

TTS	Text-To-Speech
UAI	Individualism Index
UI	User Interface
UX	User Experience
VoIP	Voice Over Internet Protocol
VUI	Voice User Interface
WIMP	Windows, Icons, Mice and Pull-down menus

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1 INTRODUCTION

1.1 Introduction

Information and Communication Technologies (ICTs) have become the most important tools for information dissemination. In the case of Marginalized Rural Areas (MRAs), Information and Communication Technologies for Development (ICTD) services have been introduced, designed and deployed to improve the rural livelihoods. This research seeks to explore the factors that affect User Experience (UX) when users from the MRAs interact with ICTs. This chapter in particular introduces UX as a concept and how it relates to the use of ICTD services. The rest of the chapter is structured as follows: literature on the research background and context, description of the problem statement and the research motivation. Subsequently, the research questions and research objectives are discussed. The research paradigm provides an outline of the research questions and objectives together with a mapping to the relevant chapters and the methodologies used to address them. Finally, this chapter is concluded with the discussion of project deliverables and the outline of the dissertation.

1.2 Research Background and Context

The introduction of ICTD in rural communities targets applying Information Technology (IT) approaches to poverty alleviation, thereby improving socio-economic conditions of these communities. A statement released by World Bank Group in 2011 states that ICTD focuses on creating an enabling environment for knowledge economy and supporting strategies for building the African digital economy (Mundial, 2011). The idea of ICTD is for development of disadvantaged communities, aimed at bridging the economic and digital divide through promoting access to modern technologies. The relevance of ICTD as a means of poverty reduction has been questioned as to whether the poor need “bread or computers” several times because of the high costs of maintenance of ICT services. From the 1990s, computers and the Internet have made possible new ways of communication and of enabling development, largely through the introduction of community access centres known as Telecenters (Weigel & Waldburger, 2004).

Heeks (2007) maintains that the 'D' in ICT4D is dominant and is less techno-centric; it draws influences from sociology, governance and management, technology and economics.

In addition, Heeks (2009) argues that proper implementation of ICT4D strategies should involve the incorporation of the three approaches to be applied to address the needs of the poor. These are:

- Inclusive – aiming at improving services and opportunities
- Enabling – aimed at supporting the context of use
- Focused – aimed at targeting needs, interest and rights of the poor.

There have been several efforts made to support largely illiterate and poor people in developing countries in the use of ICTs. These include basic computer skills training programmes, development of software applications and incorporation of relevant services with easy-to-use and accessible User Interfaces (UIs). The aim of these software applications is to present information to low-literacy users in an interface that they can easily understand and interact with. To date, there are online services aimed at bridging the economic divide and enabling economic development.

These services include government services, education, commerce and health services which are referred to using the prefix –e because they are accessible electronically. In addition there are some available Internet services including: web browsing, emails, social networking, banking and insurance services. The introduction of e-services aims at alleviating the costs of travelling long distances for acquisition of basic services including buying electricity, government inquiries, and general trading. One of the most important factors for enabling effective use of these services is through the development of usable interfaces and effective interaction techniques. By providing useful e-services socio-economic needs of rural communities can be addressed. These ICT programmes increase the effectiveness and efficiency of organizations by providing cost-effective and faster services especially to rural communities. In most rural areas the availability of ICTs is mostly limited to feature phones and sometimes basic Internet connectivity can be accessed in schools. Consequently, affordability and accessibility of the proposed services for development is still limited. However, introduction of such services in the mobile platform can help leverage these challenges since users can access them anywhere and at any time.

All the efforts for rural development are nullified by technology solutions that are not accessible and usable to the users, in terms of being aligned with their cultural context and being intuitive to the users. This is why this research aims at investigating factors of UX that

affect rural users. UX is concerned with how the user sees the system when they come into contact with it, rather than the internal workings of the product (Garrett, 2011). ISO 9241-210 defines UX as involving users' emotion, beliefs, perceptions, physical and psychological responses, preferences, behaviours and accomplishments that occur before, during and after the product use (ISO, 2009). UX is influenced by the system, users and context. Personal preferences on the UI and user interaction techniques differ according to UX, cognitive and perceptual capabilities, physical abilities and cultural background (Shneiderman, 1998). Also, suitable interaction techniques are the essential part of UX because they determine the usability and effectiveness of ICT4D initiatives. This requires matching the technologies to local realities and aligning them with local development goals. This means, that the interaction techniques should be paralleled and subject to the participation of local users.

This research was conducted in Dwesa, a rural area situated in the wild coast of the former homeland of Transkei, in the Eastern Cape Province of South Africa under the Mbhashe Municipality. The socio-economic status and infrastructure in this community is limited and little development exists in the area. As a consequence there is a limit in job opportunities leading to more than 90% of unemployment (Pade et al., 2009). This area is mostly populated by the elderly and children under the age of 17 years old as a result of lack of opportunities. In addition, females make up the majority of the population since the males migrate to the urbanized areas for work to provide for their families. Most of the people in this area rely on social grants, pension and support from members of their families in urbanized areas (Pade et al., 2009). Other forms of making a living include farming and crafting. In Dwesa, there is a high level of: illiteracy, alcohol abuse and poor government services.

An ICTD project has been implemented in this marginalized area, the Siyakhula Living Lab (SLL), which provides Internet services to the community and also serves as a platform for the design, testing and deployment of ICT projects to support the community with ICT services for social and economic improvement and better rural livelihood (Dalvit et al., 2007). This project equips the local people with technical skills in the field of e-commerce (Pade-Khene et al. 2010). Some of the e-Service projects which have been developed and deployed to support the already existing ICT infrastructures include the e-Commerce platform, e-Judiciary service, e-Health and e-Government portal (Scott et al., 2008; Jakachira et al., 2008; Njenje, 2008; Hlungulu & Thinyane, 2009). Even with all these

projects deployed in this area, they are still not realizing their full potential and benefit to the community because the community members are still faced with a challenge of illiteracy and language barrier because these services are typically accessed through English textual interfaces (Mhlana, 2011). Most people in Dwesa can only communicate in their native language, IsiXhosa, which is one of the 11 official languages in South Africa with little or no exposure to English. This project seeks to find a balance between technology and ICTD services to be used by users from all walks of life in a manner that maximizes UX.

1.3 Problem Statement

Referring to UX in the ICT context always raises the question of interfacing and interaction. In marginalized communities where a majority of the population is either old or illiterate, the populations are affected by their socio-cultural experiences which do not match those required to interact with current UIs. This situation presents usability problems to such a user population. Therefore, proposing a suitable interface for people from rural communities presents a challenge because most of the current technologies do not conform to their socio-cultural experiences. Aspects of this include challenges due to illiteracy and interaction with a system that has an interface designed in a language different to their home language, for instance becomes difficult. Also, an aspect of this is finding an interface that caters for the diverse users with different capabilities that is suitable for their environment. The key problem statement in this research is therefore that:

There is currently a lack of UX implementation framework/guidelines/process map to guide ICTD services deployment in marginalized rural areas.

1.4 Motivation

Today, poverty is no longer measured by the amount of money only, but in terms of access to knowledge. Human activities are highly based on information and since rural communities are striving for economic emancipation it is still difficult for them to reach stability because of lack of knowledge embedded into technology sources such as the Internet. Therefore, access to this information and knowledge embedded in technology help with lowering the poverty and illiteracy state of some of the rural areas residents. The information embedded in technology might as well be useless if the users do not know how to use it, that is why UX exploration is important to ensure that the products and services

available are usable to the communities. These services can help the communities in acquiring and sending information to relevant stakeholders like the government and conducting businesses online. Hence, ICT is the most appropriate tool for information dissemination with the use of interaction modelling which deals with assisting users in accomplishing goals from a domain.

1.5 Research Questions

This research seeks to answer several questions considering factors such as the types of users, the context of use, the types of activities the users need to perform and the system they use. The questions to be answered are:

Q1. What are the UX factors that affect the use of ICTD services?
Q2. Who are the users of ICTD services?
Q3. What user interfaces and user interaction techniques are available?
Q4. Which UI and interaction techniques best suits the profiled users?

1.6 Research Objectives

The main objective of this research is to propose a UX implementation guideline/framework that is suitable for the targeted Marginalized Rural Areas (MRA) users. Through realizing the people's capabilities and experiences to increase the usability of ICTs, thereby improving UX. Implementing the UX framework will require addressing the following sub-objectives:

O1. Understanding and profiling of factors that affect UX in ICTD/MRAs
O2. Profiling of the users based on the identified UX factors
O3. Identify UIs and user interaction techniques
O4. Propose/come up with recommendation for UX/HCI in ICTD

1.7 Research Paradigm

Table 1.1 indicates the research methods that have been used to answer the research questions and the corresponding objectives.

Table 1.1: Research Paradigm

Research Question	Research Objective	Methodology	Chapter
Q1. What are the UX factors that affect the use of ICTD services?	O1. Understanding and profiling of factors that affect UX in ICTD/MRAs	Literature review	3
Q2. Who are the users of ICTD services?	O2. Profiling of the users based on the identified UX factors	Literature review Surveys User observation Usability testing	3, 4 Appendix A 5
Q3. What user interfaces and user interaction techniques are available?	O3. Identify user interfaces and user interaction techniques	Literature review	3
Q4. Which UI and interaction techniques best suits the profiled users?	O4. Propose/come up with recommendation for UX/HCI in ICTD	Usability testing Surveys	5, 6 Appendix A

1.8 Research Deliverables

The project seeks to answer the identified research questions and fulfil the specified objectives with the main deliverables emanating from the research being:

- Recommendations on UI design for MRA users
- Well-defined personas (detailed profiling of the users)
- Documentation of the user needs and preferences as far as UIs and interaction techniques.

1.9 Outline of the Dissertation

The remaining chapters of the dissertation are structured as follows:

- **CHAPTER 2: RESEARCH DESIGN**

This chapter structures the rest of the dissertation through the presentation of the research design. The research design discusses the approaches, methodologies and data collection

methods. In addition, the methods used for selecting participants and the ethical precautions taken into consideration are discussed.

- **CHAPTER 3: LITERATURE REVIEW**

In this chapter, selective literature on the UX as a field in Human-Computer Interaction (HCI) is presented. Literature on UX, its factors and how it relates to usability are reviewed in this chapter. Detailed discussions of the types of UI's and interaction techniques including the definition and elucidation of multimodality will be presented. A discussion on UI involves the concept of metaphors, their benefits, disadvantages and the different types of metaphors that exist.

- **CHAPTER 4: USING PERSONAS FOR USER PROFILING**

This chapter presents the literature on using personas for user profile. This includes discussions the purpose of personas, their benefits and how they are developed. Since user characteristics and behaviours are affected by their socio-cultural environments, this chapter discusses the effects of culture on user interaction with ICTs. In addition, the dimensions of cultural diversity are discussed. The chapter is concluded with the attributes of culture that affect user interaction with ICTs.

- **CHAPTER 5: UX EVALUATION AND PERSONA MAPPING**

This chapter uses the information presented in Chapter 2 on data collection methods and the profiled users (Chapter 4) to map personas to different usability tasks that were provided to evaluate UX. In addition, the usability tests used to identify personas within the research area are presented. This chapter also presents the results obtained from the usability tests used to evaluate UX.

- **CHAPTER 6: DISCUSSION AND RECOMMENDATIONS**

This chapter presents the discussion of the results and the observations made during usability testing, subsequently discussing the recommendations. Finally, the formulation of the UX framework/guidelines is discussed.

- **CHAPTER 7: CONCLUSION**

This chapter concludes the research dissertation by providing the research contributions, the limitations and proposed future work. The discussion of how each of the research questions were answered, resulting in addressing the research objectives is provided. Finally, overall conclusions of the research are presented in this chapter.

1.10 Conclusion

Technology advances every day and with benefits such as self-education and communication, ICTs are by far the most productive and connective tools. Given that most rural areas do not have a foothold in the revolution that ICTs are ushering in because of poverty and lack of skills. It is therefore going to be beneficial if the technologies already deployed in the rural communities have interfaces that are accessible and can be used by everyone, to ensure acceptance of the technology. UX factors such as enjoy-ability and understand-ability are the most crucial in identifying how the users perceive the technology. ICTs used in MRAs require special efforts and attention to create appropriate models for people who cannot afford Internet access nor have the language capabilities to understand the content. Most importantly, there is a need for applications that are both socially and economically useful to ensure acceptance of the technology.

This chapter introduced the concept of UX in relation to the use of ICTD services. It discussed the statement of the problem and the motivation of the research. Furthermore, the research questions this research seeks to answer and the research objectives it seeks to address were discussed. Subsequently, the research deliverables were presented. The introduction chapter provided the research paradigm which summarizes how the research questions are answered, how the objectives are addressed and finally discussing the methodology used to achieve the results. Finally, the dissertation outline was provided. In the next chapter a detailing of the research design is provided.

2 RESEARCH DESIGN

2.1 Introduction

The research design is a sequence which logically associates the empirical data to the original research questions and conclusions (Bless et al., 2006). Accordingly aligned to the ultimate research objective, there must be appropriate research methodologies, approaches and analysis techniques built around the research questions. The main aim of the research design is to accomplish the main objective of the research which is to *propose a UX implementation guide/framework suitable for MRA users*. This research used the research onion adapted from (Saunders et al., 2009) to define all approaches and methods used to address the main objective. The methods used in data collection and data analysis are discussed in Section 2.4. The discussion on how participants were selected for this research is provided. In addition, the ethical considerations and protocols applied are also discussed. The role of the researcher was that of an observer to enable interpretation of the social environment's contextual situation and technology.

2.2 The Research Onion

The research onion is divided into 5 stages and in each stage more than one method can be used. The stages are as follows: philosophies; approaches; strategies; choices; time horizons; techniques and procedures as presented in Figure 2.1 (Saunders et al., 2009).

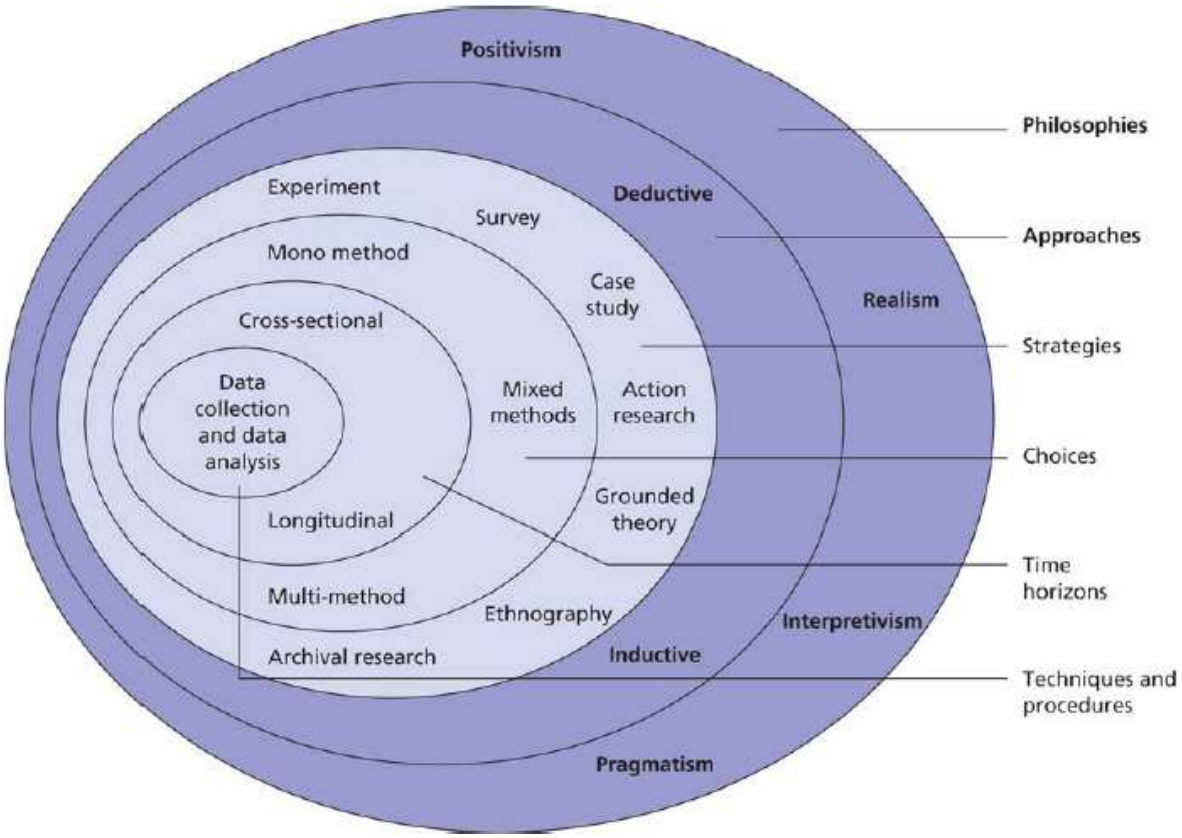

Figure 2.1: The Research Onion (Saunders et al., 2009)

2.2.1 The Philosophies

- Positivism

For this research project, a positivist approach was adopted since work on observable social reality formed a major part of the research (Bless et al., 2006). According to French philosopher August Comte, the best way to understand human behaviour is through observation, experience of senses and reason (Comte, 1988). Through observation and experimentation true knowledge can be obtained. The philosophy of positivism is based on the concept that the research can be objective, the researcher is independent of the research, and the results are reliable, valid and can be generalized (Hallebone & Priest, 2009). In addition, it seeks to ensure rationality and logic in the research process as a result it eliminates subjectivity from the research (Hallebone & Priest, 2009). Furthermore, Hallebone & Priest (2009) describe the positivistic philosophy as seeking to institute descriptive principles in an environment that exist independent of the observer. To evaluate

the factors that affect UX for ICTD services, the researcher used survey and data analysis to provide the unbiased recommendations.

- Interpretivism

This type of philosophy emphasizes the use of the empirical approach and it is constructed by observation of phenomena and the description of people's beliefs, reasons, values, intentions and meaning (Jones, 2000). Furthermore, Jones (2000) claims that an interpretivistic philosophy does not make use of numbers and statistical tests to describe social factors; instead, it can be subjectively described by what the researcher observes. In a nutshell, interpretivism suggests that the way people behave is determined by their surroundings. Chapter 3 and Chapter 4 of this research was constructed using the interpretivism approach through the use of literature review, surveys (questionnaires and informal interviews) and observation.

- Pragmatism

A pragmatism approach places the research question as the most important determinant of the direction of the research (see Section 1.5). To be precise, the type of questions the research is said to answer determines the method that is used in carrying out the research (Saunders et al., 2009).

2.2.2 The Strategies

Ethnography, surveys and action research were used in this research. This Section describes all three strategies in a complementary manner. In Cultural anthropology, a book authored by Harris & Johnson (2000) defines ethnography as: "a written description of a particular culture - the customs, beliefs, and behaviour - based on information collected through fieldwork". Its focal point is on social interactions, perceptions and behaviours including languages and practices that occur within certain groups, organizations and communities (Lazar et al., 2010). It provides an insight into real-life everyday patterns and can be used to identify unmet user needs. In addition, it provides insight as to the motivations behind actions and views of people along with the nature (e.g. sights and sounds) of the location they live in through observations, documentation and interviews. This method of research involves users in every step of the study and includes on-site visits, interviews, participatory

design, observations and user evaluations to determine the usability level of the system (Figure 2.2).

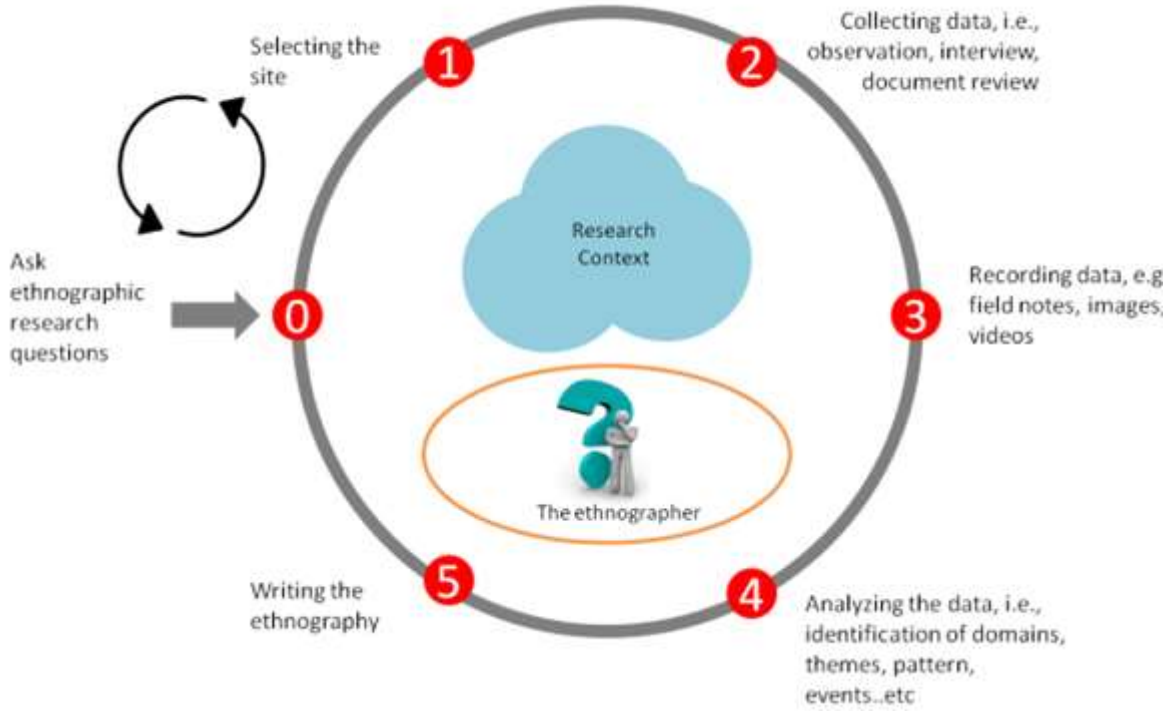

Figure 2.2: The Ethnographic Research Cycle (Aqeel & Campbell, 2012)

Forlizzi & Ford (2000) reason that the most effective way to get information about UX is to use diaries, surveys and storytelling. This is because stories are an easier way to remember and communicate experiences. When the users are not aware or cannot express their experience in words, observation becomes useful as it enables gathering UX from non-verbal expressions of users (Forlizzi & Ford, 2000).

The kind of ethnographic research method undertaken for this project is Ethnographic Action Research (EAR) which is described by Tacchi (2004) as designed to "focus on the actual use of and interaction with, technologies in the wider context of people's lives and social and cultural structures". This method draws both from action research which entails inquiry that involves engagement and goal-directed change and ethnographic research (Avison et al., 1999). Similar to ethnographic research, EAR involves a lot of listening to the users, observing them during task performances and analysing field notes. EAR is made up of: broad research that helps in understanding the wider society including its cultural, social

and technological structures in which projects work; and more directed research focused on understanding a particular issue or a set of predefined set of issues (Tacchi, 2004). The former has been used in this research project to help formulate a framework for MRA.

2.2.3 Choices

Mixed methods were used for this research. Mixed methods are defined by Johnson et al. (2007) as "the type of research in which a researcher or team of researchers combines elements of qualitative and quantitative research approaches (e.g. use of qualitative and quantitative viewpoints, data collection, analysis, inference techniques) for the purposes of breath and depth of understanding and corroboration". Where qualitative and quantitative methods are incompatible, multiple methods can be used, meaning that both qualitative and quantitative methods can be combined complementarily. Since the information acquired from literature review, surveys and observations were complementary to the usability tests used in quantitative approach. The methods and techniques used in this research are discussed in the following sub-sections.

2.2.4 Time Horizons

A research time horizon can either be cross-sectional or longitudinal. This study used the cross-sectional time horizon because user information was only needed at one point of the entire research period. Cross-sectional studies require the collection of evidence be done once during the course of the entire study (Cooper & Schindler, 2006).

2.2.5 Techniques and procedures

The relevance of collected data to the research questions is largely influenced by theoretical perspectives, research strategy and the researchers' understanding (Bless et al., 2006). In addition, data analysis can be sensibly approached firstly with a deductive approach then an inductive approach especially in mixed methods. An inductive approach requires the researcher to start with collecting data, analyze it then make recommendations and conclude (Gabriel, 2013). It is usually associated with qualitative methods. In contrast, a deductive approach requires the researcher to start a research with a social theory, such a hypothesis to

test data implications. It is usually associated with quantitative methods (Gabriel, 2013). This study used both the deductive and inductive approaches to address the sub objectives which resulted in addressing the main objective.

2.3 Selection of Participants for the Study

This study was conducted in Dwesa, a rural area where some members of the community are enrolled for basic computer training at SLL. The SLL students in Ngwane Junior Secondary School and Bade Senior Secondary school formed part of the participants together with community members who are not enrolled for computer training. The SLL students assisted with referring different people who are not enrolled in computer training who fitted the described participants that were required. The study divided the participants needed according to three age groups (16- 30 years old; 31-50 years old and 51 years+). In each of the age groups, two people of both genders were selected representing the illiterate and literate participants. In total, 10 participants were selected for the first round of task analysis which was aimed at identifying personas. This was because no illiterate people were found in the 16-30 years age group.

Communication was in IsiXhosa, the local language since English is viewed as a colonial language by most of the community members especially the elderly. The participants were open to answer any personal questions including their level of literacy and education, some even stating why they left school or could not receive an education. Because of lack of industrial or any government establishments, the participants were mostly school teachers, domestic workers, self-employed, gardeners, weavers and some unemployed. Therefore, most of them can only afford basic functionality phones since smart phones are expensive.

2.4 Data Collection Method

The most important factor to consider when designing interfaces for ICT applications and services for MRA users is their cultural experiences which influence the users' behaviour and motivation which in turn influences their interactions with technology (Shen et al., 2009). It has already been discussed that this research is dependent on ethnographical methods, which are context aware. Therefore, the different types of data collection techniques used in this research regarded the context of use. These include the primary data

such as interviews, questionnaires, observations and task analysis. Additional data was obtained from online resources such as Google, Google Scholar, online academic database and textbooks. A summary of the methods used for this research in addressing its objectives are presented in Table 2.1: Research Methods.

Table 2.1: Research Methods

Research focus	Search through	Source	Keywords
UI and interaction techniques	Textbooks, UI websites, online search (Google, Google scholar, academic databases).	Relevant scientific papers, reports, thesis, white papers, blogs	User interface, Interaction in HCI, user interface design, user interaction techniques, interaction quality, interface layout
Personas	Textbooks, online search (Google, Google scholar, academic databases), surveys and observations	Usability blogs, Relevant scientific papers, reports, thesis, white papers, community members	ICTD users, personas, users of ICTs, classifying users, user engagement, user profile
UX attributes	Textbooks, online search (Google, Google scholar, academic databases)	Relevant scientific papers, reports, thesis, white papers, blogs	User experience, UX, UX in HCI, usability and user experience, user experience in usability, UX in ICTD services, UX in rural context

As shown in Table 2.1, data collection methods varied according to the objective that the method sought to address. In this research, both empirical and non-empirical approaches were used; the non-empirical approach was used in shaping the empirical approach. Saunders et al., (2009) sustains that non-empirical research should consist of pre-existing body of knowledge which would act as a source of reference for research previously conducted and the body of theory which refers the chosen subject area. The non-empirical

approach in this research consisted of the literature review. The empirical approach consisted of the qualitative data gathered through observation and usability evaluations.

In this research visits to Dwesa constituted the empirical research which enabled the researcher to gain experience of the social setting and observe of the participants in their everyday environment. Rajasekar et al., (2006) defines qualitative research as being exploratory, non-numerical, descriptive, using words and applies reasoning. Outputs of qualitative research focus on interpreting social meanings obtained from interviews, surveys, observation and literature study. The results of quantitative research are numerical and are often represented in tables and graphs (Rajasekar et al., 2006). The quantitative data was obtained through usability tests involving the three measures of usability, i.e. the time and number of steps; number of errors and satisfaction.

2.4.1 Type of Ethnographic approaches

2.4.1.1 Surveys

An interview is a qualitative method that effectively determines users' wants, needs and the problems they encounter when interacting with systems (Rogers et al., 2011). Interviews are said to be adaptable because they offer the opportunity for the interviewer to follow up their thoughts, ideas and feelings driving their responses in a way that a questionnaire, for example cannot capture (Rogers et al., 2011). Interviews were used as follow ups to participants' reactions and emotions after usability tests. Questionnaires were handed out to various members of the community to help determine the type of users that are available within the ICTD context. Their advantage over interviews is that they reach a wider audience.

To accommodate MRA users; it is indispensible to identify their needs by directly involving them through interviews, questionnaires and observations. Since the qualitative data acquired through literature review provided information about which interaction techniques are available, it was therefore necessary to evaluate their usability using each of the identified personas. A questionnaire-centric survey was used to collect information about user demographic (including age, gender, and educational background) information, ICT ownership and satisfaction with the systems they were interacting with. To ensure that participants did not feel inadequate when answering questions from the questionnaires, the

questionnaires used a close-ended structure. This ensured that even the uneducated participants could answer the questions. Unstructured interviews were also used to collect information about participants' experience with technology and work background. Information from the survey was used to construct personas, formulate the UX framework and validate information obtained from the review of literature. The aim of the survey was to address the objectives of this research, stated as:

O1. Understanding and profiling of factors that affect UX in ICTD/MRAs
O2. Profiling of the users based on the identified UX factors
O3. Identify user interfaces and user interaction techniques
O4. Propose/come up with recommendation for UX/HCI in ICTD

The questionnaire (Appendix A) for the survey was divided into the following sections:

- Section A, Personal information
- Section B, Technical background

Section A is used to profile the users that exist within the MRA context (objective O2) based on the identified UX factors from literature review. Objective O1 and O3 were addressed through literature review. Section A required the user to provide personal information which included age, gender and literacy information. The age of the participants was an important mapping factor which was used as a constant for identifying users. The gender was also included as per literature review to evaluate if it affects interaction with ICT. Finally, the participant's literacy was significant in determining the impact of literacy to UX.

Section B was focused on the technical experience and use of technology by the participants. The first question was used to determine the mobile ownership which was important for identifying the types of services and applications that are used by the participants. In order to determine if ownership of other ICTs improved UX, Section B also included questions on ownership of other forms of ICTs.

Usability evaluations are essentially used to determine effectiveness, efficiency and satisfaction. Satisfaction is the subjective metric of usability which can be quantified using the System Usability Scale (SUS). Satisfaction was the last metric to be quantified to measure user satisfaction with the system or UI they were interacting with. The SUS is made up of 10 items which is divided into positively worded (odd-numbered) and negatively

worded items (even-numbered) (Brooke 1996). The SUS analyses two factors of the system, the usability (8 items) and the learnability of a system (2 items). The SUS uses the 5-point Likert scale which ranges from 1 (“Strongly disagree”) to 5 (“Strongly agree”) to quantify user satisfaction (see Appendix B). Brooke (1996) emphasizes that “SUS yields a single number representing a composite measure of the overall usability of the system being studied. Note that scores for individual items are not meaningful on their own”. In this research, the results obtained from the SUS were used to identify the UIs and interaction techniques that the users were satisfied with. This forms part of addressing objective O4.

2.4.1.2 Observation

The first day of the community visit was meant for introduction, this was done so that the participants would feel comfortable during observation. When observation are being carried out, the first few days might affect the way participants perform their activities due to the presence of an observer. User observations were performed during field visits to Dwesa, both as a researcher (observer) and a computer literacy trainer. The role of the researcher as an observer was to record information about how users interact with technology and also provide information about the surrounding environment. When the researcher took the role of the literacy trainer, this assisted in information about the learning patterns of the users that were enrolled in SLL. As a result of being a familiar face, the SLL students assisted the researcher with referrals to community members.

This said the views expressed in this study are objective and interpretative of what was observed during the research. These relationships helped with capturing personal experiences and stories that were only attainable in an informal home setting where the participants felt comfortable and in control of their environment. The participants from SLL were mostly closed up and only shared information that was asked in the questionnaires and interviews.

2.4.1.3 User and Environment Analysis

User analysis is the process of interacting with the user to determine their skills and knowledge of the domain being investigated. It helps the designers understand the user in their everyday environment and in turn helps them to design usable systems for the target users. User analysis is effective in determining the user characteristics and capabilities with technology, user needs, and the surrounding environment where the system is used or

deployed (Costabile, 2001). In addition, information such as age distribution, education and cultural disposition can also be determined through ethnographic methods (Johnson et al., 2005). Environmental analysis involves studying the surrounding areas, such as noises and visuals to determine the type of systems that can be deployed in the area. These are mostly influenced by social and cultural settings of the community (Johnson et al. 2005). In this research, user and environment analysis was aided by computer literacy training where learning patterns of participants were identified. Subsequently, data collection and interviews were conducted during user and environment analysis.

2.4.1.4 Task Analysis and Scenarios

User and environment analysis afforded the opportunity for task analysis. System tasks, functions, task capacities, user experience and capabilities as well as interface activities are identified during task analysis. In addition, the accuracy, simplicity and necessity of tasks are also considered. Task analysis aided in identifying user information and task capacities that the users in context can carry out. Task analysis also assisted in the selection of tasks to be used in usability testing of services that MRA users need and use daily. The scenarios were used to decompose tasks into activities describing the elements of the interface needed to perform the activities including the sequence of interactions. These were presented orally to the users, in a step-by-step manner to help the user remember them.

2.4.1.5 Usability Testing

The aim of the usability tests was to formulate the UX framework based on which UIs and interaction techniques are suitable for MRA users. Usability testing is effective for evaluating UX because it includes components that are objective (i.e. efficiency and effectiveness) and subjective (satisfaction). The recommendations provided in literature about the types of UIs and interaction techniques that are suitable for novice users are limited to the urban context. This research focuses on the types of devices which users in MRAs have access to and the tasks that they are likely to perform. The devices used to test for UX included a smartphone with touch interface, a smartphone with a QWERTY keyboard, a feature phone and a Personal Computer (PC). The choice of the devices was based on their ability to accommodate various inputs and output modalities.

The usability tests were divided into two sections in this study. The first section of the usability evaluation was aimed at identifying the personas available in the MRA context.

The second section of usability tests were given to the identified personas to assist in matching users to suitable UIs and interaction techniques. The task used to identify personas was presented as following to the participants: “Go on YouTube and play your favourite song”. This task required the users to access YouTube either through a search engine or directly by typing the web address in the address bar of the web browser.

The second section of usability tests included four tasks which were used to test the usability of different input modes for different interface components. These tasks included the text entry task for sending an email, dialling a random number, checking cell phone airtime balance and web browsing. The tasks were designed to be representative of typical uses of devices and UIs. The time it took to complete a task and the number of steps it took were used to measure efficiency and the number of errors was used to measure effectiveness. Satisfaction was measured using the SUS with a 5-point Likert scale for ranking the level of satisfaction. This was done after completion of each task i.e. sending email, dialling a 15-digit number, checking balance and web browsing. Therefore, there were four SUS forms completed by each participant at the end of the tasks. The participants were given the following task scenarios:

- Send Thabisa the following email on Gmail (www.gmail.com), her email address is thabisas@gmail.com, Subject: Time
  Hi, Thabisa
  We are leaving at 4:30pm tomorrow.
  Regards, Friend.
- Dial the following 15-digit number
- Use Google (www.google.co.za) to search “who was the first president of South Africa”.
- Check how much airtime you have. First check through dialling *111#, then dial 100 and follow the voice prompts.

The difference between the Interactive Voice Response (IVR) and the key-press method for checking balance in the mobile phone is that the key-press method provides the user with a text interface which requires the user to enter the desired choice of action from a list of numbered options. In contrast, checking balance with the IVR provides the numbered options through a speech interface and requires the user to enter the desired choice. The results of the two methods are different in the form of output they produce, i.e. the IVR

produces audio output and the key-press method produces textual output. The key-press and IVR trees are presented in Table 2.2.

Table 2.2: Key-press and IVR Trees for Checking Balance Task

Key-Press Tree	**IVR Tree**
Start: Dial *111# (1) Balance (2) Power Bundles (3) Buy (4) Promotions (5) Talking points (6) Airtime Advances & Transfers (7) Services (8) Entertainment	Start: Dial 100 Welcome to Vodacom's prepaid service, for more info on our prepaid service offerings dial 0821187 free from your cell phone
(1) Summary (2) Detailed (3) Promotional	1. Press 1 to recharge [recharge] 2. Press 2 for a summary of balances [balance] 3. Press 3 for bundle purchases [purchase] 4. Press 4 for your cell phone number [number]
Output: Airtime, voice, data, SMS and Multi-Media Message (MMS) balances	Output: Airtime, voice, data, SMS and MMS balances

The independent variables in the usability tests were the age, gender and the literacy levels of the participants. The dependent variables included the time elapsed, number of steps taken, the number of errors made and the subjective responses from the participants. There were four tasks that were designed to test elements of UI's that are relevant to the use of ICTs in the rural communities. The summary of the tasks, UX components and interaction modes examined from the usability test is presented in Table 2.3.

Table 2.3: Usability Testing Components

Task	Interaction mode	UX component
Send email	QWERTY Touch Swype keyboard Mouse and keyboard	Text entry
	Touch Tab and enter (keyboard) Scroll and click (mouse)	Navigation and selection
	PC Mobile phone	Layout (UI)
Check balance	IVR Key-press	Output presentation between text and IVR Language
Web browsing	VUI Text	Search option
Dial a 15-digit number	Touch QWERTY PC keyboard1 PC keyboard2	Layout

2.5 Ethical Considerations

Due to the ethnographic nature of the research and the fact that some of the methods require participants to provide personal information, ethics approval was required and gained from the University prior to distribution of the survey. The certificate of ethical clearance was granted by the University reference: REC-270710-028-RA Level 1 (see Appendix H). Etherington (2007) emphasizes that ethics involves how researchers should conduct themselves in relation to the people with whom they interact with during their research process. For this research, ethical principles such as respect, confidentiality, accessibility and negotiation were followed. The ethical procedures included reading and explaining (in their native language) what the research was about to all users and that participation is voluntarily. It is important to mention that all names that have been used in Appendix D are pseudonyms. To comply with ethical guidelines the following survey forms were distributed to willing participants:

- A consent form (with information sheet)
- A survey form
- SUS form

2.6 Conclusion

In summary, this chapter used the research onion to define the methods that were used during the research project. The criterion used for selecting participants for the study was discussed in detail. Several types of ethnographic approaches included during this research project were also discussed. Some of the approaches included the use of surveys such as questionnaires and the SUS; observation of users when they are interacting with ICTs and analysis of the user and environment. This chapter was concluded by including ethical issues that were considered. In the next chapter, a detailed literature review on the research area is provided.

3 LITERATURE REVIEW

3.1 Introduction

The literature reviewed in this chapter addresses two of the objectives of this project, objective O1: "*Understanding and profiling of factors that affect UX in ICTD/MRAs"* and objective O3: "*Identify user interfaces and user interaction techniques"*. This discussion includes a background of HCI as a field that UX stems from. It also presents in-depth discussion of usability and how it relates to UX. This chapter also gives an overview of the factors that affects UX and discusses the acceptance of technology highlighting factors that lead to acceptance of a technology in different regions and cultures. In addition, the discussion gives an overview of the types of user interfaces and interaction techniques. Subsequently, different modes of interactions with user interfaces are considered. The metaphors and their use in user interfaces and interaction design are also reviewed.

3.2 Human-Computer Interaction

Hewett et al., (2009) defines HCI as "a discipline concerned with the design, evaluation and implementation of interactive computing systems for human use and with the study of major phenomena surrounding them". These researchers claim that HCI is focused on the combined performance of tasks by humans and machines; the arrangement of communication between human and machine; the method of specification, design and implementation of interfaces and human abilities to use computational machines (as well as learnability of interfaces). This comprehensive HCI definition is illustrated in Figure 3.1, where use and context refers to how the computer is used, for what task and which applications are available. The human field, describe the human characteristics and ergonomics including how user process information, the languages they use as well as how they interact with the system. The computer, is concerned with interaction between human and computer (including the input and output devices used) mechanisms. Finally, the development process includes evaluation of techniques and implementation techniques and tools. HCI focuses on studying the interactions between people and computing technologies as well as the design of practical and intuitive computer systems. Interaction at the interface is the core focus of HCI that emphasizes on placing users in control of the systems they are interacting with.

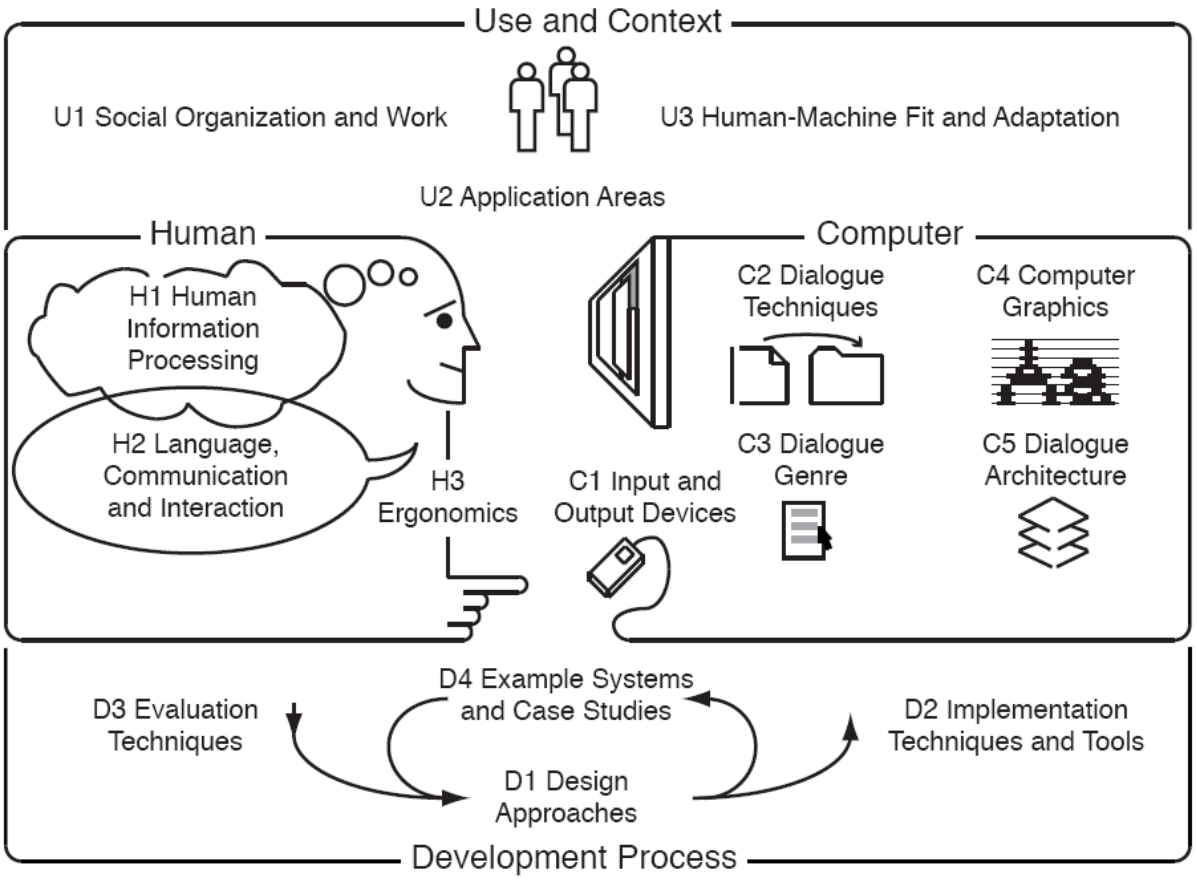

Figure 3.1: Human-Computer Interaction (Hewett et al., 2009)

Stephanidis (2000) also defined HCI but rather as a discipline that is concerned with "the design, implementation and evaluation of those interactive computer-based systems, as well as with the multi-disciplinary study of various issues affecting this interaction". This definition highlights the multi-disciplinary nature of HCI which includes social science, computer science, engineering, artificial intelligence, ergonomics and psychology. HCI's multi-disciplinary nature is mostly fixated on ensuring simplicity, ease-of-use, operability, discoverability, efficiency, learnability, safety, utility, effectiveness, accessibility and usability of a system (Stephanidis, 2000).

According to Norman (2002), HCI is the study of how interaction between human and computer systems happen including user requirements and user models and the applications to the design and evaluation to such system for usefulness, usability and accessibility. He describes HCI as a worthwhile field of study because:

- It introduces the platform within which the psychology of users can be investigated and understood in a realistic environment.
- It offers a context where user-centred design methods can be considered.
- It provides a context where design methods can be evaluated for their efficiency and effectiveness.
- It offers a platform where new theories of users can be developed in real-world environment.

When human interact with the computer, the input that they give to the computer is processed and presented to them as output by the computer and this happens through effector's motor control. The most important senses in HCI are vision, touch and hearing and the primary effectors are the eyes, voice, fingers, head and body positions (Dix et al., 2004).

HCI aims to ease the cognitive load that is linked with interacting with technology. In ubiquitous computing environments, the need for computers to interpret how a message is passed on, and what the context of that message is, is important for successful HCI (Sarroff, 2008). Shechtman & Horowitz (2003) claim that "humans have a strong tendency to respond to computers in similar ways as they do to other humans" therefore computer systems should be adaptable to human language and behaviour. Rick et al., (2013) proposed that usability is the basis of HCI and uses Norman (2002) as backing evidence, where he says, "even everyday objects can be systematically analysed in terms of their usability." The focus of HCI has expanded since its introduction where it focused on individual and basic user behaviour to catering for a wide range of human experiences and activities including social and organizational computing , accessibility for the elderly and for the cognitively and physically diminished (Carroll, 2009).

3.3 Usability

Usability is the ability in human functional terms for ease of use and effectiveness by the specific group of users, given specific training and user support, to achieve specific goals within a specific series of environmental scenarios (Costabile, 2001). Since usability really depends on an individual, Brooke (1996) sums it up as being appropriate to purpose and context in which it is used. With reference to information systems, Bevan et al., (1991)

explains that the effective way to specify usability of a system is through: (a) describing the intended users of the system, (b) the tasks they want to perform in the system and (c) the characteristics of the physical, organisational and social environment in which it is used. The most used definition is from ISO (2009) and Nielsen (1994) stating that usability is the level to which a system, product or service can be used to achieve specific goals by users in an effective, efficient and satisfactory way in a specified context of use. This definition highlights the three attributes of usability (Frøkjær et al., 2000; Jeng, 2005):

- Effectiveness – ensures that users achieve their tasks completely and accurately. It is indicated by quality of solution and error rates. The measure of effectiveness depends on the type of tasks carried out with the system (Brooke, 1996).
- Efficiency – is the relationship between accuracy and completeness with which users achieve their goals and the resources used to achieve them. It is indicated by task completion time and learning time.
- Satisfaction – is users' comfort and positive attitudes towards the use of the system. It is indicated by attitude. Satisfaction motivates acceptability of a system.

In addition to these three components, the following aspects can also be used to measure usability (Nielsen, 1994; Sharp et al., 2007; Stone et al., 2005):

- Learnability – The time and effort it takes to reach a level of performance with the system.
- Memorability – The time and effort it takes to get the users to remember how to interact with the system.
- Flexibility – The system's extent to which it can accommodate changes beyond those specified.
- Safety – The ability of a system to protect and curb dangerous conditions and undesirable conditions.
- Utility – The system's ability to provide proper functionalities that caters for what the user want and need.

The definition provided by Blandford & Buchanan (2003), states that usability defines (a) the efficiency and effectiveness with which users can achieve their goals using a system, (b) time and effort it takes to reach a level of user performance with the system (learnability) (c) the level to which the system helps the user recover or avoid errors (d) the attitude when

interacting with the system (is it enjoyable or frustrating?) and (e) how fitting the system is within the context in which it is used.

The descriptions provided above reflect that usability cannot be constrained into one meaning but it depends on the context of use, goals and the users that are in contact with the system at that particular moment. Hix & Hartson (1993) argue that usability depends on the time spent with the system i.e. the system becomes more usable with familiarity, and they classify usability into: initial performance, learnability, retainability, advanced feature usage, first impression, and long-term user satisfaction. Norman (2002) proposed that usable artefacts must have the following four characteristics: affordances, constraints, good mappings, and feedback. Affordances are the properties that determine how a system can be used i.e. they provide clues so that no instructions are needed. Inversely, constraints limit the use of an object as a means of avoiding usage errors. Good mappings facilitate ease-of-use and are a great transition from the real world to the computing environment. Feedback provides indication of the extent to which a goal was or was not achieved.

There are two categories that Tractinsky (1997) have grouped usability into: inherent usability and apparent usability. Inherent usability include the attributes which focus on making the product easy to understand and learn, efficient to use and pleasurable. In contrast, apparent usability is linked to the aesthetics (visual impressions) of the interface. Thomas & Dviser-Kazlauskas (1998) has proposed a categorization of usability into: outcome, process and task. The outcome group includes main elements of usability i.e. effectiveness, efficiency, and satisfaction. The process group comprises ease of use, interface, learnability, memorability, and error recovery. Finally, the task group comprises functionality and compatibility.

There are guidelines for ensuring good usability ranging from heuristics (high level guidelines) provided by Nielsen (1994) to the more meticulous guidelines proposed by the ISO 9241-11 standard presented in Table 3.1. These usability guidelines aim to provide an application that can be used without causing frustration to the user. They are meant to provide a good UX since a system with poor usability can lead to poor UX (Nielsen, 1994).

Table 3.1: Nielsen's Usability Heuristics (Nielsen 1994)

Guideline	Description
Visibility of system status	The system should users about what is going on within reasonable time
Match between system and the real world	The system should use natural language and use real-world concepts rather than system-orientated terms
User control and freedom	The system should support undo and redo
Consistency and standards	Words, situations or actions should mean the same thing throughout. The system should be consistent in the following aspects: • Visual consistency: the user interface elements should be consistent • Functional consistency: the way a task is carried must be consistent every time • Evolutionary consistency: consistency n software products of the same manufacturer
Error prevention	Prevents errors by eliminating error-prone conditions or provide a confirmation option before user performs an action
Recognition rather than recall	Instructions, objects, actions and options should be visible or easily retrievable
Flexibility and efficiency of use	Allow users to modify frequent actions
Aesthetic and minimalist Design	Only necessary information should be included
Help users recognize, diagnose, and recover from errors	Error message should clearly indicate the problem and suggest a solution
Help and documentation	Provide help information that can be easily located and understood

Mayhew (1999) argues that not many software engineering methodologies effectively address usability since all their focus is on maximum functionality within cost and performance constraints. This argument holds especially when it comes to interface design

because of conflicting goals, such as wanting a powerful functionality yet a simple and clear interface or a flexible system that also provides error handling. Bevan (2001) described usability as having two roles:

- To be part of a detailed software design process
- Ensure that the software meets user needs and this is termed Quality in use.

Quality in use ensures that the software product enables the user to achieve specific goals with effectiveness, satisfaction, productivity and safety in a specific context of use (Bevan, 2001). The quality in use for an end user is determined by functionality, efficiency, reliability and usability in a particular context. While the quality in use for a support user is concerned with maintenance and portability tasks (Bevan, 2001).

To assess usability, the use of scenarios is usually beneficial. Scenarios are important for interface design and usability testing as they note goals and questions to be achieved and provide possible answers and methods of achieving them. In addition, they define the context and stories behind who and why a specific group of users use the system (Go & Carroll, 2003). They describe how a person interacts with a system; therefore helps focus designers' efforts on the user's requirements. They may be related to use cases, however, unlike use cases they can be easily understood by people without any technical background. Scenarios contain actors, their background information and assumptions about their surrounding environment, their goals or objectives and the order of their actions and events (Go & Carroll, 2003). Scenarios preserve real-world flow and contents of the users' dynamic world because they describe incidents that trigger when and whether a task is performed, then followed by an array of steps to completing a task. They are expressed in several media and forms including storyboards, textual narratives, scripted prototypes or video mock-ups (Go & Carroll, 2003). Weidenhaupt et al. (1998) conducted a study on the use of scenarios in 15 real-world projects. They noted that across all these projects, the consistent use of scenarios was to:

- Enable consistent and shared understanding amongst the engineering team
- Make abstract models concrete
- Strengthen interdisciplinary discovery and learning

Some of the key questions that scenarios have to answer include the following:

- Who is the user? – determined from the personas who represent a specific type of users
- Why does the user use the system/ application? – list the motives and expectations of the user when interacting with your system
- What are the user's goals? – use task analysis to understand what the user needs to achieve in your system and what the system must have to satisfy the need/goal
- How can the user achieve their goals in your system/application? – identify possible in which the user can complete their tasks and any possible barriers.

3.4 User Experience

UX describes all aspects of interactions between a user and a product, the results of this interaction reveals the user's internal state, the system's characteristics and the context of use (Hassenzahl & Tractinsky, 2006; Alben, 1996; Forlizzi & Ford 2000; Marcus, 2002; Kuniavsky, 2007). In addition, UX includes affect or usability engineering. UX focuses on the user rather than system features. It ensures user satisfaction and efficient use of product. The goal of UX is to create user engagement with applications that are beyond the point of user frustration by using applications that are developed to meet users' needs (Garrett, 2011). Ambiguity of UX is instigated by being associated with a wide variety of dynamic concepts such as emotional, hedonic, effective and experiential (Law et al., 2008). Also, its definition is too flexible and fragmented by theoretical models with emphasis on pleasure, beauty and value (Desmet & Hekkert, 2007; Tractinsky et al., 2000; Mccarthy & Wright, 2004). A study presented in Karapanos (2010) focused on UX as temporal, that is, UX may vary over time. In early stages of interaction, the experience relates to hedonic aspect of the product use and familiarity with the product which results in subjective aspect such as significance and meaning of product in one's life.

The UX model presented by Hassenzahl (2005) proposes three properties that make a system: functionality, usability and aesthetically pleasing. The functional property ensures that the system serves its purpose. The usability concept of the system has to do with achieving the goal effectively, efficiently and affordably. The aesthetics deals with appeal because more often than not, the visuals influence the experience. The system is described

as having a character which is defined by its features such as presentation style, functionality, content, interaction style (Hassenzahl, 2005). In addition, the character triggers consequences such as emotional consequences which include pleasure and satisfaction; and behavioural consequences (for example, increased time spent with the product) depending on the usage situation.

In Quality of Experience, Alben (1996) defines UX as how an interactive product feels in the user's hands, how well it is understood, emotions when using it, how well it serves its purpose and its efficiency. He stresses that although experience is emotional in nature, the product ought to be linked to the needs, dreams and motivations of the users. Using a pragmatic approach, Forlizzi & Ford (2000) noted that experience is something that sways between states of cognition, storytelling and sub consciousness, depending on the users' actions and environment. This means that UX changes with time, experience and perception after use. Conversely, hedonic quality has to do with the product's apparent ability to satisfy basic human needs such as need for novelty and change, competence, autonomy, self-expression, personal growth and/or relatedness (Russell, 2003).

Mccarthy & Wright (2004) present UX in a framework with four components: compositional, sensual, emotional and spatio-temporal. The components define how the user connects and makes sense of the experience by anticipating, connecting, interpreting, reflecting, appropriating and recounting. The compositional thread deals with how the elements fit together to form a logical explanation of actions and consequences; whilst spatio-temporal deals with the effects point of view and how the user reacts to the experience is the emotional thread. When the user interacts with a system the following takes place to formulate the experience:

- Anticipation relates the user's information prior to the encounter with technology again;
- Connecting relates to the judgement the user makes when they start the experience;
- Interpreting narrates how the user perceives what is happening and how the experience evolves;
- Revisiting what happened and how it changes the user is reflecting;
- Appropriating is the connection of the experience to the user's past experiences and finally storytelling of experiences is Recounting.

The different perspectives that affect UX are highlighted in a framework that is presented by Jääskö & Mattelmäki (2003) as shown in Figure 3.2. They emphasize that although these perspectives are separable in theory, in reality they are interlinked and depend on each other to form an experience.

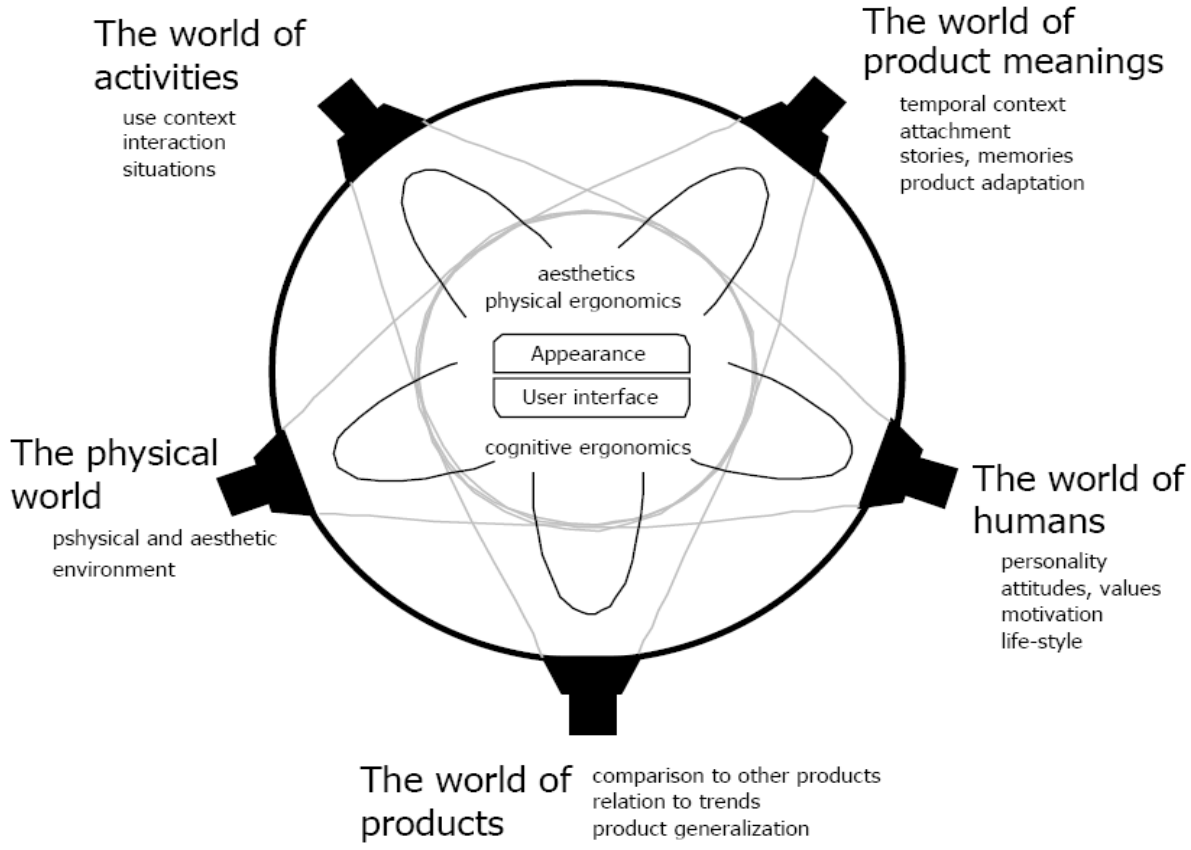

Figure 3.2: The Perspectives of UX (Jääskö & Mattelmäki, 2003)

In Figure 3.2:

- The world of humans – describes people who are social, experience things together and are emotional beings in terms of personalities, values and motivations. In a design project, they can be represented in forms of personas and personal goal descriptions.
- The world of products – defines sentiments and roles that products take in people's lives. They can be studied by using for example, interviews, storytelling and collages.

- The world of activities – focuses on how things such as interactions, actions, tasks, situations, and practical goals are done. It is studied through observation, shadowing, role play and experimentation with prototypes.
- The physical world – this can be studied by observing and documenting the physical conditions, qualities and the aesthetics, and atmosphere of the environment.
- The world of product meanings – depicts how the product is perceived by the user i.e. the physical aesthetics, features, usability and desirability. It can be studied by conducting interviews on focus groups, collages and observation.

Forlizzi & Battarbee (2004) have suggested that experience can be divided into three categories: experience, an experience and co-experience which are a result of three types of user-product interactions: fluent, cognitive and expressive. Fluent interaction is automatic and does not compete for the users' attention. Cognitive interaction depends on the history of product use which results in knowledge, confusion or error. Expressive interaction is the interaction that permits modification of the product to form a relationship with it. Experience is constant and does not change; from experience, an experience can be named which inspires emotional and behavioural changes. Finally, co-experience is UX in a social context including aspects such as the environment and culture.

3.4.1 Factors Affecting UX

Understanding the elements affecting UX will assist in defining and evaluating UX since experience does not exist in a vacuum. Hassenzahl & Tractinsky (2006) have summarized factors affecting UX by using its three main building blocks:

- User – UX is personalized by the differing user characteristics in their motivations, emotional state, current mental and physical resources, and expectations.
- System – UX is influenced by the user's perception of the system's properties, for example, sustainability and the properties that the user can add or change. Consequently, the system's characteristics such as complexity, functionality, usability and aesthetics are important for UX.
- Context of use – The context of use refers to a combination of physical context (e.g., using a device on a quiet office vs. while walking), social context (e.g., working with

other people) and task context (including other tasks that also require attention). A change in the context of use may change UX.

Roto (2006) then describes a system as a collection of attributes including products, services, people and infrastructure. In addition, the experience can change altogether if any of the attributes can be removed. Roto (2006) defines context as including system and objects that affect UX but are not part of the system (Roto, 2006). The context can either be physical i.e. comprising of everything tangible, their movement, temperature, lightning, current location and noises; or social i.e. only denotes willingness of user to participate in a social situation and the influences and expectations placed on the user by the surrounding people (Roto, 2006). The user's internal expectations for the system influences UX, e.g. a user in a bad mood is likely to be impatient with the system thus leading to bad UX (Hassenzahl & Tractinsky, 2006). All the building blocks of UX are represented in Figure 3.3.

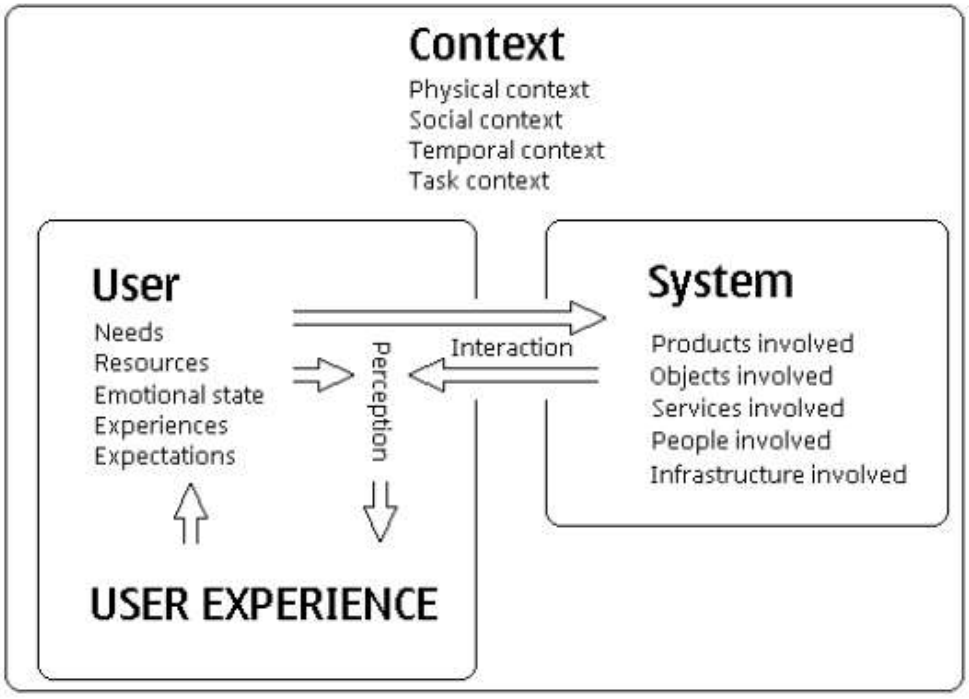

Figure 3.3: UX Building Blocks (Hassenzahl & Tractinsky, 2006)

Kankainen (2003) defines UX as "the result of a motivated action in a certain context". The action refers to "how the user is doing what he does" and it is driven by motivation. Furthermore, the user's previous experiences and expectation greatly influences the present experience which results to more experiences and modified expectations (Figure 3.4). All

this takes place within a context defined by the user during interaction and it is important for product to meet user's expectation formed by previous experiences.

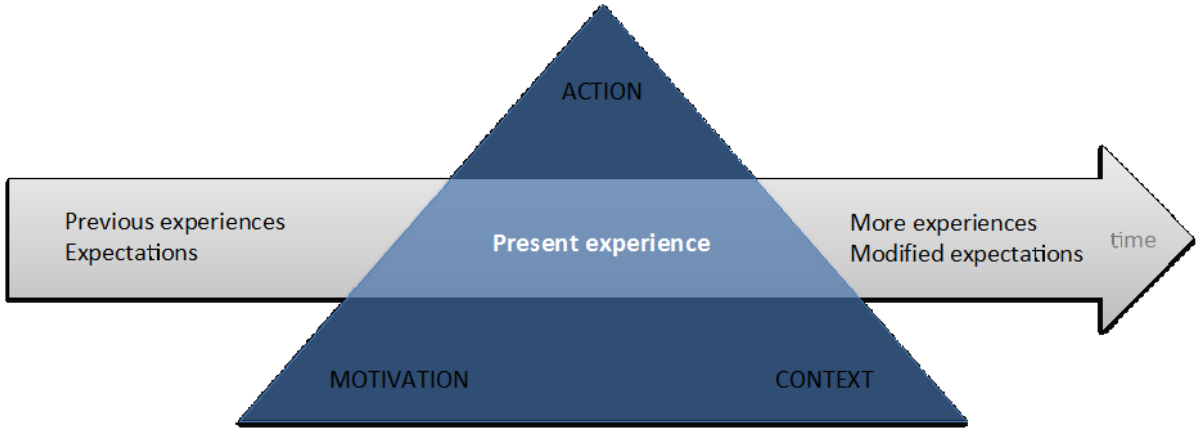

Figure 3.4: UX Definition by (Kankainen, 2003)

UX can be used to help ascertain the reasons behind certain experiences. This said, describing the factors that affect UX does not describe the UX itself; however, the use of UX factors and their main categories can be helpful in describing the situation in which a person felt a certain UX (Roto et al., 2011).

3.5 User Interfaces and Interaction Techniques

An interaction technique is a way to perform a generic task using a physical input/output device in a human-computer dialog (Sajja & Akerkar, 2012). The interaction between instruments, processes and users is facilitated by the UI of the interactive application. The UI facilitates the interaction between the user and the system, thus enabling a two-way communication through providing the user with feedback and providing functions for entering the data needed by the system (Sajja & Akerkar, 2012). The user is required to issue commands and actions to be performed by the device. These actions then involves input devices to capture the user input, output devices that displays user feedback and a software that converts the user inputs into commands that the computer can understand then produce user feedback based on the input provided by the user and the state of the system (Sajja & Akerkar, 2012). These include input and output devices, such as the mouse, speakers, keyboard and monitors along with the software units such as toolbars, menus (Hix & Hartson, 1993). New input devices are used with the emerging of new hardware technologies such as haptic sensors, olfactory, cameras, and microphones. Output devices of

the new age include head-mounted displays, touchable three-dimensional displays, auto stereoscopic displays, non-speech audio output for data visualization (Fetaji et al., 2007). The type of interaction technique suitable for certain users is determined by the components of UI which includes mental models (tasks, functions, roles and structure of data), metaphors (communication concepts presented through words, sounds and image), navigation, interaction, and appearance (visual).

According to Foley et al., (1984) an interaction technique is a way to perform a generic task using a physical input/output device in a human-computer dialog. It provides a method for the user to finish a low-level task. The sensed information about the physical environment makes up the input, an example, the mouse sense the movement across a surface then responds by moving. Output includes any modification or emission to the physical environment such as display and sound. The process of a user performing a task on a computer by means of a user interface is referred to as interaction technique (Norman, 2002).

On early computers, interaction was through the command-line interface and special-purpose language to communicate with the machine but to this day, a number of approaches have been developed and defined (Shneiderman, 1998). This was because the earlier methods of interaction were mainly suited for expert users. The type of interaction technique used may depend on the application and some applications may use more than one technique. Fitrianie et al., (2008) discovered that accessibility barriers posed by most computer applications are caused by the heavy use of text on everything from document content to menus; this is why most semiliterate and illiterate users are unable to use these services. A solution to this is a text-free interface which makes use of graphics and photographs for information and voice for delivering information that is normally delivered in text-form.

The principles of UI design are all centred on the idea of a user friendly environment. These principles are important because they ensure that the system adapts to the user and provides successful experience to the user which builds their confidence (Shneiderman, 1998). A good UI should guide the user to learn and even challenge them to explore beyond their normal limits and stretch their understanding of the interface. Interface design principles are useful in the production of user interfaces that are usable and useful to the user and Hansen (1971) was the first to propose a list of the principles. Hansen's principles for designing a

good UI are: know the user, minimize memorization, optimize operations and engineer for errors. In addition to these principles, (Mayhew, 1999; Shneiderman, 1992) also defined some interface design principles. There are three main interface categories that interactions are classified into and each category has been further subdivided into various interaction styles as follows:

- Direct manipulation
- Key-modal interaction
- Linguistic interaction

3.5.1 Direct Manipulation

Direct manipulation interfaces offer manipulations that are equivalent to human skills rather than trained behaviour, for example pointing, moving objects in space and grabbing (Fetaji et al., 2007). Each of the manipulation is performed directly and graphically. Direct manipulation is object-action orientated, it includes a pointing device such as a mouse, a trackball, a finger or a stylus which serves as an indicator of the objects to be manipulated and the action, specifying what should be done to the object. Shneiderman (1982) explains that it is referred to as direct manipulation because the interface contains no intermediaries (such as commands or menus) amid the user and the task to be performed. For example, to move a file, you may click on the icon it represents then drag it to the desired location. This technique therefore is easy to learn which makes it suitable for novice users. Furthermore, direct manipulation has eliminated some classes of syntax errors, for example, one cannot point at a non-existent object (Shneiderman, 1982). The only expertise required is on the task domain and only minimal knowledge of the computer (Shneiderman, 1982).

It is fast, intuitive and easy to learn but it is only fit for where there is a visual metaphor for tasks and objects. Metaphors are used in visual representations which allow users to determine the actions they want to perform according to what they see. It offers fast incremental reversible operations on whose influence on the object acted on is instantaneously visible (Shneiderman, 1982). Psychology studies have shown that the use of direct manipulation interfaces enhances learning speed and retention which in turn increases confidence in users because they are in control and the system responses are immediate and predictable (Norman, 1988). Also, since the actions are rapid, incremental and reversible, it causes the users to feel in control of the system they are using.

Some of the qualities of direct manipulation are as follows (Shneiderman, 1982):

- Novices can quickly learn basic functionality, usually with the help of an experienced user.
- Experts can work rapidly to carry out a wide array of tasks including defining new features and functions.
- Error messages seldom needed.
- Non-regular expert users can preserve operational concepts.
- Actions readily lead to immediate visible results.

Some of the techniques using direct manipulation include (Preece et al., 1994):

1. Graphical User Interface (GUI)

Accepts input from devices such as computer keyboard, mouse and provide the output on the computer monitor. It is also referred to as a WIMP interface because it facilitates interaction using windows, icons, menus and pointers (or windows, icons, mice and pull-down menus) (Sajja & Akerkar, 2012). The pointer which uses the mouse is the most significant component of the WIMP interface, since it facilitates the selection, pointing, pressing, clicking and dragging of objects on the screen which can be edited, explored, moved and executed to fit the user's vision. All the other components of the WIMP interface can be manipulated using the pointer. Pointing is a natural way of human communication, using devices for exchange information therefore becomes easier. The use of icons and other visual information makes it easier for users to understand the contents. These include metaphors such as the popular desktop metaphor which help users understand computer systems. Some of the advantages of GUI include: simplicity, intuitiveness, adaptability and flexibility. System changes are transparent to the user and reversible.

2. Web-based UI

Accepts input and provides output by generating web pages which are then transmitted through the Internet and viewed by the user using a web-based program.

3. Touchscreens

Accepts input by fingers touching the screen and the screen functions as both input and output device.

4. Form Fill-in

This type of interaction involves user filling in fields on a form. Some of these fields may have menus associated with them and the form may even have action buttons which when pressed triggers some action to be performed. The TAB-key is used as means of switching between fields with ENTER used for submission of the form, thus eliminating the need for a pointing device such as a mouse (Soegaart 2010). It simplifies data entry and also shortens learning because the fields are predefined and need only be 'recognised' (Preece et al., 1994). A Limitation to this technique is that it becomes complicated when used for operations such as file deletion (Soegaart, 2010). Spreadsheets are considered a sophisticated variation of form fill-in (Fetaji et al., 2007).

5. Stylus-based UI

A stylus affords the ability to write text by hand hence mimicking the pen and paper metaphor. It is a good pointing device which does not require an intermediary; it only requires the user to place the stylus directly on the screen at the location of desire. A stylus uses hand print recognition system to interpret the users' input into single characters (Goodisman, 1991). In addition, the specification of commands is easier with a stylus than a mouse since it can be used to draw symbolic marks that represent commands and parameters. The use of the pen and paper metaphor makes the stylus to be an easy to use and learn interface because it makes use of skills that even users who are e-illiterate possess, i.e. using a pen to write. It has an advantage over the other input devices since it requires only one hand and the commands are symbolic therefore easy to remember.

6. Virtual Reality

Virtual environments "typically offer a sense of direct physical presence, sensory cues in three dimensions, and a natural form of interaction (for example via natural gestures)" (Preece et al., 1994). Virtual realities are usually 3-dimensional (3D) and comprise of selection, manipulation, system control and navigation techniques. The navigation techniques additionally use techniques such as way finding and travelling. Graphical menus, voice commands, gestural interaction and virtual tools with specific functions support system control function in 3D (Sajja & Akerkar, 2012). Furthermore, the travel technique is classified into these five categories:

- Physical movement-requires movement of user through the virtual world
- Steering- specifies direction
- Route planning- specifies the path
- Manual viewpoint manipulation- to achieve motion, the hands are used
- Target-based planning- specifies destination

3.5.2 Key-Modal Interface

Key-modal interface derives its name from its two main features, i.e., interaction through pressing some keys and the different modes (or states) that the system exhibits (Pearce, 2009). In addition, a key press may lead to different effects on the system state (mode) depending on the current state (mode) of the system. An example of a mostly key-modal interface where the user provides input by pressing keys is the Automatic Teller Machine (ATM) where the same key (Enter) can be used for different modes. Key-modal interfaces are often found in public places like information kiosks, therefore they are suited for even the most inexperienced users since they are used for simple tasks. Key-modal interfaces are modelled as finite-state machines as a result of their simple inputs (key presses) and modes (Pearce, 2009). It is mostly used in the following interaction styles:

1. Menu Selection

Preece et al., (1994) defines a menu as "a set of options displayed on the screen where the selection and execution of one (or more) of the options results in a change in the state of the interface. Unlike command-driven systems, menus have the advantage that users do not have to remember the item they want; they only need to recognize it". The menu consists of a list of commands which can be used to perform a certain action. The user is presented with various options to choose from by various means of selection (Pearce, 2009). Shneiderman (1992) presented three types of menus:

- Pull-down menus
- Pop-up menus
- Hierarchical menus

Menu selection is best suited for inexperienced users as it requires less typing therefore eliminating errors. For experienced users, it might be slow and can become cumbersome and complicated when there are many menus. Selection method in a menu-based interaction is

done by: cursor or tab keys, function key alongside displayed item, typing option letter or number and pointing and selecting with mouse or trackball (Pearce, 2009). It can easily be integrated into other systems.

2. Question-and-Answer and Query Dialog

In question/answer dialogue, the user is presented with a series of questions which mainly require yes/no responses, multiple choices or codes (Fetaji et al., 2007). Query languages are an interactive way to pass structured query (e.g. Structured Query Language (SQL)) to get response from the web, used in combination with database along with the web. For ease of use, it may use natural language (Sajja & Akerkar, 2012). Both these are limited in power and functionality.

3. Function-Key Interaction

The user provides the system with input through pushing function keys or other special hardware whilst being prompted with displayed information (Pearce, 2009).

4. Voice-Based Interaction (structured)

This type of interaction presents the user with options through recorded or synthesized voice where they make choices with telephone keypad or record voice response, for example, voice-mail retrieval (Pearce, 2009). Such interfaces use an IVR system that enables computer systems to detect and process options entered by the user through speech or touch tones (Baird et al., 2011). The IVR systems present the options as a number of menu choices referred to as an IVR tree. Using an IVR system requires the user to press a number that is associated with the preferred menu option (Baird et al., 2011) on a keypad. Where the system requires verbal or speech responses from the user, speech recognition is used to interpret the spoken answers (Baird et al., 2011).

Voice User Interfaces (VUIs) are enabled by speech recognition technologies and they are a terminal, display and possibly location-independent user interface technology. Speech or auditory interactions accommodate a diverse user demographic irrespective of their experiences and educational background. In addition, it reduces screen presentation and limitations presented by text. An application presented by Tsai (2006) that uses a voice interface in the Mandarin language to provide web services for the illiterate and semiliterate.

The interface is accessed through a Voice Over Internet Protocol (VoIP) telephone which through Automatic Speech Recognition (ASR) and Text-To-Speech (TTS) synthesis enables the user to access web services. Raza et al., (2013) proposed a speech-based system, Polly that delivers services which are already available in textual form including speech-based message boards and blogs; speech-based mailing lists; speech-based market trade and citizen journalism which depends on viral spread for popularization.

As compared to GUIs, speech interfaces provide a quicker way of interaction as the natural way of human communication (voice/speech) is the most effective way to perform a task through allowing users to pinpoint what they want (Bell, 2003). Hauptmann & Rudnicky (1990) compared typed and speech input and discovered that speech is faster and a more efficient input modality. This is because it does not require tedious typing which is especially advantageous for motor challenged people. However, a study has shown that tasks that require real-time planning such as word processing cannot be successfully carried out by speech (Karl et al., 1993; Shneiderman, 2000). Some of the disadvantages of using speech in a user interface include the risk of interference with other similar cognitive activities and sensitivity to background noise (Karat et al., 1999). Speech interfaces are more error prone since spoken languages cannot be edited, are apt to contain hesitations, pauses and restarts (Miller et al., 1998).

When there is a problem of visual information or in environments where auditory signals are understood better than visual, auditory output is useful. It is also used by a system during a performance to indicate background processes. It is more flexible as compared to the other modalities in that, it does not require the user to be within sight lines of a computer screen / device nor does it bind the user to a specific location.

3.5.3 Linguistic Interaction

Linguistic interaction is a type of interaction that features interfaces that use natural language and words in their interaction, including command-line interaction and human language. For an interaction to be considered as linguistic, the user's input has to have some linguistic richness, some interpretation and non-trivial parsing of the input (Pearce, 2009). Pearce (2009) further clarifies with examples of interactions that cannot be considered as linguistic because they lack trivial parsing and interpretation of input even though they use natural language. The question-and-answer interface which uses natural language to ask

questions requires answers in a form of simple words, data (e.g., address) and numbers which do not need interpretation or parsing.

1. Command Language

Provides a means of articulating instructions to the computer directly, it uses single characters, function keys, abbreviations or whole word commands (Preece et al., 1994). These commands are associated with strict syntax which the user should know before using the system which is usually difficult to learn. Therefore it is mostly suitable for expert users. It is poor in error management. It requires typing ability and knowledge of the command language hence preferred by experienced users because they allow faster interaction with the system.

2. Natural Language

Natural language processing requires either speech input or written input which is then parsed and translated into system commands (Fetaji et al., 2007). Since the computer needs strict instructions, the users are required to learn which phrases the computer understands in the case of speech input. It can be regarded as the front end to command language. It is mostly suited for users who have limitations to keyboard interactions. Its disadvantage is the ambiguity of natural language and different accents which might cause user frustrations. In the case of written input, the downside can be the tedious typing required. When human communicate they make use of gestures therefore natural language systems ought to be stretched-out to include non-verbal dialogues (Buxton, 1990). This is because non-verbal dialogues are "in many ways, more natural than those based on words" (Buxton, 1990).

The types of UIs used for testing in this research are defined below.

- QWERTY

This type of a keyboard derives its name from the layout of the first six keys that appear on the top left letter row of the keyboard from left to right (QWERTY). This keyboard was designed in 1868 by the inventor of the Typewriter, Christopher Sholes claiming that arranging the keys in this fashion prevents jamming on mechanical typewriters (ISO/IEC, 2009). This is due to the separation of commonly used letter combinations. The mobile QWERTY keyboard is illustrated in Figure 3.5, which consists of alphanumeric keys to

accommodate the numbers 0-9. In contrast, the PC QWERTY keyboard is free of alphanumeric keys, see Figure 3.6.

Figure 3.5: Mobile Phone QWERTY Keyboard

Figure 3.6: PC QWERTY Keyboard

- Swype keyboard

Touchscreen smartphones contain a virtual keyboard that requires users to enter words by sliding a stylus or finger from the first to the last letter of a word without lifting a finger. This type of a keyboard is referred to as the Swype keyboard (Boehret, 2010). It uses predictive text. This type of a keyboard is illustrated in Figure 3.7.

Figure 3.7: Swype Keyboard

- 3x4 keyboard

This type of keyboard contains only 12 keys with numbers 0-9 and two additional keys (* and #). It is called the 3x4 keyboard because of its 3 horizontal by 4 vertical keys. For text entry, the characters A-Z are located over the 2-9 keys in alphabetic order and require continuous (or multi-tap) to reach some of the keys. It also uses the T9 technology for predicting text (MacKenzie & Tanaka-Ishii, 2007). In this research it was only used for numeric entry. This type of keyboard is illustrated in Figure 3.8.

Figure 3.8: 3x4 Keyboard

3.5.4 Technology Acceptance

The Technology Acceptance Model (TAM) considers the user's perception of ease of use, value, trust and ease of adoption before the user comes into contact with the system as the key influence to system acceptance (Kaasinen, 2005). It suggests that the user accepts the system solely based on perception and expectation, therefore if it meets the expectations, the UX is good. Roto (2006) points out that acceptance means neutral UX because it does not involve strong emotions but only meets the user's expectations without delighting them by exceeding what they expected of the system. In addition, acceptance takes place prior to use of the system and whether they are able to use it with success is determined by UX. As a result, acceptance means impartial UX, that is, the system does not amuse the user by exceeding their expectations.

Users' understanding and the way they perceive the world around them is important to their existence as human beings. Hence, acceptance depends on perception, knowledge and

assumption of the system before the user interacts with it. This is referred to as its Mental Model, which users bases their predictions and plan their future actions based on it (Andersson, 2012).

The RuTAM (Rural Technology Acceptance Model) proposed by Islam (2011) which aims at including factors that directly and indirectly affect rural commuters is a modification of the original TAM (Venkatesh & Davis, 2000). Facilitating conditions from the model are said to be conditions that influences the acceptance of technology indirectly, from individual's use, delay to rejection (Islam, 2011). The market structure and taxes govern the pricing of the technologies which can increase customer base if prices can be reduced. Tech-service promotion involves building awareness using operators, technology (e.g., mobile phones) and its associated services (e.g. information). Whilst, tech-service attributes involves all the external factors that affect adoption which are not specific to any ICT, these include the cost of subscription and the usability of interfaces of these ICTs.

In addition to external factors that indirectly influence technology acceptance, Islam (2011) has also identified individual factors such as the need for visualization which emphasizes on the users' need to 'feel and touch' a technology before they can accept it. Some of the ICT user's buying patterns have been found to be individual and not dependent on income and consumption, this is referred to as extravagance buying behaviour. Demographics (such as age, gender and education) is not one of the determinant factors of ICT ownership, however it influences the adoption and use of technology. In his study, Islam (2011) found that education is directly correlated to accessing advanced features such as reading or creating a Short Message Service (SMS). The effect of age is found to be significant also in that those who are between the ages of 19 and 30 use mobile technology frequently than those who are above the age of 30. This is because they relate to the modernity of these technologies. In relation to gender, males have been found to be the dominant users of technology. The reported influence of the social context is great because users claimed that they use mobile phones because some family member, friend or neighbor is already using it.

Users regarded mobility, connectivity, productivity as important factors of usefulness. Mobility and connectivity are perceived as useful because of their ability to overcome time and location barriers. The mobile phone is perceived as productive by local farmers because its saves money. Features such as games and social networks bring the enjoyment factors especially for young adults (Islam, 2011). Usefulness affects the behavioral intention.

Perceived ease of use is not influenced by perceived usefulness or social influence but it ensures better access to new technology. The RuTAM is presented in Figure 3.9.

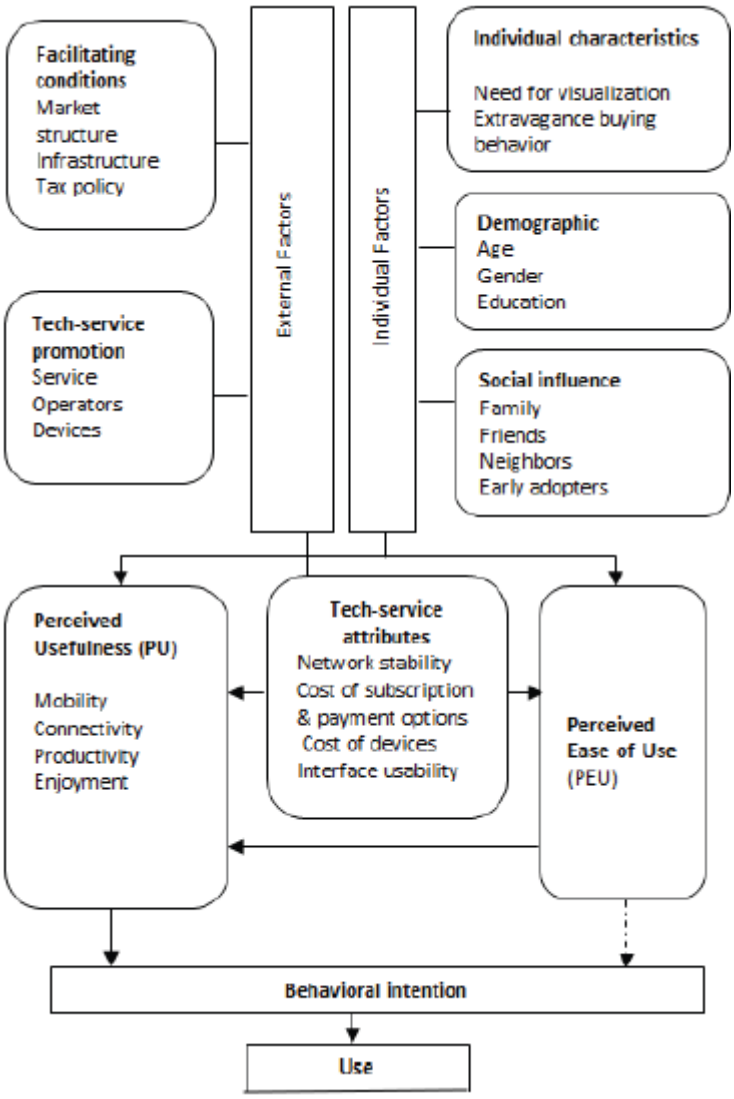

Figure 3.9: The Rural Technology Acceptance Model (RuTAM) (Islam, 2011)

Mobile Technology Adoption Model (MOPTAM) is a proposed mobile phone acceptance model by Biljon & Kotze (2007) which focuses on four types of mobile phone contexts. These contexts are: physical, social, mental and technological. It combines three arbitrary factors: personal, demographic and socio-economic. It also includes four determining factors: social influence, perceived ease of use, perceived use and facilitating conditions over behavioural intentions. Consequently, the effect of the facilitating conditions and personal factors (behavioural intention), which directs an individual's use of technology is the most significant feature of MOPTAM (Biljon & Kotze, 2007). Venkatesh et al., (2003)

defines facilitating conditions as "the degree to which an individual believes that an organizational and technical infrastructure exists to support the use of the system".

3.6 Modes of Interaction

Zaguia et al., (2010) defines modality as a path or channel of interaction between a human and a machine. These include: mouse, screen and keyboard. Wahlster (2006) describes modality as referring to human senses including vision, touch, audition, taste and olfaction and emphasizes that human communication depends on code systems shared socially like body languages, natural languages and pictorial languages which have their own syntax and semantics. When more than one mode of interaction is used to accomplish a task, the system is referred to as multimodal. Multimodality accommodates diverse user population due to the different interaction techniques available.

Multimodality permits a flexible interaction by allowing users to use other modalities rather than the traditional mouse, screen and keyboard devices. These include: gadgets and sensors such as stylus, camera and human natural modalities, such as gesture, eye gaze and speech (Zaguia et al., 2010). Multimodal applications are effective when integrated with natural interactions because they assist users who cannot use a mouse or keyboard such as the visually handicapped, weakened, or mobile users with wireless mobile devices (Zaguia et al., 2010). When it comes to multimodality, a single code may be supported by many modalities, for example, language can be supported aurally (spoken language), visually (lip-reading and written language) or tactilely (braille scripts) (Wahlster, 2006). In 'A context aware and user-tailored multimodal information' by Fitrianie et al., (2008) it is maintained that the system must be context aware, i.e. the user interface must adapt or change according to variables such as user profile, user emotion and location.

Wahlster (2006) designed Smartkom which introduced symmetric multimodality for dialogue system where all input modes (such as speech and facial expression) are also available for output and vice versa. Wahlster et al., (2001) explains the Smartkom system which has merged three modes of communications, these are: GUI, spoken language and gestural interaction as multimodal system. Smartkom supports natural gestural interaction together with facial expressions instead of the traditional WIMP interface.

An example of co-ordinated speech and gesture interaction is moving a block of text to a new location: 'move that' (speech) and pointing to block of text 'to there' to target location

(Rachovides et al., 2001). Speech is usually the primary input mode in multimodal system that it is included in. Rachovides et al., (2001) maintains that the downfall in speech being a primary input mode is that speech is not an exclusive carrier of information; it works best with other modalities to dissolve linguistic complexities. Different modalities may vary in their functionality during communication in that they specify different content, their integration with each other and suitability for integration into various interaction styles.

Rachovides et al., (2001) contends that the effects of facial expressions, gestures or voice tones are often overlooked because of inadequate analysis on human-human multimodal interactions. In addition, output systems introduce redundancy in the content indicated by the different modalities, in that, conveying the same information in different modalities does not mean the user will use all of them to interact at any one time. Also, this means that the user might miss some important information by focusing on the preferred modality/media type. A concern with these multiple modalities is that they are insufficient at communicating human information because neither of them simulates the communication that occurs naturally in the human-to-human world (Sarroff, 2008). In addition, he claims that these input/output methods encourage humans to adapt their language and behaviour to that of the machines, this creates a stiff and uncreative relationship between human and machines. Furthermore, the human's 'affective state' assimilated from across multiple modalities must be interpreted by computers to achieve success of multiple modalities (Pantic et al., 2006).

Voice recognition, gesture recognition and access technology reference the term eyes-free for the visually impaired with efforts to reduce the GUI through presentation of audio, earcons (audio messages that are structured and composed of variations in the major properties of sounds such as pitch and rhythm), speech or haptic feedback (Crease and Brewster, 1998). Eye-free focuses on notification events which do not require visual attention (Smyth & Kirkpatrick, 2006). These include vocalization, gestures, haptic signals and touch.

1. Visual

Visual-based interaction provides a natural platform where a user can interact with through the motion of the body or facial expression. A common platform for visual-based interaction is mobile gaming, an example, the maze game which uses the camera of a mobile for interacting with the user when playing the game (Bucolo et al., 2005). The user translates or

tilts the camera to interact with the ball, making use of the tilt and translation interface. Visual-based interactions include body movement tracking, gaze detection (Eyes Movement Tracking), gesture recognition and facial expression analysis (Smyth & Kirkpatrick, 2006). Facial expression analysis is use in recognition of emotions visually and gaze detection is used for understanding user's attention and focus in context sensitive situations (Newell 1990; Jason, 2005). In addition, eye tracking systems are used for helping users with disabilities where the eye is used for commands and action scenarios, for example, blinking for clicking and pointer movement (Jason, 2005). On the computer output side, the computer images should be displayed in a way that human can instantly recognize them although they exhibit the computer's own affective state. The computer input should have the capability to read human gestural communications, for instance, eye and face tracking should enable human to direct computing environments in more humanistic ways to overcome mode-specific noises.

Gesture greatly relies on all modalities to communicate an extensive breadth of information. Kurtenbach & Hulteen (1990) define a gesture as a "motion of the body that contains information". Gesture-based interaction is the most natural way of user interaction with technology and is usually used together with speech to simulate a more natural interaction. Human use gestures to clarify expressions through the use of hands, eyes, head or mouth. Crossan & Murray-Smith (2006) discuss selection of songs in a mobile music player by using a simple wave/movement of the body or hand. This is an easy and natural way of interacting with the player since it does not require the user to click a button, read instructions or commands on the phone interface before performing the action. Gesture recognition is referred to as eye-free because once a user has learnt the gestures; they can perform them in the absence of graphical feedback. In Oakley & Park (2007), extensive description of how the designed WristMenu which takes input from a wrist mounted motion sensor then outputs on a vibrotactile display works as an eye-free interface. Input modes include styli, the finger, the hand, head and muscular gestures.

There are five approaches to gesture-based interactions: manipulation, gesticulation (gesture and speech), semaphores, deictic and language gestures (Quek et al., 2002). In addition to these, symbolic, iconic and pantomimic gestures are defined by (Billinghurst & Buxton, 2011). McNeil (1992) describes beat and cohesive gestures as the types of gestures that relate to the process of communication. Billinghurst & Buxton (2011) introduced the

following structure that ties all the types and approaches to gesture based interaction together:

Gesticulation -> Language-Like -> Pantomimes -> Emblems -> Sign Language
(Beat, Cohesive) (Iconic) (Pantomimic) (Deictic) (Symbolic).

2. Haptic

Haptic interfaces "generate sensations to the skin and muscles through touch, weight and relative rigidity" (Harish et al., 2013). With haptic input, humans are able to apply knowledge they have of the physical world to a virtual world (Fetaji et al., 2007). It allows users to assign values to a virtual environment with better precision than is possible with auditory or visual input. Device designed for haptic interfaces are made for disability assistive applications (Fetaji et al., 2007). This approach toward haptic input and output provides an increased sense of kinaesthetic output by shifting cognitive load away from objects being manipulated.

3. Touch

Human use touch as a form of expression and communication in everyday life, the new generation of mobile devices have applications that enable it to be used as touching devices on other objects to establish communication . The home care service application discussed by Isomursu et al., (2008), which is implemented in mobile devices that are equipped with Near Field Communication (NFC) devices to Radio Frequency Identification (RFID) tags placed in their homes requires users to simply touch their phone to establish communication between the users and the home care providers for services. An advantage of this technique is that it is easy to use. Touch-enhanced motion techniques combines touch and motion, this can include information such as the number of contacts and their positions, from the touch as parameters to a motion gesture i.e. places "touch in motion" (Hinckley & Song, 2011). Motion-enhanced techniques enable the expressiveness of touch techniques i.e. puts "motion in touch" by using incidental vibratory motion that is finger contact induced to add distinctions to the expression of touch or to infer context of use (e.g. the way the user held the device when they touched the screen). For example, soft vs. hard taps, or gentle swipes vs. drags with a hard onset.

4. Audio

Input to a computer system can be provided through using different forms of audio signals which are facilitated by technologies such as speech recognition, speaker recognition, human-made noise/sign detection (e.g. sigh, laugh, gasp and cry) and musical interaction (Fetaji et al., 2007). In speech recognition the term hands-free is usually used to describe its two features which are: no mouse and no screen input technologies. The voice interaction technique which uses speech recognition technology has been defined in detail in section 3.5.2.

3.7 Metaphors

Metaphors are a figure of speech that describe a subject by using some type of comparison of the subject to another otherwise unrelated object, its effects are achieved by resemblance such as hyperbole and simile to help people to remember objects easy (Marcus, 1994). Using metaphors means that the underlying system becomes invisible to the user making it easy to work with especially for inexperienced users; the metaphor becomes the way that the user thinks about the system. Metaphors are used to break down the complexity of business-office terminology into that which can be easily understood and remembered by rural communities' users. Basically metaphors should be designed using concepts that the local users are familiar with and can relate to for them to be applicable. Some of the metaphors that already exist and are easy to associate include the 'recycle bin' which translates to the trash can in the real world, users can associate using the recycle bin with throwing unneeded thing away, i.e. delete (Barr, 2003).

The arguments that a metaphor is subjective and depends on the context of the interpreter which may prove to be different from the inventors' context is solidified in (Steen, 1994) where a metaphor is defined as "a relation between language as an abstract system, individual language users, and cultural knowledge". Culture plays an important role in context of the metaphors because it affects the behaviour and perceptions of the individuals interpreting it. "Culture is the shared knowledge and schemes created by a set of people for perceiving, interpreting, expressing, and responding to the social realities around them" (Lederach, 1995). Metaphors invoke familiarity with certain real-world objects.

Metaphors help users understand the behaviour of the system (Lakoff & Johnson, 1980). This involves the use of words like my machine "refreshes, creates, kills and buries"

windows and “reads, writes, copies and edits” files. Therefore, using software can be explained using already understood concepts; however, inappropriate metaphors may lead to confusion which may degrade user performance. In addition, metaphors can be divided into conversational and simulated world metaphors. Conversational metaphors facilitate interaction in a form of conversation where the user issues a command and the system responds. It was mostly used in command-line interfaces and also in today’s GUIs menu command and dialog boxes. Simulated world metaphors have objects of computer applications mimicking the real-world e.g. the desktop metaphor for PC where programs and data are presented as files which can be placed in folders. The messy desktop metaphor introduced by Apple Macintosh in the 1980s was not really easy to use but it captured the philosophy of a messy office desktop where some file can be dragged under others and be misplaced just like in a physical desktop (Carroll, 2009).

A user interface metaphor which uses the hand for direct manipulation was developed by Poupyev et al., (1996) that facilitates natural and intuitive interaction. This interface creates an illusion that users can grasp, touch and manipulate virtual objects with their own hands. The metaphor presented here is the use of the arm to touch/grasp objects located far and closing by lengthening and shortening the arm. However, Song & Norman (1993) dismiss the idea of using the hand as an input device since this means that the users cannot interact with objects away from their reach.

3.7.1 Benefits

The basic benefit of using metaphors is to help increase familiarity with the system. According to Carroll (2009) a metaphor “seeks to increase the initial familiarity of actions, procedures and concepts by making them similar to actions, procedures and concepts that are already known”. Erickson (1990) shares the same idea which is; a metaphor works as a natural model which affords users the chance to use knowledge of familiar, concrete objects and experiences to give structure to more abstract concepts.

3.7.2 Disadvantages

Since a metaphors tries to represent one subject using another when the other is not the same, Norman suggests that this can get in the way of learning because a metaphor uses two

phenomena that are not the same (Norman, 2002). He suggests moderation to avoid compromising usability for the sake of metaphors. Barr (2003) explains that the use of metaphors presents a problem in that the designers themselves do not necessarily have a deep understanding of what a metaphor is and how it behaved and perceived especially when used in an interface. He shares that this is because the blurriness of what a metaphor is.

3.7.3 Types of Metaphors

There are three types of metaphors describing different aspects of human computer interface design described by (Lakoff & Johnson, 1980):

- Activity metaphors – These refer to the metaphors that regard the outcome of the interaction to structures expectations or intentions. For example, when the user is playing a game or controlling a process, the outcome is determined by the activity metaphor.
- Mode of interaction metaphors – These refer to the metaphors that only regard the relationship between the user and the computer without concerning the task that the user is trying to accomplish using the computer. Whether the user regards the computer as an environment for action or a conversational partner or a tool box and materials should determines the mode of interaction.
- Task domain metaphors – These refer to the metaphors that structure the nature of a task as presented by the computer in a way that can be understood by the user. For example, with the metaphor for information management store in computers (file metaphor), the user can add or delete from the file, or create a new file.

3.8 Related Research

Section 3.1 through Section 3.7 has provided literature on subtopics that this research has focused on. In addition, reference to related work is provided in the respective sub-topics. This section gives a summary of some of the studies related to the work this dissertation seeks to achieve with reference to their results.

There is considerable contribution to the body of research on UX and usability but to date, only a few of these studies are experimentally conducted to evaluate interface and modality preference of MRA users who have limited or no exposure to ICTs. In addition, a lot of attention in this area has been focused to improving user experience for agricultural-based systems (Patel et al., 2009). Cultural preferences and experiences have become the most significant subjects and focuses of ICT research today, especially for ICTD to realize the users' social and cultural backgrounds with the hope of increasing technology acceptability.

Sharma et al., (2009) presented a comparative study of a system using Dial-Tone Mutli-Frequency and a speech interface to identify which of the two modes interaction did users from low literacy backgrounds preferred for entering information. The system in context was a health information IVR service (OpenPhone) for HIV-positive children caregivers in Botswana. The result metrics were based on measurable performance matrices such as average response time, completion rates and the number of user turns taken per call. The findings were reported as 59% user preference for DTMF, 19% for speech input and 22% for no preference (Sharma et al., 2009). However, this study did not use satisfaction which is one of the important matrices of measuring UX to determine user preference.

Edim (2010) designed a GUI and VUI for MRA users with the aim of meeting their cultural experiences and preferences. These interfaces were designed for a mobile commerce application in the mobile platform for micro-entrepreneurs in Dwesa. The types of users for the interfaces were divided into shop owners and customers, each with their own interface. The VUI provided two flavours, voice input and DTMF for both the shop owners and customer side. The results of the evaluation recorded show that the users were more successful and had minimum errors when using the DTMF input interface as compared to the voice input interface (Edim, 2010). The aim of the study was to design mobile user interfaces that meet needs and experiences from MRA instead of being a comparative analysis of different interfaces. As a result only the interfaces designed for the study were evaluated to determine which one the users preferred. Prior to design of the interfaces a background study onto the surrounding environment were performed including using Hofstede's dimensions of cultural diversity and deriving metaphors from the surroundings. This study defined the types of users and interfaces that might be suitable for their experiences. The interfaces were presented in English instead of IsiXhosa (home language of the community) because designing a voice recognition and synthesis was beyond the

scope of the study. In addition to using English in the interfaces, the users were grouped into customers and shop owners instead of considering their skills and abilities to group them.

Roto (2006a) presented a study where UX was measured for web browsing using mobile phones. In this study, usability was considered one of the quantitative metrics to measure UX and that UX in mobile browsing is affected by the content, user's state, mobile device and web sites. Users from different backgrounds, genders, ages and experiences were involved in the usability tests. To conduct the usability tests, three different UI styles were used to provide the same content. The first was content-based: long pages, flat hierarchy, images, selection lists and layout tables. The second UI style was slice-based: short pages, deep hierarchy, choice for text input or value selection, multi-page forms, data tables and small tables. The last one was meant for experts: no images, textual input and accesskey shortcuts. The results show that interactive pages should be short with images, informational pages should be long and navigational pages should be short with no images. Furthermore, Roto (2006a) argues that the look and feel of the content affects usability. Therefore, it is important for the look and feel of the content, background and interface components to be consistent for both mobile and desktop environment. This is because users do not recognize them as the same pages if they are different in the two platforms (mobile and desktop). This study was limited in that the results were only qualitative and not quantitative. In addition, they were only dependent on what the users in the study were saying.

3.9 Conclusion

This chapter covered literature on HCI and UX including the factors that affect UX and what can improve UX. In addition, a discussion on the acceptance of technology was included highlighting factors that lead to acceptance of a technology in different regions and cultures. UX is said to be affected by the user, system and context of use. The technology acceptance model has also proved that how users perceive, use and whether they accept technology or not is influenced by their cultural background. Therefore, the three factors that affect UX are dependent on each other, that is to say, a change in one of the factors will lead to a different UX. The discussion on user interfaces and interaction modalities has further shown that UIs can be suitable or easy to use for a group of users in a certain context and be totally unsuitable for another group of users. This is also depended on the socio-cultural experiences of users, which bring the discussion of metaphors which have to be tailored to suit users of certain cultures and experiences. It can be concluded that for a great UX, the

user, system and context have to be at harmony. The user's experiences and needs and the context which the user intends to use the system should be fitting to the purpose of the system (i.e., the UI and mode of interaction). The next chapter covers literature on using personas for user profiling.

4 USING PERSONAS FOR USER PROFILING

4.1 Introduction

One of the objectives of this research (i.e. Objective O2) was to identify users within the rural context and classify them into personas. Further literature presented in this chapter answers the research question Q2: "*Who are the users of ICTD services?"* Answering this question then addressed objective O2: "*Profiling of the users based on the identified UX factors"*. The aim was to gather literature on what personas are and how they are constructed. The literature focused on how personas can be developed with reference to culture, hence the discussion on the dimensions of cultural diversity. The information obtained from the literature review and the quantitative analyses, through the use of ethnographic methods, were used in identifying personas. This then answers question Q4: "*Which UI and interaction techniques best suit the profiled users?"*

4.2 Personas

Pruitt and Adlin (2010) defined a persona as a representation of target users that are fictitious, specific and concrete who share common behavioural characteristics. The representations of these fictitious characters include a name and a picture. The name is a representation of who the persona is, what they do and what motivates them. Including the role of the persona also forms part of the name as it gives clear description of the users' personality, for example, "parent," or "student". The most effective personas deliverables as described by Long (2009) are those that can produce larger usability characteristics, include a photo (rather than a sketch) and illustrated storyboards presenting task scenarios. In addition, they should include experience with the Internet and related technology, key demographics and information about the user's goals, behaviours and attitudes and a short, unified story including scenarios that would explain how the persona would use the product.

A persona groups a demographic of like user traits, including similar behavioural patterns, in terms of attributes such as their technology use and lifestyle choices. These patterns, motivations and attitudes are used to define the personas, along with their age, gender or education (O'Connor, 2011). Personas assist the design team with communicating the users' capabilities and needs. They can also be used to guide usability reviews and testing, user documentation and marketing efforts (Richeson, 2009). Nielsen (2013) emphasizes that

when describing a persona, there is no need to look at the complete person, but only focus on a domain that highlights the relevant attitudes and context related to the area of work in question. According to Miaskiewicz & Kozar (2011) a persona is labelled in narrative form and this is to: (a) give the impression that the persona is a real person; (b) paint a vivid story which concerns the needs of the persona in the context of the product concerned. Firstly, the narrative of a persona describes the type of individual that the persona is, together with attributes such as the likes, dislikes and occupation (Grudin & Pruitt, 2002). In addition, personas must use the right goals and be specific to the design problem.

4.3 The Purpose of Personas

According to Bryan (2013), the use of personas assists in exploring questions such as the following:

- What makes a product relevant to its users?
- Why do different types of users behave differently from one another when using the product?
- What factors influence interaction or other conversion behaviours?
- Which characteristics differentiate user types from another for the purposes of designing a user experience?'

4.4 The Benefits of Personas

According to Calibria (2004) creating personas for website and the Internet have many benefits although they may be criticized at time and these include:

- Personas enable designers to focus on users' goals and needs
- Personas are manageable yet represent the needs of many users
- Personas are quick to develop and replace
- The trap of building what users ask instead of what they will use can be avoided by using personas.

In addition to these benefits Pruitt & Adlin (2010) deliberate that personas can assist in the design process in the following ways:

- Narrows the users the product is being designed for
- Lead to better design decisions
- Increase the design team engagement
- Builds empathy for users

Portigal (2008) dismisses the idea of personas claiming that they are dehumanizing and they distance the development team from the real concerns of real users. He claims that using personas creates a false front of user centeredness. According to Richeson (2009), the personas described by Portigal are not based on reality of real users' lives, they have silly, repetitive names with impractical photos from stock photography sites and traits based more on the product and sales development. The argument about how large of a user community personas cover, the observation by Grudin & Pruitt (2002) for Microsoft shows that their personas are mostly Americans and this limit the accessibility as Microsoft is an international product.

The view adopted in this research is that personas are a perfect tool that can be used to group users specific factors into the various categories, allowing for a more efficient usability evaluation and user interaction. This removes the need of having to undertake test and evaluation with users who do not provide any new insight into the usability of the various products, due to the similarities with other users who share similar significant traits.

4.5 Development of Personas

The first step to building personas is by conducting one-on-one interviews with the targeted users. Conducting the interview in-context (such as users' home or office) helps with gathering information about their environment which provides insight into their attitudes, behaviours and motivations (Bryan, 2013). Then analysis on the data collected, to identify extremes in user behaviour and grouping similar users together. Finally, conduct another round of research according to the behaviour and motivation criteria representing each user type. This is to validate the persona characteristics and ask specific behavioural questions for use in understanding how the personas relate to products.

Nielsen (2013) has highlighted the importance of creating an engaging persona to provide the reader with a clear description of the user to enable identification with the user

throughout the design process. Identification is said to cover the recognition, alignment and allegiance processes. Recognition enables the reader to construct the character as an individual and human agent with the information it provides. The process of alignment places the reader in relation to the character's actions, knowledge, and emotions. Allegiance is the moral evaluation produced by the reader about the character and the moral evaluation the text permits the reader to produce. Engagement in the character can be enabled by the derived description of emotions as well as of alignment and allegiance from the material.

4.6 The Effects of Culture on User Interaction with ICTs

Interaction with technology is influenced by the environment, including, the cultural occurrences which are formed by economical, socio-cultural, legal and political influences. These norms are in turn facilitated by media in literature, television and through technologies such as the Internet. Spence (2010) emphasized that technology use and its accessibility is dictated by social environment, which is also shaped by geographical conditions, local histories and everyday cultural practices, but there also exist unequal power relations such as gender. Identifying the communal divisions within a community such as age, gender, ethnicity, race and class are important in understanding the value of technology. This is because users within these social divisions are affected and view technology differently. The gender-biased nature of ICTs is a reflection on socio-cultural and economic context within which technologies are produced and use (Huyer & Sikoska, 2003).

Human beings have the similar psychological characteristics that result in the equivalent reasoning and thinking patterns; this is influenced by the environment and culture (Pinker, 2006). Pinker continues to reason that even though humans share similar elementary cognitive functions, cultural differences influence their application of preferred skills and strategies to cognitive processes (Pinker, 2006). Miller (2005) argues that communication patterns differ according to different cultures, for instance, lower-context culture members only derive the meaning of a message from the verbal content instead of the context; i.e., they do not try to decode the message beyond what is said. As a result, in high-context cultures, communication involves awareness of the social situation, status and relationships among participants in the interaction and the cultural customs involved.

Culture plays a role in gender restrictions, for instance, women in the Arabic culture are subject to restrictions inhibiting them from interacting with people outside their family members (Shen et al., 2009). The perceptions of individuals' innovations that directly affect their lives are shaped by culture within an organization, community or nation (Albirini, 2006). This then means that the environment directly affects how users interact with ICT; hence those from different cultural backgrounds behave, make decisions and communicate differently. It is important to note that language is one important aspect of culture and one of the major barriers between ICT and users, especially those in Africa. South Africa has 11 official languages and over 15 dialects and English is sometimes still viewed from the perspective of neo-colonization, especially in MRAs.

Cultural differences between the end user and the creators of technology can lead to problems in communication mainly because of difference in standards of communication (for example, writing dates and numbers) and differences in colours, symbols and metaphors. In one culture particular style of writing might be acceptable whilst it is offensive in another (Mushtaha & De Troyer, 2012). Users from different cultural backgrounds prefer different cultural markers (Barber & Badre, 1998). These cultural markers include symbols, colours, layout, language, text, icons, sound, image, patterns, metaphors, navigation control, etc. and they increase usability and adoptability of a technology. User preference of cultural markers can be different depending on the genre of the service, that is, cultural icons, themes and cues maybe specific to a certain genre for example, a government site might include national symbols and a social network site might not be required to include such symbols. Marcus (2002) believes that the uniform entities and attributes that relate to the dimension of culture are: metaphors, mental models, navigation, interaction, and appearance. He emphasizes that they contribute to user interface usability and aesthetics thus it is important to understand the cultural standing of the targeted users.

4.6.1 Dimensions of Cultural Diversity

There are four dimensions of cultural diversity that members of the same cultural society show in trends and tendencies (Hofstede & Hofstede, 1991). These dimensions influences the type of community and environment, they are:

4.6.1.1 Power Distance (PD)

Describes the relationship between higher and lower members of a society and how human inequality and differences in power and wealth are dealt with (Hofstede & Hofstede, 1991). For example, the respect expected from children towards their elders can be predisposed by Power Distance. Communities with higher Power Distance Index (PDI) have larger disparities in power distribution and wealth whereas, in communities with a lower PDI, preference is given to equality and legitimate power. Therefore it can be concluded that most people are used to following orders in communities with higher PDI (Hofstede & Hofstede, 1991). That means they are not comfortable with taking initiative because they do not feel that they have the power to make right decisions.

4.6.1.2 Collectivism versus Individualism

Collectivism versus Individualism describes the degree members of a society/culture rely on either the group (collective) or their self (individual) (Hofstede & Hofstede, 1991). Individualism means a strong sense and opinion of self (including immediate family) where self-actualization and freedom are an important factor. On the other hand, collectivism modifies the importance of dependence on other members of the society in exchange for loyalty. In communities with low Individualism Index (IDV) confrontations are avoided and harmony and accord are an important entity (Hofstede & Hofstede, 1991).

4.6.1.3 Femininity versus Masculinity

Cultures play a role in differentiating the way in which gender roles are distributed and these are the identifying factors of the type of relationships that exists within a community between the two genders. According to Hofstede & Hofstede (1991), femininity ‘‘pertains to societies in which social gender roles overlap (i.e., both men and women are supposed to be modest, tender, and concerned with the quality of life)’’. Whilst in contrast, masculinity ‘‘pertains to societies in which social gender roles are clearly distinct (i.e., men are supposed to be assertive, tough, and focused on material success whereas women are supposed to be more modest, tender, and concerned with the quality of life)”. A community is said to have high Masculinity Index (MAS) when success, ambition and assertiveness is valued over relationships with other people and the preservation of the environment (Hofstede & Hofstede, 1991). In contrast, femininity represents unassertiveness and life-quality centred perceptions.

4.6.1.4 Uncertainty Avoidance

Uncertainty Avoidance is "the extent to which the members of a culture feel threatened by uncertain or unknown situations. This feeling is, among other things, expressed through nervous stress and in a need for predictability: A need for written and unwritten rules'' (Hofstede & Hofstede, 1991). It can be measured with Uncertainty Avoidance Index (UAI) and when it is high there is no tolerance of different and unfamiliar situations only structure, precision, hard work and punctuality are desired. In contrast, a community with low UAI is less aggressive when it comes to tolerance of unfamiliar risks and situations, and differing behaviours and opinions (Hofstede & Hofstede, 1991).

4.6.1.5 Long-term versus Short-term Orientation

The difference is presented in terms of separation of western and eastern countries for Long-term orientation. Western countries are more focused on belief and the search for the truth, contrary to eastern countries that are more focused on application and virtual behaviours (Hofstede & Hofstede, 1991).

4.6.2 Attributes of Culture That Affect User Interaction with ICTs

4.6.2.1 Age

Many studies presented by Gerontologists prove that age has an effect on physical and cognitive abilities of human which in turn affect the way older people interact with technology (Owsley et al., 1991). For instance, elderly users have shown a decline in higher order cognitive processes, such as attention and speed instance, in tasks that required rapid performance (Owsley et al., 1991). Also, a decline in, physiology and neurophysiology of the eye has been found as a consequence of aging (Darin et al., 2000). Age may lead to deterioration of visual sharpness, that is, vulnerability to glare and colour perception. Increasingly, age-related differences are a result of income inequalities, cognitive and perceptual abilities, and attitudes and beliefs (Charness & Boot, 2009).

Some differences in age are presented in speed of task completion between younger and older users. Older adults tend to be slower when using ICTs because they take time to plan their actions more carefully to increase accuracy. Also, they may fear exploration of technology through trial-and-error to avoid disruption of the device, from lessons learned

earlier in life that a device must be treated with proper care (Harrington & Harrington, 2000). As a result of aging, elderly users develop computer anxiety which contribute indirectly negatively to interests in adopting the Internet and computers (Carstensen & Mikels, 2005). This may also be caused by deteriorating fluid intelligence which they have to depend on when acquiring new skills, therefore, requiring longer training periods and a great number of errors before grasping the concept. This is supported by the evidence from Kensinger (2009) that old age comes with cognitive decay, this means that, although crystallized intelligence (mental ability) remain strong into old age, fluid intelligence (learning ability) declines with age. There is empirical evidence suggesting that older adults are more probable to forget and take longer to reach a level of proficiency than younger people (Dickinson et al., 2007).

A study conducted on different users of ranging age revealed that the observed error frequency, the number of interaction steps, the success of physical operation methods, the rigidity of exploration and the subjective perception of temporal demand and performance were affected by age (Kang & Yoon, 2008). Older adults' performance is affected by belief of being too old to learn new technology before even attempting to use technology. This is evident in study which proved that the negative self-belief shown by the older users is a consequence of negative stereotypes held by tutors training the older users which results in poor performance (Hawthorn, 2007). However, anxiety of technology use in older adults may be mediated by perceived usability and benefit of use for a particular type of technology (Venkatesh & Davis, 2000). Charness & Boot (2009) maintain that the UI's complexity contributes to computer anxiety in adult users because it is not designed for their capabilities, including motor, physical and cognitive capabilities.

Hawthorn (2007) labels older people as selective computer users, arguing that they are not entirely avoidant of technology; rather avoidant of errors by limiting the tasks they perform to those they are familiar with. Since young people view technology as a form of entertainment, they show more willingness to learn as compared to older adults. Given that the elderly have a limited time to live; this might also contribute to their lack of interest in technology which may be seen as useless and a waste of time.

4.6.2.2 Gender

Gender variation is not merely bound by biological sex differences instead it is governed by cultural constructs (Silverstone & Hirsch, 1992). In principle, they are generated through dichotomies which order our world (e.g. black/white, up/down) and which are also typically hierarchical (Goodison, 1990). Through cultural processes, gender conveys a differentiation in appearance and behaviour, action, thought, and language mapped onto male and female bodies (Silverstone & Hirsch, 1992). These differences also include variations in terms of: importance where, in some cultures, females represent the weaker gender and the males the stronger gender; and colour, for example pink/blue. In addition, Silverstone & Hirsch (1992) emphasize gender is usually linked to aspects of an individual's social status.

The differences in gender attitudes and use in ICT dates back to the time when computers were used by white males in research and administrative offices for advanced math classes, while females used them for word processing in secretarial classes (Linn, 1999). The gender distribution of ICT access is one-sided, leaning more to men than women, in that men can access the Internet from both work and home while women are most probable to access it from educational institutions (OECD, 2009). There are specific structural inequalities that make up the barriers to accessing ICT for women in the rural areas; these include (Huyer & Sikoska, 2003; Hafkin & Taggart, 2001):

- Economic inequality
- Lower literacy and education levels especially in languages used in ICTs
- Traditional cultural beliefs and practices
- In rural areas where women are viewed as caregivers, the time women have is limited due to their domestic roles and productive responsibilities
- Disadvantaged geographical locations: women tend to live in rural areas where there is little or no infrastructure
- In addition to this, ICT decision-makers and designers are males hence women do not really relate to it.

Hafkin & Taggart (2001) argue that technologies are shaped by a gendered context instead of a social one which is disadvantaging for women. In addition to this, new technology tend to be expensive and with wealth often favouring male counterparts, it is no wonder women, the poor and rural residents are always the last, if at all, adopters of technology (Huyer &

Sikoska, 2003). It has been noted that the reason behind males being early adopters might be because males have a dominant role in most societies hence able to afford technology before women could (Pavlik, 1998). Women are viewed as caregivers who have no time to interact with technology instead of professionals. Access to household assets is affected by gender in rural areas, for instance, in a home with one radio, there is a high probability of the women neither listening nor even be allowed to join the men in listening to the radio.

Gender differences are also visible in how males and female judge their own computer skills and self-efficacy in relation to how they perform ICT-related tasks. Males are said to be more capable of dealing with advanced high-level ICT skills such as programming and downloading new software as compared to women (Broos, 2005). A study carried out by Broos (2005) on gender aspects established that women showed a greater computer anxiety than men, this implying that women are more hesitant while men are self-assured. Although computer experience has a positive impact on increasing confidence on technology therefore decreasing anxiety for men, the opposite is applicable for women (Broos, 2005). Females perceive technology differently from males, for example, females view the computer as a tool, while males view the computer more as a toy for entertainment (Sorensen, 2002). This explains the why females spent most of their time on the computer sending e-mails and males playing games (Teasdale & Lupart, 2001). This is evident in reports that women show less ease and comfort in adapting to technology as compared to men.

An argument about the masculine design of technology as a factor that drives females away from technology has been raised. Tailoring ICT tools to be specific to women's needs by installing a sense of ownership to ICT can overcome the gender imbalance (Hafkin & Taggart, 2001). During a study on mobile Internet use at Khayelitsha, Cape Town, there were difficulties in women using the mobile Internet which echoed on common gender differences in ICT use (Donner et al., 2011). The women were unaware of mobile Internet on the phones they already owned or found it too intricate while others relied on male counterparts to use it for them.

4.6.2.3 Education and Literacy

The difference between education and literacy is sometimes blurry, especially when it comes to ICT use but for this research, the importance of education/literacy is in the ability to read and write. Literacy is defined as the ability to read and write in at least one language (Big

Foot, 2009). Education is more of a process which enables the ability to think, question, observe, learn, understand and apply knowledge (Marian, 2012). Some of the benefits of education include (Marian, 2012):

- Broadening the horizon and giving an individual a better understanding of how things work around the world
- Better problem solving skills and higher self-esteem
- Ability to think rationally.

Papen (2005) maintains that being literate is strongly related to being educated and knowledgeable. In relation to ICT literacy, a barrier in acquiring the relevant skills are presented by limited skills in areas such as numeracy, reading and problem solving (OECD, 2009). In addition to basic literacy, scientific and technological literacy are also a necessity to help with grasping concepts of basic operation such as Internet connection (Huyer & Sikoska, 2003). Studies conducted in Malawi and Ethiopia have shown that English is a strong influence in education therefore being educated was considered the same as knowing English and being literate considered synonymous with being able to read, write and communicate in English (Geldof, 2010).

Other forms of literacy in ICT include digital literacy and ICT literacy. Someone who is digitally literate is defined by Bawden (2008) as possessing the following:

- Literacy and underpinned by basic skills (computer/ICT literacy)
- Background knowledge, assumed of any educated person
- Central competencies reading, creating, communicating and understanding digital/non-digital formats
- Attitudes and perspectives – independent learning and social literacy, to help understand issues of sensible behaviour including privacy and security.

Digital literacy is related to media literacy because it addresses issues related to digital residency including social, human, cultural and ethical issues. It stresses the significant role of digital mass media of expression and also considers their characteristics, merits and limitations (Martin, 2005). Some of the attitudes and expressions can only be acquired through education. On the other hand, the definition of ICT literacy provided by Lennon et al., (2003) proves that without education or literacy, interaction with ICT may prove to be a difficult task; ICT literacy is the interest, attitude, and ability of individuals to appropriately

use digital technology and communication tools to access, manage, integrate, and evaluate information, construct new knowledge, and communicate with others in order to participate effectively in society. Therefore there is a need for, at least, basic literacy for successful interaction with technology.

Many South Africans from marginalized areas are only able to identify letters in the alphabets but do not have adequate reading or writing skills enough to apply this knowledge in a useful manner (Kirsch et al., 1993). This phenomenon is termed as functional illiteracy. Kirsch et al., (1993) defines functional literacy, that is, "the ability to use reading, writing, and computational skills at a level adequate to meet the needs of everyday situations". This is an irony in that the older generation, typically living in these marginalized areas, depend on government services which are presented in writing. This means that the functionally illiterate have to be considered when designing user interfaces.

4.7 Conclusion

This chapter covered literature on personas including their purpose, benefits and how they are developed. It has been discussed in previous chapters that the way users (personas in this case) behave and interact with technology is affected by their socio-cultural surroundings and experience, hence the discussion on the effects of culture on interaction with ICTs. Furthermore, the attributes of culture that were identified through literature that are said to affect user interaction with ICTs were discussed and will be used in latter chapters for usability tests on identified personas. It is important to note that literacy and education will be used in the context of users' ability to read and write for this research. Finally, the dimensions of cultural diversity were identified and discussed. In the next chapter, results and analysis of UX evaluation and mapping are provided.

5 UX EVALUATION AND PERSONA MAPPING

5.1 Introduction

This chapter addresses one of the research objectives of this research, objective O2: "*Profiling of the users based on the identified UX factors and answers questions"* Q2: "*Who are the users of ICTD services?"* and Q4: "*Which UI and interaction techniques best suits the profiled users?"* Roto et al., (2011) maintain that the distinction between UX and usability is blurred out due to the dependency of UX on usability. Usability is both objective and subjective therefore adequate for measuring UX. It is for this reason that the usability tests will measure user satisfaction with the SUS using a 5-point Likert scale. This section provides a summary of how UX was evaluated through usability tests. The first section discusses how personas were identified from the performance of the 10 participants in the first task. These personas were then given further generic tasks to test for usability of interfaces and different interaction modes. The tasks were used to analyse three functional areas: device usage, user differences and context of use. The methods described in Section 2.4.1.5 were used in this evaluation. The aim of this chapter is to define and map personas against the UX factors that are being evaluated. Section 5.3 provides the analysis of the results obtained from the usability tests.

5.2 Persona Identification

Spence (2010) and Huyer & Sikoska (2003) suggests that the use and accessibility of technology is dictated by socio-cultural conditions which introduce imbalance in power relations such as age, gender and literacy. These socio-cultural conditions were used in this research to profile the users that exist within the Dwesa community. The selected participants represented users from the three age groups, 16-30 years; 31-50 years; and 51years and above. On each of these age groups, participants representing illiterate and literate users were selected. These participants also represented the two genders for both literate and illiterate users. Therefore, in total 10 participants took part in the first round of task analysis with the purpose of deriving personas. The reason why only 10 participants were selected instead of 12 is because there were no illiterate people identified in the 16-30 years age group. Table 5.1 shows the information on participants used to identify personas.

Table 5.1: Participants in the First Task

Age	16-30 years	31-50 years	51 years+
Literate	Female	Female	Female
	Male	Male	Male
Illiterate	None	Female	Female
	None	Male	Male

The following task was used in identifying different personas that exist within the rural context of Dwesa, which was presented to the participants as a scenario: "Go on YouTube and play your favourite song". The number of steps and the time (in minutes) it took to complete the task were used to measure user performance. In addition, the number of questions the users asked during task performance was recorded. Finally, whether the user completed the task or not was also recorded (see Appendix C). Participants who did not complete the tasks do not have time, number of steps and questions values. Figure 5.1 represents uncompleted tasks as zero and completed tasks as one.

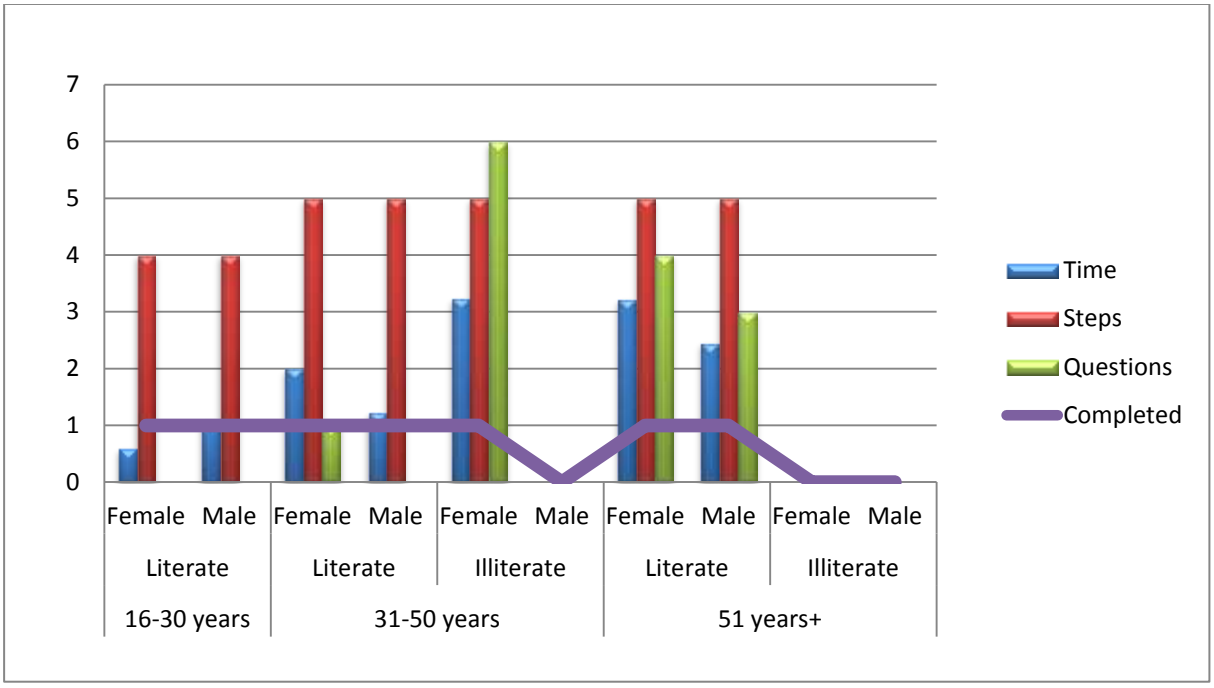

Figure 5.1: User Performances in Task 1

The results from the first task (as shown in the Figure 5.1) show that there was no significant difference in task performance between males and females in the age group 16-30 years. Therefore one persona was derived from that age group (i.e. 16-30 year old literate

individual). There was a difference in task performance from users in the 31-50 years age group. The performance was gendered and literacy was meaningful. Therefore two personas were derived from this age group representing those who are illiterate and literate taking into consideration the gender. In the 51 years+, the performance in the task revealed that literacy plays a bigger role than gender in ICT use, therefore two personas representing literate and illiterate users were used. Although gender did not seem to affect the way this group of users, the personas represented both genders to create a balance and for testing reasons. The personas were constructed using the demographic information obtained from the questionnaire and are presented in Appendix A. The following is a summary of the personas (see Appendix D):

- Persona 1 (Thoko) – represents users in the 16-30 years age group who are interested in social networking and surfing the net.
- Persona 2 (Litha) – represents users in the 31-50 years age group who are literate and use ICTs to stay connected through calls and emails.
- Persona 3 (Zenande) – represents users in the 31-50 years age group who are illiterate who use ICTs to stay connected through calls only.
- Persona 4 (Nomnyama) – represents users in the 50 years+ age group who are literate and who are not interested in any features if ICTs but only concerned about staying connected
- Persona 5 (John) – represents users in the 50 years+ age group who are illiterate and not interested in learning about new things but are concerned about staying connected.

5.3 Results and Analysis

Only users representing the different personas undertook the usability tests which is in line with an argument made by Nielsen (2012) that only 5 participants are needed for usability testing and anything above that is useless (see Appendix D). From here on, the personas are referred to by their fictional names. The results from the usability tests indicate a variation in user performance on the text entry task (see Appendix E). The minimum number of errors across all the interfaces for all personas was (Min=9) and the maximum errors (Max=25). Thoko was highly effective (least errors) when using the mouse and keyboard (Mouse/k in Figure 5.2), in contrast, John was least effective using the mouse and keyboard for the text entry task, consequently accounting for the maximum number of errors across all interfaces.

The Swype keyboard (SwypeK in Figure 5.2) accounted for long completion times for text entry with one of the participants not completing the task. The maximum time spent on the Swype keyboard was (Max=8.02m) and the minimum time was (Min=2.38m). The graph shows that overall; Litha was more efficient and effective with the four interfaces for text entry while John was less effective and the least efficient with all four interfaces. In addition, the personas were more efficient and effective with the QWERTY UI which accounted for the minimum completion times, number of steps and error rates with the exception of Litha who was more efficient and effective with the mouse and keyboard. On average, the time it took users to send an email was (Mean= 4.37m).

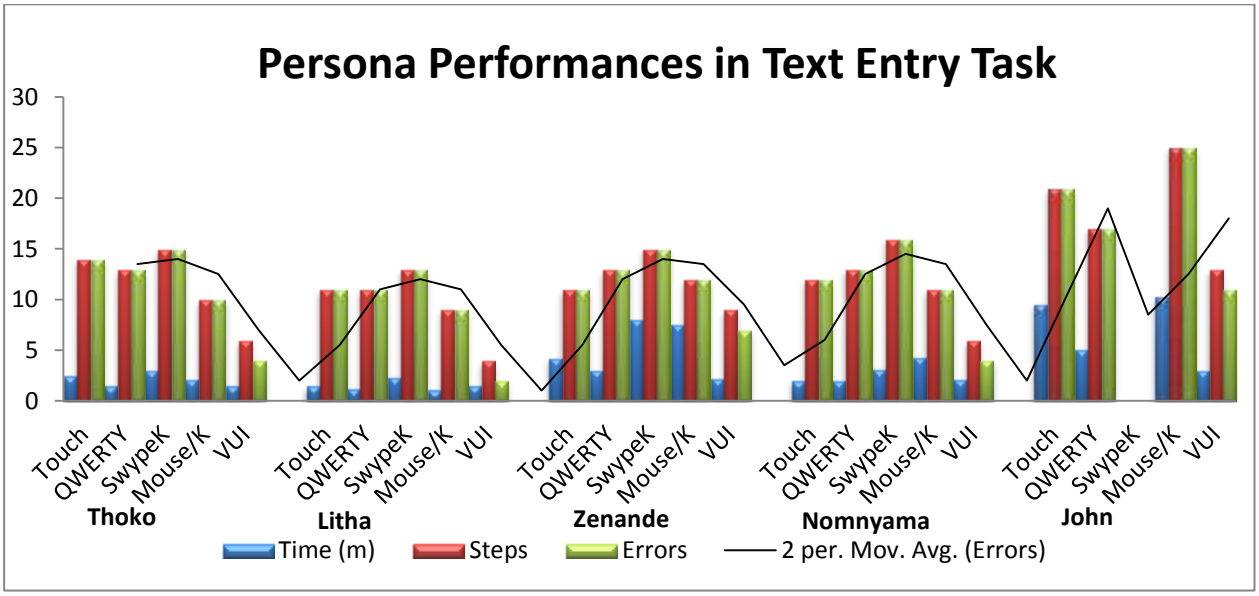

Figure 5.2: Persona Performances in Text Entry Task

The average completion time for navigation and selection using touch interface was 0.25m, whilst the average completion time using Tab & Enter was 0.50m and for Scroll & Click the average time was 0.52m. Thoko obtained the lowest combination of task time, number of errors and number of steps it took to complete the task using the touch interface as compared to the other personas. The number of steps it took to complete this task was much higher using Tab and Enter than the other interaction modes (Max=8 and Min=5) and this is illustrated in Figure 5.3. Contrary to the aforementioned, the maximum number of steps for touch and Scroll & Click was (Max=3) whilst the minimum was (Min=1). On average, the touch interface accounted for most of the errors (Mean=1.2) against (Mean=0.8) for Tab & Enter and (Mean=0.6) for Scroll & Click. The ranges for the minimum and maximum across the three interaction modes are reported as follows: touch (Min=0; Max=2); Tab & Enter

(Min=0; Max=2) and Scroll & Click (Min=0; Max=3). The Scroll & Click errors are accounted for by one persona (Zenande).

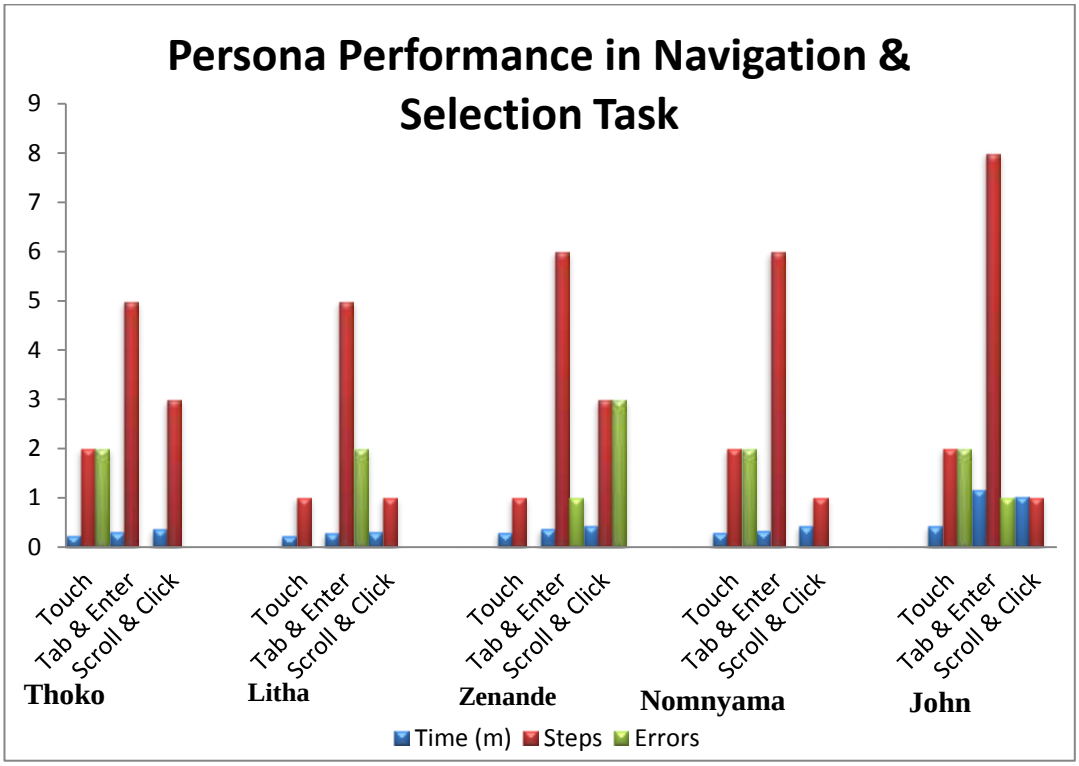

Figure 5.3: Persona Performances in Navigation & Selection Task

For the task that was testing the effect of layout on user performance, the users were given a random number to input in three different number keyboard layouts. These included a 3x4 keyboard from a mobile phone (3x4 K/b) and the PC keyboard. The numbers are located across the top of the keyboard (PC keyboard1) and in some cases, on the right hand corner of the keyboard on the numeric keypad (PC Keyboard2), in the QWERTY PC keyboard. The numeric keypads in the PC have a similar layout to that of the calculator, whereas the phone layout (3x4) is different but similar to the ATM. The calculator style keypad has '123' on the bottom and the telephone style keypad has '123' at the top. The PC keyboard number layout was divided into PC keyboard1 (labelled PC K/b1) and PC Keyboard2 (labelled PC K/b1 in Figure 5.4). The most important factor of usability to test for in the number interfaces is the effectiveness of the system. Three different 15-digit random numbers were given to the personas to input in each of the keyboards, these included the characters '*' and '#'. Number input using the 3x4 keyboard produced less errors across the five personas as compared to the other two keyboard layouts (Min=0; Max=6). On average,

the errors on the three keyboards were as follows: for the 3x4 keyboard (Mean= 1.4), PC keyboard1 (Mean= 3.8) and PC keyboard2 (Mean=2.75). Thoko and Zenande were highly effective with the 3x4 keyboard. The time it took to complete a task on average using the 3x4 keyboard was 0.55m, whilst it was 1.34s for the PC keyboard1 and 1s for PC keyboard2. Litha completed the number input task on PC keyboard1 with the least time as compared to the other personas across all the keyboards. John completed the task in the least amount of time (2.21m) using the PC keyboard2 layout compared to the other interfaces. The number of steps it took to complete a task were around a minimum of (Min= 15) and maximum (Max=22).

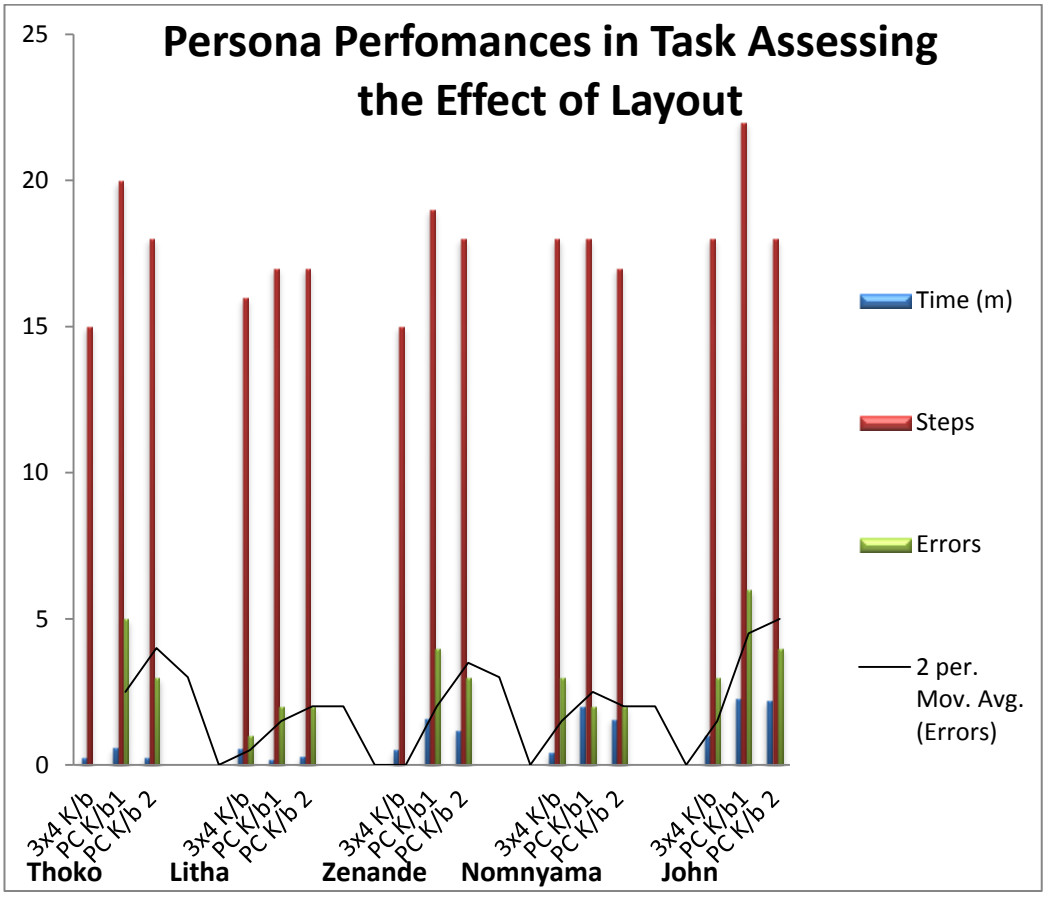

Figure 5.4: Persona Performances in Task Assessing the Effect of Layout

The task for sending an email was used to compare the performance between literate and illiterate participants. Due to the uneven distribution of the participants between the literate and illiterate group, the weighted averages were calculated with consideration to the number of participants in each group. An independent T-test was used to analyse the data to help formulate the averages and standard deviations (SD) of the participants' performance using

literacy as a constant. Among the participants (N=5) who performed the task of sending email using touch, QWERTY, Swype keyboard and the mouse/keyboard interface, the literate user group (N=3) was associated with a task completion time using touch Mean=2.04m (SD=0.46). By, comparison, the illiterate user group (N=2) was associated with a numerically higher task completion time Mean=7.31m (see Appendix F). The literate user achieved lower task completion times as compared to the illiterate users with the exception of the Swype keyboard interface (presented as SwypeK in Figure 5.5). This was because only one of the two completed the task using Swype keyboard. The difference in performance times was greater when the participants were using the mouse and keyboard interface than between the two user groups (6.43m).

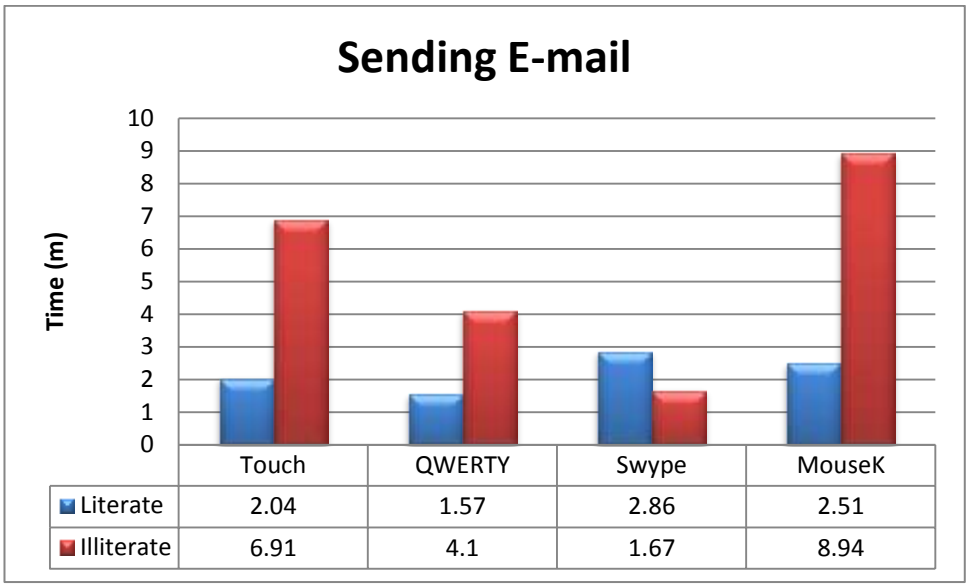

Figure 5.5: Comparing Efficiency (Time) for Literate and Illiterate Users in Text Entry Task

A comparison between male and female participants in text input task for sending email and web browsing indicate that females are more efficient when compared to the male participants. An independent T-test was used to compare the means of the two genders. Among the participants (N=5) who performed the text input tasks using touch QWERTY, Swype keyboard (SwypeK) and the mouse and keyboard (MouseK) for sending email; and using QWERTY (QWERTYw) and VUI for web browsing. The male participants (N=2) was associated with higher error rates (see Figure 5.6) compared to the female participants (N=3) with the exception of input using the Swype keyboard (Mean=3; SD=4.24). The female participants had an average of (Mean=8.33) errors with SD=0.58 (See Appendix G).

There was not much difference between males and females in the tasks that required the input of text using a QWERTY keyboard (Mean=7 for males; Mean=6 for females) and using the VUI (Mean=6.5 for males; Mean=5 for females). A significant difference is presented in the tasks for task input using mouse and keyboard (Mean=10 for males; Mean=4 for females) and QWERTY (Mean=10.5 for males; Mean=4 for females).

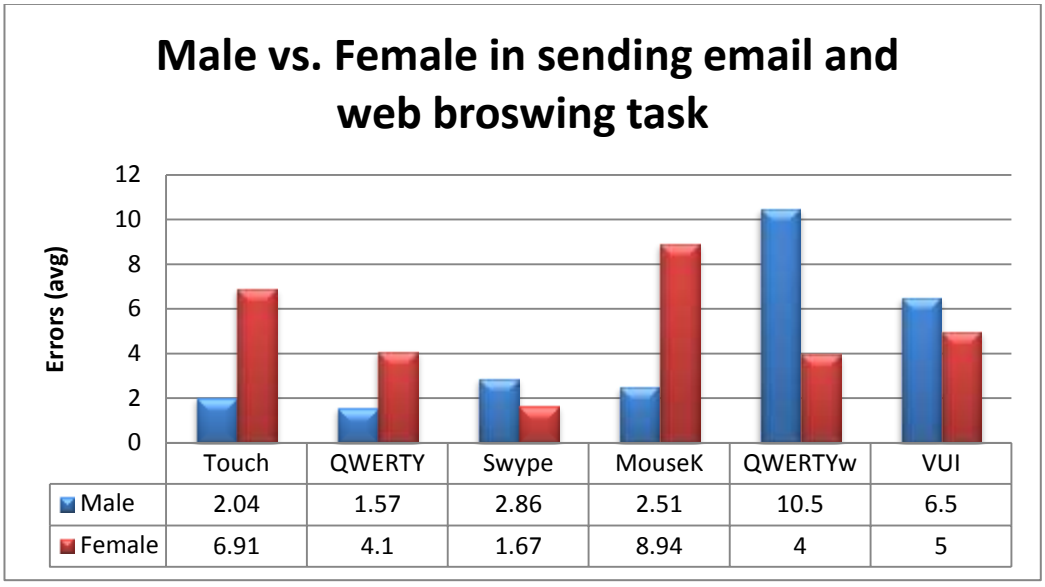

Figure 5.6: Comparing Male and Female Users' Effectiveness (Errors) in Sending Email and Web Browsing Task

Results from the SUS not only show user satisfaction with the interfaces but also the ratings of the interface according to the scale provided by (Bangor et al., 2009). The scale is a representative of the level of acceptability and usability. User satisfaction was measured for the different interaction modes which were representing different UX components. Table 5.2 shows the scores obtained from the SUS. The meanings of the scores are also included in the Table 5.2. These scores represent the mean satisfaction rate of the interfaces between the users across all the personas because the scores from individuals are not meaningful on their own (Bangor et al., 2009). The results from the SUS survey show that users were more satisfied with the touch and voice interface for text entry (Table 5.2). The QWERTY and Mouse/keyboard interfaces were also rated as good by the personas. The Swype keyboard had the lowest satisfaction score, this was reflective of the task completion time for Swype keyboard (Max=8.02m) which was high for all personas in comparison to the other interfaces.

Table 5.2: User Satisfaction Results for Text Entry

Text entry					
	Touch	**QWERTY**	**Swype keyboard**	**Mouse/keyboard**	**VUI**
Score	71	67	34	56	70
Meaning	Good	Good	Poor	Good	Good

The personas were more satisfied with the Tab & Enter method of navigation and selection with a SUS score of 96 meaning it is the best imaginable according to user satisfaction (Table 5.3). The Scroll & Click had a 'good' rating from the overall user ratings. Even though the number of steps personas took to complete the task using the Tab & Enter mode of interaction (Max=8 and Min=5), the mode had less errors.

Table 5.3: User Satisfaction Results for Navigation & selection

Navigation & Selection			
	Touch	**Tab & Enter**	**Scroll & Click**
Score	93	96	61
Meaning	Best imaginable	Best imaginable	Good

The task of dialling 15 randomly chosen numbers and characters were to test for usability of different keyboard layouts. The personas were more satisfied with the 3x4 keyboard which was presented in a mobile phone (Figure 5.5). The PC keyboard 2 was rated 'good' by the personas with a score of 65. The PC keyboard 1 which places numbers in a sequential manner receives a score of 77.

Table 5.4: User Satisfaction Results for Layout

Layout			
	3x4	**PC keyboard1**	**PC keyboard2**
Score	97	77	65
Meaning	Best imaginable	Excellent	Good

The participant's satisfactions using the various modes of interactions are represented graphically in Figure 5.7.

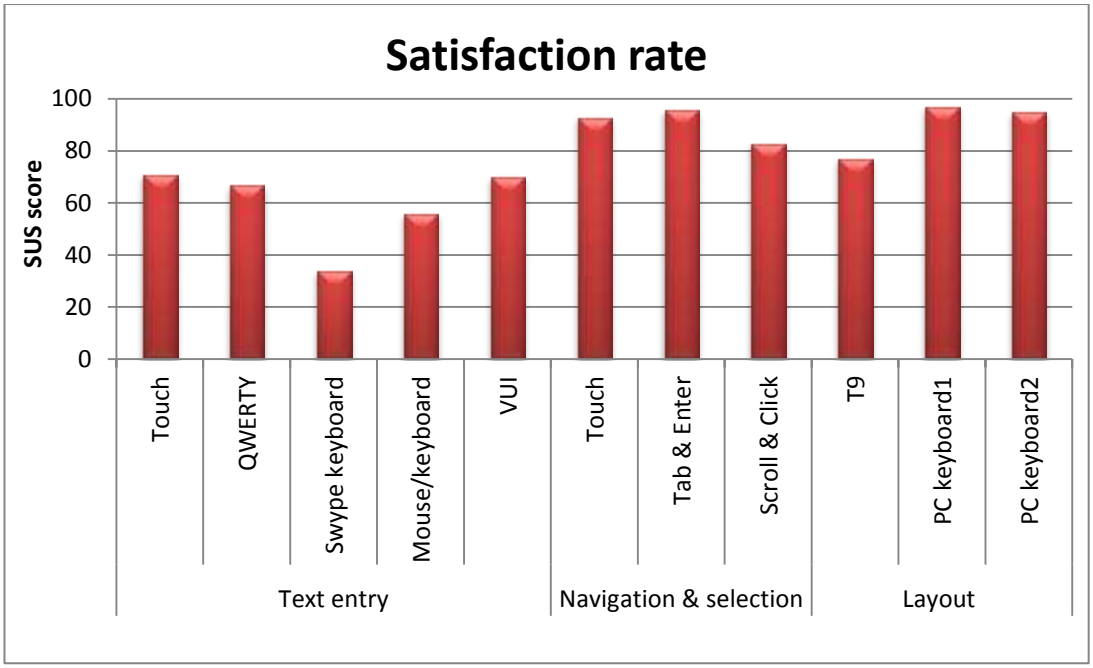

Figure 5.7: Persona Satisfaction Rate

5.4 Conclusion

This chapter presented the personas identified in the rural context and how they were identified; this addresses objective O2 of this research. The personas were further presented with usability testing tasks which were used to quantify effectiveness, efficiency and satisfaction. The results obtained from the usability tests were presented for both objective and subjective measures of usability (see Appendix E). Subjective information was essential to map UX to the users. For a system to be considered as that which has delivered a good UX, it has to be usable. In this research, literature on what affects UX has been reviewed (see Section 3.4.1) including how it relates to usability. Since UX of ICTs involves interaction techniques and UIs, this research has also provided a review of different interfaces and interaction techniques that users can use to access information. This contributes to human computer interaction with focus on users from the rural areas. A focus on rural area users introduces the concept of culture which shapes experience and attitudes of users towards ICTs. The next chapter discusses the results, thereafter presents the proposed UX framework.

6 DISCUSSION AND RECOMMENDATIONS

6.1 Introduction

The acceptance of any service or technology by users depends on their attitudes which are influenced in turn by their needs and perceptions which are based on the socio-economic and technological realities. Hence, this study focused on mapping the personas that exist within rural contexts including their socio-economic realities, environmental conditions and technological realities. A poorly thought out UX design may present problems which in turn affect user satisfaction, these may include: navigation problems, confusing menus, and difficulty to locate information. Understanding specific needs of MRA users is an important factor in tailoring services according to the user's needs to increase usability of ICTs according to Lalmas et al., (2007). This chapter discusses the results obtained from the usability tests introduced in Chapter 5. Together with the aforementioned usability evaluations, a complete framework applicable for either designing for UX or usability of interfaces or specifically, to understand the types of users available within a marginalized rural context is presented. This addresses objective O4: *"Propose/come up with recommendation for UX/HCI in ICTD of this research"*. The proposed framework also takes into consideration the dimensions of cultural diversity.

6.2 Discussion

This research used a within-group type of usability testing which required all selected participants to take part in all the tasks (Lazar et al., 2010). This was to ensure that personas are subjected to all the types of interaction modes and UIs that were being tested to come up with a concrete recommendation. Effectiveness was measured by the number of errors the participants made during task performance. The number of steps and time it took for participants to complete a task was used to measure efficiency. Finally satisfaction was measured using the SUS with Likert scale.

Measuring UX has trade-offs, as a result it is subjective and highly dependent on the context of use. For example, efficiency is important in tasks that are time sensitive, therefore needing UIs that cater for faster interactions, whilst effectiveness is more relevant in tasks that cause a change in the state of the system when a user makes an error. These types of systems require an interface that is less subjected to errors since users from low literacy

backgrounds are usually alarmed by a change in system which they did not expect. Some of the users fail to return back to the system's original state. Completion time is not correlated to the number of errors, i.e., completion time does not increase with error rate. Some of the participants took longer to complete tasks because of fear of making an error that they would be unable to recover from. However, the number of steps a participant took to complete a task can be used as a reflection of errors, only when there are no alternatives to the method used to complete the task.

The task of sending an email which required interaction with the GUI through text input revealed that most of the participants were unfamiliar with this mode of interaction which caused anxiety for most of the participants thereby increasing task completion times. This is because most of the participants only used their phones for making and receiving calls. The personas were more confident with the task of checking balance using IVR because the voice prompts were in their local language. This task is reflective of everyday form of human communication especially in rural areas which are mostly auditory, such as listening to the radio. This is much more effective if presented in a native language. These types of communication mediums are different from reading because they require listening then applying.

Several limitations were uncovered on the task for checking balance on the GUI which yielded text output where some of the users did not know which number to press because of the textual descriptions and the inability for some of the users to interpret the message because more than one number was provided on the output. The completion rates were only high and efficient because they received direct instructions on which number to press next. Difficulties were also revealed when the personas were interacting with a touch interface. This type of interface caused anxiety to users who were unsure of where to locate the keyboard.

The personas were more drawn to the VUI although it misinterpreted most of their words due to their accent. The participants liked the idea of an "understanding" interface. Some of the participants referred to it as "the talking technology"; whilst others exclaimed that "it was just like trying to communicate with a person who does not understand IsiXhosa". This therefore, made them feel more at ease and willing to interact with the interface regardless of the number of errors generated. It is worth noting that UX involves how a user feels after interacting with a system. This is evident in the case where the users were more satisfied

with the VUI which had a low efficiency and effectiveness rate but was still considered as satisfying and enjoyable because it was more intuitive for the participants.

For navigation & selection, the results show that users were more satisfied with the Tab & Enter interface which afforded a chance to see where they are every time in the screen. This interaction mode required a lot of steps but the users preferred it over the mouse which they could not move once it reached the end of the table. Also, it afforded the users a chance to think about their next actions. Interacting with the UI using touch is still not natural with most of the users but they appreciated its direct manipulation nature. The participants were not comfortable with touching the mobile phone's screen as one claimed that "I don't know what will happen if I push it too hard". The elderly participants were the most anxious with using this interface. In addition, most of the users did not know how to undo an action that they had performed incorrectly or selected by mistake. It is evident that some assumptions which can be considered an advantage by designers can be mismatched to what the users will perceive as advantageous. For example, designers claim that one advantage of a mouse is that it requires less physical space but for the tasks that required the use of navigation using the mouse, some of the participants lifted up the mouse to another position to move the cursor because they were not aware of what the designers thought was an advantage. In addition, the participants complained about the confusion it caused with regards to hand-eye coordination. One participant mentioned that "I didn't know whether to look at the mouse or the screen to ensure the mouse is moving in the right direction".

All of the participants were comfortable with locating and typing numeric inputs, but most of them spent most of their time trying to locate the symbols '*' and '#' especially on the PC interface. The difference in keyboard layout between the PC and mobile phone interface played a role in the effective completion of the dialling a 15-digit number task. The participants would press '2' instead of '8' in the PC interface. This might have been caused by the fact that the mobile phone, with which most of personas are familiar, uses an inverted keyboard. High efficiency and effectiveness was achieved by the personas during interaction with a 3x4 keyboard because of familiarity. Most of the participants owned a phone which has a 3x4 keyboard.

The results demonstrated that female were more effective in the text entry than males. This is a consequence of the skills and experiences in the male group, where only one participant was literate out of the two participants. This is substantiated by evidence from usability tests

results that have illustrated that literate participants were more efficient and effective in the tasks (See Figure 5.6 and Appendix E). In addition, of the two males, only one owned at least one form of ICT, in contrast the female participants all owned at least one form of ICT (see Appendix D). Again, out of the three female participants, only one was illiterate but the experience with technology has elevated their chances of a better experience that the persona who did not have any experience with technology.

The trends in persona performance illustrate that interaction is influenced more by literacy than by age (see Figure 5.2, Figure 5.4 and Figure 5.5). This can also be noted in the results, Litha is educated and obtained the lowest task completion times with a few number of steps and less errors. Litha is the youngest and literate with completion times and errors almost similar to those of persona 1. Despite being older than Zenande, Nomnyama has also performed better in the tasks and was more comfortable than the illiterate persona in the same age group (John). It can be concluded therefore that from the three factors of culture affecting user interaction with ICTs (Section 4.6.2); literacy has a significant effect as compared to gender and age.

The use of the SUS was essential in understanding users' subjective views on the different UI's. Recalling definition of UX discussed in Section 3.4, UX is highly concerned with the users' internal feelings when interacting with a system, these shape the user experience. The results Table 5.2, Table 5.3, Table 5.4) obtained from the usability evaluations echoes Tractinsky et al., (2000) on the statement that "What is beautiful is usable." Users perceive usability through the appearance of the ICT. For rural area users this may be a disadvantage caused by power distance issues where they view what is beautiful as luxurious and costly. Overall, the Likert scale revealed a positive to strongly positive responses to the use of QWERTY, touch, VUI, IVR, 3x4, PC1 and PC2 from persona 1, Litha and Nomnyama. These responses revealed that these personas found the above mentioned UIs and interaction modes usable and easy to learn. They commented that their features are simple, intuitive and easy to navigate. In contrast, scores from these personas individually, revealed that they were unsatisfied with the usability and learnability of the Swype keyboard interface. Litha is an exception because they gave a neutral or mild response to satisfaction with the Swype keyboard. The participant representing the persona commented that the interface can become easy to use with frequent use. In addition, the participant felt that it is more suitable for literate users who are familiar with text entry tasks.

Responses from Zenande tended towards negative to strongly negative responses on the usability and learnability of both the mouse and keyboard and the Swype keyboard interface. The persona complained about how uncomfortable they felt when using the mouse and how the Swype keyboard is for the literate because it solely involves tracing characters that the user already knows. The persona exclaimed that the Swype keyboard is only possible to use for those users who do not need time to think about which letter to press next. The persona rated the touch interface neutral, commenting that it is intuitive and easy to use but it is not seamless or fluent. Nomnyama rated the QWERTY, touch, mouse keyboard and Swype keyboard with negative to strongly negative usability and learnability scores. The persona found the VUI fairly usable and learnable. In addition to this, the persona commented that these interfaces were more suited for literate users since they do not provide affordances or guidance for novice users. Across all personas, the participants were happy with the DTMF (IVR) and ASR (VUI) interfaces, this reflecting that implementation of speech interfaces can improve UX of ICTD services and information access. From the SUS scores, it is evident that usability and learnability are correlated.

This research built a guideline for the development of interfaces for ICTD services. This is because the current UIs are designed with a restricted knowledge of the user demographic and their socio-cultural backgrounds and experiences. This research has acknowledged that to meet the need of such a user demographic it is important to broaden the perspective of designing by exploring questions such as who are the users in these environments (rural) and what they conceive technology as, in their lives and how it fits into their context. Answering these questions and ensuring that ICTD services are delivered in UIs with interaction techniques that are aligned with the types of activities and tasks the services offer. Interface choice depends on the goal of the user, for instance, a task that requires users to provide a small amount of information can make use of question-and-answer interfaces (Lansdale and Ormerod, 1994). For larger amount information input from users, form-filling interfaces are more suitable. To ensure that they are compatible for novice users, these can make use of menus. These types of interfaces help the user focus on the task at hand without being disturbed by elaborate graphics. In addition to this view, Lansdale and Ormerod (1994) argue that in most cases, the nature of the task dictates the suitability of a certain interface instead of the type of user.

6.3 The UX Framework/Guidelines

This section presents the UX framework proposed for interfaces and services for ICTD. The framework is based on the qualitative information discussed in literature (Chapter 3 and Chapter 4) and from the quantitative results from the usability evaluations. The framework is divided into two parts; the first part includes information collected from usability evaluations and maps the identified personas to two of the most suitable interfaces. The second part consists of the recommendations formulated from the study of literature and outlines guidelines for design ICTD services. This section addresses objective O4 of this research.

The usability tests exposed several problems that users have when interacting with ICTs including, difficulties to use or identify scroll bars, soft keys, understanding hierarchical structures and nonnumeric inputs. This UX framework is formulated on the basis that users from MRA have a challenge with the current ICTs and focuses on recommending a guideline for such users. This framework proposes the provision of voice annotations, local language support systems, simple menu structures and graphical cues. A study conducted by Medhi et al., (2011) to assess the usability of text interfaces and text-free interface resulted in conclusions that textual interfaces are error-prone for the literate novice users and unusable for novice low-literacy users. As a result, they recommend the use of a GUI and a spoken dialog system for those who can understand the system.

6.3.1 Recommendations Based on Results Obtained from Usability Tests

Figure 6.1 presents an illustration of the results of the usability tests in a visual form. For checking balance, users with the same characteristics as Personas 1, 2 and 4 can be successful using the key-press method. Users with the same characteristics as persona 3 and 5 are going to be more successful on the task of checking balance using the IVR. For text entry, persona 3 and 5 are going to be more successful with using QWERTY and VUI. While, Personas 1, 2 and 3 can successfully complete the task using the touch interface and QWERTY keyboard, persona 2 can also the mouse/keyboard with ease more than the other personas for text entry. The illiterate personas (Zenande and John) and Nomnyama (older) have found Tab & Enter and Touch interface more usable for navigation and selection. This must be due to their accuracy in the task of selection. While, in contrast Thoko and Litha

were more comfortable with the scroll & Click method. Four out of five personas found the 3x4 keyboard more usable (except Litha). In addition, only Thoko and Litha thought the PC keyboard 1 layout was usable.

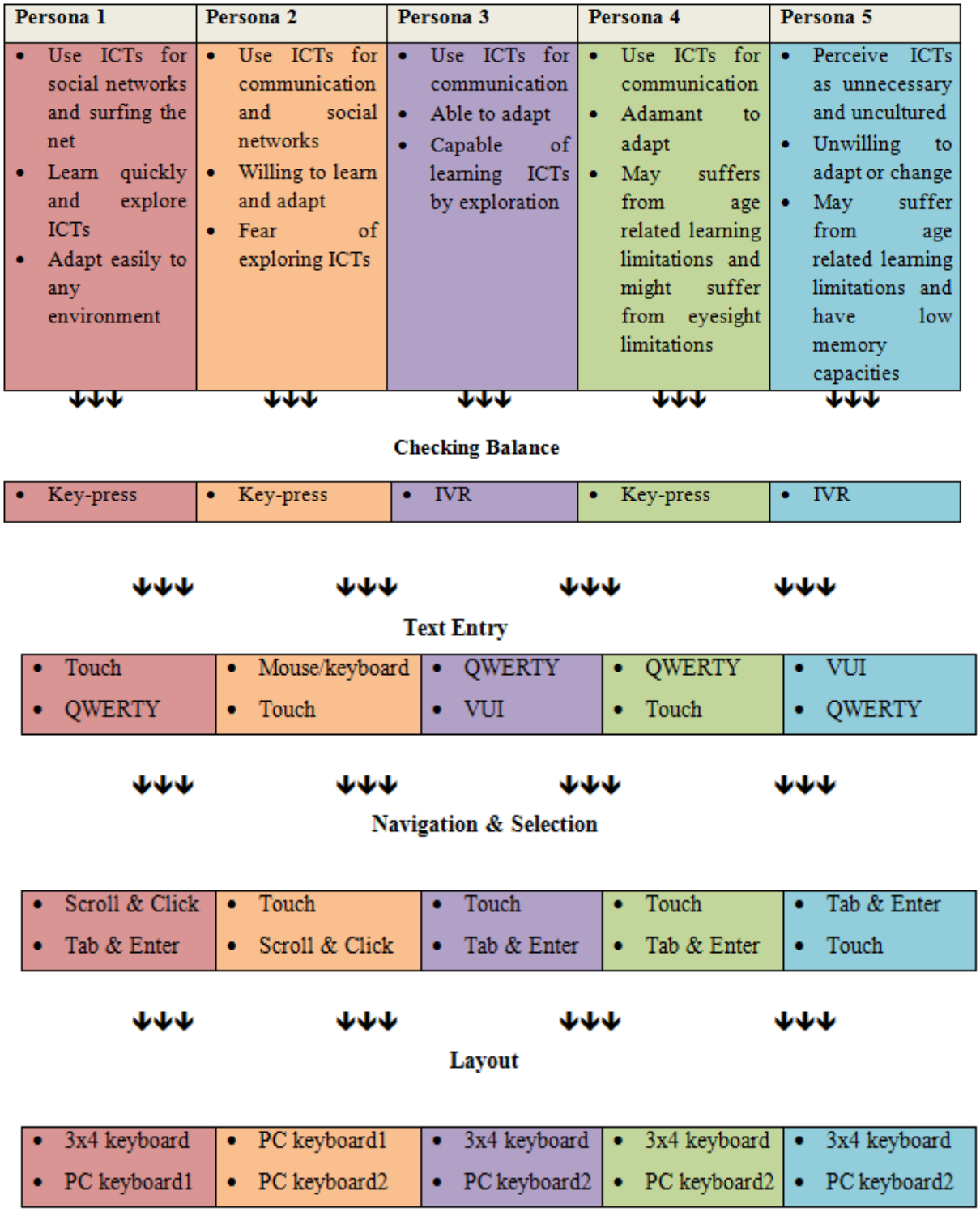

Figure 6.1: Representation of UX from Usability Results

The results of persona performances in the usability tests which forms part of the UX framework/guideline are presented in Figure 6.1. In Figure 6.1, the personas are mapped to the interface most suitable for their skills and experiences as obtained from the usability tests. The personas are mapped to the relevant text entry methods, navigation & selection and their preference of keyboard layout. This guideline can be used together with the following guidelines presented in Table 6.2 to develop interfaces for ICTD services.

According to (Deo et al., 2004 and Medhi et al., 2006) an interface that can successfully accommodate novice or illiterate users has to meet one or more of the following requirements: provide ease of resemblance to ensure ease of learning, have no textual requirements, support graphics and possibly speech in local language, provide simple, accurate content and be tolerant of errors, accommodate localization and be robust in noisy and distracting public spaces. Localization of UIs must be subject to accommodate change of the following components to suit different linguistic and native formats: colours, fonts, abbreviations, currency, dates, icons, concept of time and space, register and behavioral systems (Deo et al., 2004). In addition, UIs should be suitable to cultural models of how people work and communicate.

With respect to the barriers observed during the usability tests the following guidelines are proposed for designing UI for MRA and low literacy users. The guidelines are focused on the presentation of content (screen layout) to enable ease of navigation and access, and error handling. The screen layout must be easy to navigate and assistive in terms of users locating information in a time-effective manner. This could be done through providing expected flow of information with the content evenly spaced out and meaningful (Medhi et al., 2011). In addition, the layout should ensure ease of access, i.e., frequent tasks should be readily displayed and discoverable. It should offer intuitiveness, in that elements should be where they are expected to be, e.g. alerts should be displayed at the centre of the screen. Only core elements should be displayed. If possible, meaningful metaphors, icons and images should be incorporated to assist illiterate users. The design should be leading, for example, steps required to complete a task must be sequential or grouped together. For touch interfaces, only the needed control elements should be presented, for example, zooming requires user to stretch out fingers apart whilst touching in two places (Wigdor & Wixon, 2011). Therefore, there is no need for a control element for zooming.

Most of the time novice users prefer not using ICTs as a result of anxiety; therefore the system's error handling facility has to be sensitive to such users. This can be achieved by using consistent terms across different applications, for example, an error message should not include an 'OK' button instead a 'Close' button to avoid confusing the user. This is because the users may fear that they are agreeing to the effects of the error (Medhi et al., 2011). Error messages should avoid the use of words such as catastrophic, abort, kill, failed, illegal and replace with polite terms such as serious, stop, unable, and incorrect (Medhi et al., 2011). This is to ensure that the user is not alarmed and fear completing their task after encountering an error. Text boxes and other data fields should be designed to accept only the valid data types to avoid errors. Finally, help tools must include screenshots instead of lengthy text.

For tasks that are instructional such as form fill-in and question-and-answer, IVR or a human operator in a local language can be used to guide users on the information they need to provide next. The use of an auto completion or auto suggestion tool can assist the users in text entry tasks by suggesting possible words to be typed (Dyakalashe, 2009). Minimizing unlabelled or soft keys can also improve UX.

People from MRAs mostly communicate orally than textually therefore speech interfaces that uses ASR, VUI and DTMF can be very helpful in delivering information and services to these communities. These interfaces accommodate larger user demographics because they only require is the ability for a user to communicate verbally. Their efficiency can be improved by developing interfaces that accommodate different speech dialects especially for rural communities. This is because interface has the ability to function in noisy environments.

6.3.2 Recommendations Based on Literature Review

A study by Sun (2001) about cultural effects on web pages exposes that during the evaluation process of a web page, users take into account cultural priorities. Therefore, web pages with icons, figures, texts, sounds and texts that represent certain cultural symbols increase user satisfaction and ease of use, and as a consequence increase the level of user friendliness. The literature provided in Section 4.6 has shown that culture should be taken into consideration when designing UIs and interaction techniques. The cultural dimension

ratings can be used to deduce the type of user interface design the users would be most comfortable with Marcus (2001). The scores for the cultural dimensions of the Dwesa community were extracted from Edim (2010), see Table 6.1. This information can therefore be applied to design for other communities with similar cultural dimensions. This is meant to increase usability and UX.

Table 6.1: Scores of Dimensions of Cultural Diversity for Dwesa (Edim 2010)

Culture Dimension	Score	Rating
Power Distance (PD)	66.5	Moderate power distance
Masculinity vs. Femininity (MAS)	68	Masculinity
Collectivism vs. Individualism (IDV)	-24.5	Strongly collective
Uncertainty Avoidance (UAI)	122.50	High uncertainty avoidance

According to the information provided in Table 6.2, the following recommendations are proposed for each of the cultural dimensions defined in Chapter 4 (Table 6.2):

Table 6.2: Recommendation on Interface Design Based on the Dimensions of Cultural Diversity (Marcus 2001)

PD	MAS	IDV	UAI
Interactions should be leading, supportive, informative and guiding	Metaphors: the visuals should represent gendered themes	Traditional colours and images of monuments	Interaction, use, and navigation is restricted by clear and strict rules
Neutral and guiding error messages	Mental models: the site should be result and objective orientated	High multi-modality	Choices should be clear, simple, limited and prominent with a high number of metaphors and markers
Appearance: visuals, logos, colours, page layout should reflect a culture or beliefs	Appearance: use of soft colours and figures	Use of local language	Messages, visuals and contents should have direct meanings
Navigation: flat and sequential layout		Localization of interface elements to regional standards such as date, number, currency and time formats	Indicators that relate to use of the site (e.g. site map, important announcements and links)

6.4 Conclusion

The proliferation of computer-based information systems need to be met with ICTs that enable the intended users to fully access these services. Users from MRA are usually unaware of the capabilities of the ICT devices that they own due to the limiting nature of current designs. This therefore introduces the need to clearly map user needs to appropriate functions of devices. Designing for UX requires simplicity to be the key in delivering UI's that are intuitive and usable for such a user demographic.

This chapter analysed the data obtained from the usability tests and formulated the results from them. The results were usability-orientated; they focused on the effectiveness, efficiency and the satisfaction of the users with the system. Following the results, a UX framework/guideline was proposed, addressing objective O4 of this research. The UX

framework/guideline was presented in regards to 3 separate contexts: the first set of guidelines were formulated with reference from tasks given in usability tests results; followed by guidelines formulated from the review of literature and the observations made during usability tests; finally, the guidelines based on the dimensions of cultural diversity. The next chapter concludes the dissertation by discussing the contribution this research has made to the body of research, the limitations, future work and how the research objectives were addressed.

7 CONCLUSION

7.1 Introduction

This chapter presents a summary of the abstract, methodological and experimental contributions of this dissertation in relation to the objectives stated in Section 1.8. These contributions are in line with the project deliverables listed in Section 1.8, which were the aim of conducting this research. Subsequently, some of the challenges and limitations encountered during this research are highlighted which gave directions for future research are highlighted. Finally, the summary of the whole thesis as directed by the research objectives and questions is presented.

7.2 Contributions

The application of Hassenzahl & Tractinsky (2006) UX building blocks to this research in Chapter 2 has provided a structure which shaped this research. The authors argue that UX is affected by the user, the system and the context of use. These three factors were dissolved and moulded into the whole thesis where users with similar characteristics and skills were clustered into personas. Therefore the first contribution of this dissertation is the documentation and presentation of well-defined personas which exist within the rural context. Section 2.2 and Section 5.2 elucidated the process used in developing these personas which can be used in detail. The presentation of personas resonate with the argument by Suchman (2007) that the term ‘user’ represents a variety of actors with differing relations to a given technology. The UIs design reflects the misconception that designers have about the user demographic. This research has therefore sought to make a distinctive contribution to the lack of empirical evidence on the type of personas that exist within rural context and what their needs are.

In addition, it has added to the information about these types of user’s experiences and the effects that ICT have on their lives. Since literacy and ICT are linked to language, this dissertation has emphasized the importance of the language of presentation of these ICTs. The introduction of cultural considerations in this research seeks to bridge the divide that language has played especially for the illiterate user in the way they perceive ICTs even before they come into contact with them. The contribution of this research is not only scientific but also focuses on the user’s socio-cultural background to assist in mapping the

needs of the low literate and illiterate in a way that interviews cannot. The use of ethnographic methods has helped in achieving this.

The usability tests demonstrated and provided an *in situ* perspective on the UIs and interaction techniques that users in the MRAs have access to. Therefore, this opens the opportunity to clearly understand these types of user's needs and preferences according to UIs and interaction techniques which are available to them. In summary, the recommendations made for UIs and interactions in this research are tailored especially for the MRA context thereby making a contribution to the HCI. The above demonstrates that this dissertation contributes strongly to the understanding of UX dynamics in ICTD context and through that, makes a contribution to the HCI research and body of knowledge. The research's strength lies in its specific and realistic nature of focusing on MRA users with ICTs they can afford and use on a daily basis to access potential ICTD services. Ultimately, the UX framework clearly specifies elements of UIs that need attention in order to design for a better UX for users from MRAs and low-literacy backgrounds.

7.3 Limitations

In this research, the people who were profiled were only from the Dwesa community. Nevertheless, the researcher maintains that the information provided in this dissertation can be applied to other marginalized communities of similar profiles. This is because most MRA issues with ICTs are centred on the issue of the modern-nature of the current interface. Such issues include the language used in information presentation, the interaction techniques, and highly textual interfaces, lack of metaphors relevant to the rural context and inaccessibility of these technologies for the rural illiterates.

The ICTs used for this research did not allow for exploration of the new modes of interaction such as haptic and virtual reality that allow for more natural interactions. This was a result of the expensive nature of the devices that house such techniques which are more intuitive. This research focused on the UI and interaction techniques for generic tasks that users in the rural context are likely to perform. This therefore limited the exploration of UX to mental models, navigation and text selection for design of services that can serve the MRA communities. The use of 5 participants limited the exploration of some factors of culture, in particular age, for this research. This meant that the level of variability in factors such as age, were not as extensive as they could have been. Quantifying user satisfaction

using the SUS requires adding scores of all participants because individual scores are meaningless. This presented a limitation in that user satisfaction was rounded up for all participants who belonged to different personas. Hence, the use of a large number would be helpful in identifying user satisfaction according to the personas preferences not the average group score.

7.4 Future Work

Identifying needs of low-literate to illiterate users presented a challenge of users not being able to express their needs because of being unaware of what ICTs can offer them. This dissertation has argued that conventional design approaches are only rarely suitable for rural African contexts. Therefore, future direction of this research would be an inclusive investigation of the effects of literacy in users' ability to express their needs with ICTs and explore new methods that are more appropriate for designing for rural African contexts. In addition, work can be done on metaphors that users from marginalized rural areas understand. During the usability tests, most of the participants did not know that the back arrow '🡐' was meant to undo their actions. This therefore becomes an area of interest to determine which signs, themes, icons and images are relevant to their context. This research only covered metaphors from a literature review reference view.

7.5 Addressing the research questions and objectives

This research's problem statement states that *"there is currently a lack of UX implementation framework/guidelines/process map to guide ICTD services deployment in marginalized rural areas"*. This guided the main objective of this research which aimed at proposing a UX implementation framework/guideline for ICTD service development in MRAs. The evidence from literature has shown that there is a limit in the information available for strategies for service deployment in the rural areas. This is caused by the lack of usability guidelines that can ensure that services and ICTs provide a good UX. This research has addressed this problem throughout the dissertation using different methods. The following questions were formulated to serve as a guideline to address the problem mentioned above:

- Q1. What are the UX factors that affect the use of ICTD services?
- Q2. Who are the users of ICTD services?

- Q3. What user interfaces and user interaction techniques are available?
- Q4. Which UI and IT best suits the profiled users?

Question Q1 was important for the development of the UX framework because it provided understanding on the factors that affect UX. There are three factors that affect UX during interaction with ICTD services, these are: user, context and system. These three factors are interdependent and put the user at the centre of the experience (hence user experience). The four questions were designed in a way that enabled each of the factors of UX to be addressed through literature review and usability tests. The definition of UX highlighted the concept of usability which was used as a quantitative measure of UX.

ICTD aims at developing MRAs through introduction of services that enables bridging the information and knowledge divide between the urban and rural areas. Efforts to implement such services have been inadequate and largely unsuccessful due to foreign (i.e., relative to the community, and therefore largely inaccessible and irrelevant) influences in the design of the interfaces through which these services are delivered. Question Q2 seeks to address this problem through identifying and profiling the types of users that exist within this context. This was achieved through using ethnographic methods which provided the opportunity to learn about the users through observations, surveys, and task and environment analysis. The use of ethnographic methods introduced the need to acknowledge culture as a factor that influences ICT use and acceptance. After reviewing literature on how to profile users (see Chapter 2), usability testing assisted in classifying the users to personas according to similar characteristics. A simple survey was used to collect user demographic information and their experience with ICTs (see Appendix A). This information was then used to select users to participate in the usability test which was used to identify the five personas used in this research to propose a UX framework (see Chapter 5).

Question Q3 was addressed through the review of literature on which types of UIs and interaction techniques are available. This information included a discussion on which types of users are most likely to be comfortable with which interfaces. It assisted in shaping the usability tests, which were used to test UIs and different interaction techniques. The limitation in the number of devices to accommodate most of the interaction techniques was overcome by the use of the types of devices that were identified in the area of research (Dwesa). The UIs used in the usability tests only accommodated GUI, touch, IVR and VUI. This was a positive in that the emerging forms of UIs and interaction require special

infrastructures which are currently unavailable in the MRAs. Therefore, the information presented in this research is relevant for any service to be introduced in such areas since all the types of UIs and interaction techniques being used have been tested. Question Q3 presents the investigation of 'the system', which is one of the factors of UX.

Literature review (see Chapter 2) provided information on the types of UIs and interaction techniques available and through the usability tests, these were tested on the users to determine which best delivers a great UX to the profiled users. Therefore, addressing question Q4. The use of subjective and objective measures of UX assisted in answering the question Q4. Usability enabled quantifying the subjective and objective measures of UX through quantifying effectiveness (number of errors), efficiency (time and number of steps) and satisfaction. Satisfaction was the most important measure of UX because literature stresses that UX is personal and subjective. This was quantified using the SUS with a 5-point Likert scale. The personas were matched to the relevant UIs and interaction techniques which are more intuitive and easy to interact with, after the usability test and these are illustrated in Figure 6.1.

7.6 Conclusion

Finally, through answering the four questions the main problem this research aimed to unravel was solved. The problem is as follows: "*there is currently a lack of UX implementation framework/guidelines/process map to guide ICTD services deployment in marginalized rural areas"*. This was achieved through the proposal of a UX implementation framework/guideline which focused on three areas that affect UX during interaction with ICTs. These are: the personas; the system component, including the interaction modes, the types of interfaces and the layout of these systems; and the context of use. Furthermore, the proposed UX framework/guideline was culture-centric as suggested in Chapter 2. ICT and literacy are the two most important drivers of development but for users who do not possess skills in any of the two, it is essential to find ways to project their needs and design for their abilities. Together with consideration of the context of use successful ICTD services can be implemented to suit such a user demographic.

The traditional wireless radio has always been used as the form of media to disseminate and access information in most rural areas. This form of media reached large user demographics mostly because the information is always presented in local languages using a form of

communication that is natural and intuitive to the listeners, i.e., spoken language. Government and other bodies of development have taken advantage of recent ICTs such as the mobile phone and PC to reach MRAs with services that are aimed at bridging the distance from infrastructures such as health facilities and government facilities. This research has sought to understand the types of users and their needs in rural areas to ensure that sustainability of these ICTD services through recommendation of UX designs suitable for this user demographic.

This research focused on interfacing and interactions of users with technology to identify possible adjustments that need to be made to current ICTs to suit MRA users. This was achieved through conducting task-orientated usability tests with the goal of evaluating UX of UIs and interaction techniques. Since UX emphasizes that HCI is more than and goes beyond the technology, its main focus is on the emotional effects of ICTs as a form of experience to users. ICTD services deployed to improve the rural livelihood can only be sustainable and useful to the intended users if they can employ strategies that ensure great UX which is the foundation of information access. Hence, personas were used to categorize users who exist within the rural context to overcome the 'typical user' method of characterizing users which overlooks the abilities and short comings of users in MRAs. The information obtained from the literature review and usability tests revealed that literacy is important for successful interaction with ICTs due to the high-textual nature of UIs and applications. This therefore limits the applications and services that users from low to no literacy backgrounds can use which might lead to rejection of technology. This research sought to identify possible recommendations and guidelines for designing interfaces that can provide a better UX without losing the value of the context for low to no-literacy users.

Through usability tests conducted in this research, issues of usability were uncovered for the different personas and this was used as a basis for the recommendations on the suitable UIs for each persona (see Section 6.3). Such recommendations include the use of cultural artefacts that users are familiar with and the use of techniques that require natural interactions such as speaking, gestures and moving physical objects which are the basis of human communication.

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Appendix A: Questionnaire

The following questions will be used in categorizing participants into specific personas.

SECTION A: PERSONAL INFORMATION

- Age

16-30	
31-50	
51+	

- Gender

Male	
Female	

- Can you read and write?

Yes	
No	

SECTION B: TECHNICAL

- Do you own a mobile phone?

Yes	
No	

- What kind of a mobile phone?

Feature phone- A phone that has limited or no Internet access at all	
Smartphone- It has unlimited Internet access and functions	

- What do you use your mobile phone for, mostly?

Making and receiving calls	
Sending and receiving SMS	
Surfing the net	
Social network	
All of the above	

- Which other technological devices do you own?

Tablet	
Personal Computer	
All of the above	
None	

- How does technology benefit your everyday life?

Keeping in touch with family and friends	
Source of information	
Work related	
All of the above	
None	

- What are the problems you face when interacting with technology?

The language use	
Interface related	
All of the above	
None	

Appendix B: The System Usability Scale

Key: 1= Strongly-disagree, 2= Disagree, 3= In-between, 4= Agree, 5= Strongly-agree

1. I think that I would like to use this system frequently

1	2	3	4	5

2. I found the system unnecessarily complex

1	2	3	4	5

3. I thought the system was easy to use

1	2	3	4	5

4. I think that I would need the support of a technical person to be able to use this system

1	2	3	4	5

5. I found the various functions in the system were well integrated

1	2	3	4	5

6. I thought there was too much inconsistency in the system

1	2	3	4	5

7. I imagine that most people would learn to use this system very quickly

1	2	3	4	5

8. I found the system very cumbersome to use

1	2	3	4	5

9. I felt very confident using the system

1	2	3	4	5

10. I needed to learn a lot of things before I could get going with this system

1	2	3	4	5

Appendix C: User Performances in Task 1

Age	Literacy	Gender	Time(m)	Steps	Questions	Completed
16-30 years	Literate	Female	0.59	4	0	1
		Male	1.09	4	0	1
31-50 years	Literate	Female	200	5	1	1
		Male	1.23	5	0	1
	Illiterate	Female	3.24	5	6	1
		Male	-	-	-	0
51 years+	Literate	Female	3.01	5	4	1
		Male	2.45	5	3	1
	Illiterate	Female	-	-	-	0
		Male	-	-	-	0

Appendix D: Personas Within the rural Context

1. Attributes of users representing Persona 1

Fictional Name: Thoko Persona: 1	
Age group	16-30 years
Gender	Female
Literacy	High School graduate (literate)
Language	Xhosa
ICT devices owned	Smart phone
Applications	Calls, SMS, camera, Facebook and Whatsapp
Time spent with devices	Spends most of her time on Whatsapp and Facebook
System needs	Photo editor and social networking
Environment	Noisy and busy

2. Attributes of users representing Persona 2

Fictional Name: Litha Persona: 2	
Age	31-50 Years
Gender	Male
Literacy	College graduate (literacy)
Language	Xhosa
ICT devices owned	Owns a smart phone, tablet and laptop
Applications	Whatsapp, browsing the net, Facebook, emails, calls and SMS
Time spent with devices	Mostly uses his phone and tablet, still unable to use his laptop
System needs	Needs to learn how to use applications like the Microsoft office suit to type his work
Environment	Office

3. Attributes of users representing Persona 3

Fictional name: Zenande Persona: 3	
Age	31-50 years
Gender	Female
Literacy	Illiterate
Language	Xhosa
ICT devices owned	Feature phone
Applications	Calls and SMS
Time spent with devices	Rarely (Only when necessary)
System needs	Needs to stay connected with friends and family
Environment	Home

4. Attributes of users representing Persona 4

Fictional name: Nomnyama Persona: 4	
Age	50 years+
Gender	Female
Literacy	Unfinished primary school education (literate)
Language	Xhosa
ICT devices owned	Feature phone
Applications	Calls and SMS
Time spent with devices	Rarely (only when necessary)
System needs	Learn how to use the calendar and alarm for reminders
Environment	Home environment (quiet)

5. Attributes of users representing Persona 5

Fictional name: John Persona: 5	
Age	50 years+
Gender	Male
Literacy	Illiterate
Language	Xhosa
ICT devices owned	None
Applications	None
Time spent with devices	None
System needs	Needs to stay connected; needs a simple interface
Environment	Home

Appendix E: Persona Performances in Usability Tests

1. Persona 1 performances

Task	Method	Mode	Effectiveness (errors)	Efficiency Time(m)	Steps
Sending email	Text entry	Touch	7	2.50	14
		QWERTY	6	1.51	13
		Swiping	8	3.05	15
		Mouse/keyboard	3	2.13	10
	Navigation & Selection	Touch	2	0.25	2
		Tabs & Enter	0	0.31	5
		Scroll & Click	0	0.37	3
Checking balance	Text entry	Key-press	1	0.12	4
		IVR	0	0.34	4
Web browsing	Text entry	QWERTY	6	2.12	11
		VUI	4	1.52	8
Dial a 15-digit number	Layout	3x4 keyboard	2	0.29	17
		PC keyboard1	5	0.59	20
		PC keyboard2	3	0.27	18

2. Persona 2 performances

Task	Method	Mode	Effectiveness (errors)	Effectiveness Time(m)	Steps
Sending email	Text entry	Touch	4	1.58	11
		QWERTY	4	1.20	11
		Swiping	6	2.38	13
		Mouse/keyboard	2	1.12	9
	Navigation & Selection	Touch	0	0.23	2
		Tabs & Enter	2	0.29	5
		Scroll & Click	0	0.32	2
Checking balance	Text entry	Key-press	0	0.07	4
		IVR	0	0.30	4
Web browsing	Text entry	QWERTY	3	2.12	9
		VUI	2	1.52	6
Dial a 15-digit number	Layout	3x4 keyboard	1	0.57	16
		PC keyboard1	2	1.06	17
		PC keyboard2	2	0.30	17

3. Persona 3 performances

Task	Method	Mode	Effectiveness (errors)	Efficiency Time(m)	Steps
Sending email	Text entry	Touch	4	4.25	11
		QWERTY	6	3.07	13
		Swiping	8	8.02	15
		Mouse/keyboard	5	7.56	12
	Navigation & Selection	Touch	0	0.30	2
		Tabs & Enter	1	0.38	6
		Scroll & Click	3	0.45	3
Checking balance	Text entry	Key-press	1	0.15	4
		IVR	0	1.21	4
Web browsing	Text entry	QWERTY	4	3.46	11
		VUI	7	2.20	15
Dial a 15-digit number	Layout	3x4 keyboard	0	0.52	15
		PC keyboard1	4	1.58	19
		PC keyboard2	3	1.20	18

4. Persona 4 performances

Task	Method	Mode	Effectiveness (errors)	Efficiency Time(m)	Steps
Sending email	Text entry	Touch	5	2.05	12
		QWERTY	6	2.00	13
		Swiping	9	3.15	16
		Mouse/keyboard	4	4.28	11
	Navigation & Selection	Touch	2	0.30	2
		Tabs & Enter	0	0.34	6
		Scroll & Click	0	0.45	2
Checking balance	Text entry	Key-press	0	0.08	4
		IVR	3	1.00	7
Web browsing	Text entry	QWERTY	2	3.05	6
		VUI	4	2.00	11
Dial a 15-digit number	Layout	3x4 keyboard	3	0.42	3
		PC keyboard1	2	2.01	18
		PC keyboard2	2	1.57	17

5. Persona 5 performances

Task	Method	Mode	Effectiveness (errors)	Efficiency Time(m)	Steps
Sending email	Text entry	Touch	14	9.56	21
		QWERTY	10	5.12	17
		Swiping	-	-	-
		Mouse/keyboard	18	10.31	25
	Navigation & Selection	Touch	2	0.44	3
		Tabs & Enter	1	1.17	8
		Scroll & Click	0	1.02	4
Checking balance	Text entry	Key-press	1	0.17	4
		IVR	3	0.57	6
Web browsing	Text entry	QWERTY	18	5.17	26
		VUI	11	3.00	15
Dial a 15-digit number	Layout	3x4 keyboard	3	1.0	18
		PC keyboard1	6	2.30	22
		PC keyboard2	4	2.21	18

Appendix F: Literate vs. Illiterate User Performance in Sending Email Tasks Across Different Modes of Interaction

Mode of interaction	Literacy	N	Mean	Std. deviation
Touch	Literate	3	2.04	0.46
	Illiterate	2	6.91	3.75
QWERTY	Literate	3	1.57	0.40
	Illiterate	2	4.10	1.45
SwypeK	Literate	3	2.86	0.42
	Illiterate	2	1.62	2.28
MouseK	Literate	3	2.51	1.61
	Illiterate	2	8.94	1.94

Appendix G: Male vs. Female Effectiveness in Sending Email and Web Browsing Tasks

Mode of interaction	Gender	N	Mean	Std. deviation
Touch	Male	2	9.00	7.07
	Female	3	5.33	1.53
QWERTY	Male	2	7.00	4.24
	Female	3	6.00	0.00
SwypeK	Male	2	3.00	4.24
	Female	3	8.33	0.58
MouseK	Male	2	10.00	11.31
	Female	3	4.00	1.00
QWERTYw	Male	2	10.50	10.61
	Female	3	4.00	2.00
VUI	Male	2	6.50	6.36
	Female	3	5.00	1.73

Appendix H: Ethical Clearance Certificate

University of Fort Hare
Together in Excellence

ETHICAL CLEARANCE CERTIFICATE
REC-270710-028-RA Level 01

Certificate Reference Number:	THI031SNYA01
Project title:	**Exploring user experience (UX) for Information and Communication Technology for Development (ICTD) services**
Nature of Project:	Masters
Principal Researcher:	Pride Bongiwe Nyambi
Supervisor:	Prof M Thinyane
Co-supervisor:	

On behalf of the University of Fort Hare's Research Ethics Committee (UREC) I hereby give ethical approval in respect of the undertakings contained in the above-mentioned project and research instrument(s). Should any other instruments be used, these require separate authorization. The Researcher may therefore commence with the research as from the date of this certificate, using the reference number indicated above.

Please note that the UREC must be informed immediately of

- Any material change in the conditions or undertakings mentioned in the document
- Any material breaches of ethical undertakings or events that impact upon the ethical conduct of the research

The Principal Researcher must report to the UREC in the prescribed format, where applicable, annually, and at the end of the project, in respect of ethical compliance.

Special conditions: Research that includes children as per the official regulations of the act must take the following into account:

Note: The UREC is aware of the provisions of s71 of the National Health Act 61 of 2003 and that matters pertaining to obtaining the Minister's consent are under discussion and remain unresolved. Nonetheless, as was decided at a meeting between the National Health Research Ethics Committee and stakeholders on 6 June 2013, university ethics committees may continue to grant ethical clearance for research involving children without the Minister's consent, provided that the prescripts of the previous rules have been met. This certificate is granted in terms of this agreement.

The UREC retains the right to

- Withdraw or amend this Ethical Clearance Certificate if
  - Any unethical principal or practices are revealed or suspected
  - Relevant information has been withheld or misrepresented
  - Regulatory changes of whatsoever nature so require
  - The conditions contained in the Certificate have not been adhered to

- Request access to any information or data at any time during the course or after completion of the project.

- In addition to the need to comply with the highest level of ethical conduct principle investigators must report back annually as an evaluation and monitoring mechanism on the progress being made by the research. Such a report must be sent to the Dean of Research's office

The Ethics Committee wished you well in your research.

Yours sincerely

Professor Gideon de Wet
Dean of Research

06 June 2014