University of Fort Hare

Together in Excellence

Mobile Phones Interaction Techniques for Second Economy People

A thesis submitted in fulfilment of the requirements for the degree
Doctor of Philosophy
in
Computer Science

by

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December 2010

Declaration

I hereby declare that the work contained in this thesis is my own original work. It has not previously been presented in application for a similar or any other degree. References made to published literature have been duly acknowledged.

Signature----------

Edim Azom Emmanuel

Date ……..

Dedication

I dedicate this thesis to my family, my wife (Mrs. Kate Abima-Edim), my children (Enuobha-Osowo Emmanuel Edim and Kaetim-Osowo Emmanuel Edim), my mother (Mrs. Cecilia Osim-Enagu), and my late grandmother (Mama Atuora Osim nee Atuora Ogar) and to all my brothers and sisters.

My late grandmother is my source of inspiration and my achievements are due to the love and encouragement and support I have received from my family.

Acknowledgements

I am sincerely grateful to Almighty God whose blessings, love and care for me and my family I cannot quantify. God has made it possible that I complete this programme. He has been a father to my family in my absence.

My profound gratitude goes to my supervisor Prof. Muyingi Hippolyte N. who gave me the opportunity and support, both academically and financially, to carry out this study. His supervision and advice made this study a success. His sacrifice even in the midst of a tight schedule has made it possible for me to complete this work.

I am also grateful to the Telkom Centre of Excellence, Information and Communication Technology, for the developmental and financial support given to me, without which this study would have been very difficult to achieve.

I am grateful to Mr. Sibanda Khulumani whose contribution during this study was tremendous. I appreciate your brotherly advice.

I am very grateful to my wife and children who have been praying for me day and night and the love they have shown to me from thousands of miles away. I also acknowledge the support of my parents, uncle, brothers and sisters.

Abstract

Second economy people in developing countries are people living in communities that are underserved in terms of basic amenities and social services. Due to literacy challenges and user accessibility problems in rural communities, it is often difficult to design user interfaces that conform to the capabilities and cultural experiences of low-literacy rural community users. Rural community users are technologically illiterate and lack the knowledge of the potential of information and communication technologies. In order to embrace new technology, users will need to perceive the user interface and application as useful and easy to interact with. This requires proper understanding of the users and their socio-cultural environment. This will enable the interfaces and interactions to conform to their behaviours, motivations as well as cultural experiences and preferences and thus enhance usability and user experience.

Mobile phones have the potential to increase access to information and provide a platform for economic development in rural communities. Rural communities have economic potential in terms of agriculture and micro-enterprises. Information technology can be used to enhance socio-economic activities and improve rural livelihood.

We conducted a study to design user interfaces for a mobile commerce application for micro-entrepreneurs in a rural community in South Africa. The aim of the study was to design mobile interfaces and interaction techniques that are easy to use and meet the cultural preferences and experiences of users who have little to no previous experience of mobile commerce technology. And also to explore the potentials of information technologies rural community users, and bring mobile added value services to rural micro-entrepreneurs.

We applied a user-centred design approach in Dwesa community and used qualitative and quantitative research methods to collect data for the design of the user interfaces (graphic user interface and voice user interface) and mobile commerce application.

We identified and used several interface elements to design and finally evaluate the graphical user interface. The statistics analysis of the evaluation results show that the users in the community have positive perception of the usefulness of the application, the ease of use and intention to use the application. Community users with no prior experience with this technology were able to learn and understand the interface, recorded minimum errors and a high level of

precision during task performance when they interacted with the shop-owner graphic user interface.

The voice user interface designed in this study consists of two flavours (dual tone multi-frequency input and voice input) for rural users. The evaluation results show that community users recorded higher tasks successes and minimum errors with the dual tone multi-frequency input interface than the voice only input interface. Also, a higher percentage of users prefer the dual tone multi-frequency input interface. The t-Test statistical analysis performed on the tasks completion times and error rate show that there was significant statistical difference between the dual tone multi-frequency input interface and the voice input interface. The interfaces were easy to learn, understand and use.

Properly designed user interfaces that meet the experience and capabilities of low-literacy users in rural areas will improve usability and users' experiences. Adaptation of interfaces to users' culture and preferences will enhance information services accessibility among different user groups in different regions. This will promote technology acceptance in rural communities for socio-economic benefits. The user interfaces presented in this study can be adapted to different cultures to provide similar services for marginalised communities in developing countries.

Academic Publications presented relating to this work

Edim, A.E. and Muyingi, H.N. (2010) **A Cultural User Interface for a Rural Community in South Africa**, in *Proceedings of SATNAC-2010*, Stellenbosch, South Africa, 231-236.

Edim, A.E. and Muyingi, H.N. (2010) **A Mobile Commerce Application for Rural Economy Development**: A Case Study for Dwesa, in *Proceedings of SAICSIT-2010*, ACM press, Bela Bela, South Africa, 58-66.

Edim, A.E. and Muyingi, H.N. (2010) **A User Interface For Micro-Entrepreneurs in a Rural Community**, *Electronic Journal of Information Systems in Developing Countries*, 3, 2, 1-19.

Edim, A.E. and Muyingi, H.N. (2010) **Mobile Phone Interaction Techniques for Rural Economy Development** – A Review, *Global Journal of Pure and Applied Science*, 16, 3, 365-373.

Acronyms

ASR	Automatic Speech Recognition
CDMA	Code Division Multiple Access
CSS	Cascading Style Sheets
GSM	Global System for Mobile communication
GUI	Graphical User Interface
HTML-MP	Hyper Text Mark-up Language Mobile Profile
HTTP	Hyper Text Transfer Protocol
ICT	Information and Communications Technology
ICT4D	ICT for Development
ITU	International Telecommunication Union
LAMP	Linux, Apache, MySQL, PHP
PHP	Hyper Text Pre-processor
SLL	Siyakhula Living Lab
TDMA	Time Division Multiple Access
TTS	Text-To-Speech
URL	Uniform Resource Locator
VUI	Voice User Interface
WAMP	Windows Apache, MySQL, PHP
WAP	Wireless Application Protocol
WML	Wireless Mark-up Language
Wi-Fi	Wireless Fidelity
W3C	World Wide Web consortium
HSCSD	High-Speed Circuit-Switched Data
EDGE	Enhanced Data GSM Environment
GPRS	General Packet Radio Services
UMTS	Universal Mobile Telephone System
WiMax	Worldwide Interoperability for Microwave Access
W-CDMA	Wideband CDMA
IMT-Advance	International Mobile Telecommunications Advance
Wireless LAN	Wireless Local Area Network

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CHAPTER ONE: INTRODUCTION

1.1 Introduction

Mobile phones have penetrated so many poor communities and households making it the only information technology to have reached the poor at a very significant level (id21, 2007). It has enabled poor rural households and communities to gain access to digital information and communication media. The mobile phone subscription rate in developing countries is more than twice the rate in developed countries and Africa's annual subscription growth rate of 50% is the highest in the world (id21, 2007). The global subscription rate is estimated at 5 billion before the end of 2010 (ITU, 2010a).

The propagation of mobile phones to every part of the world is gradually narrowing down the digital gap in poor communities. A positive impact has been experienced by people in communities that mobile communication has reached. Mobile communication has provided an opportunity for the poor and unemployed to engage in micro-businesses such as the sale of mobile phones, prepaid cards and payphone call services (mobile pay phone booths) (id21, 2007), which connect rural people with those outside their communities. People can now share information with friends and relatives living outside the community. There is significant potential in ICTs for social and economic development of people and communities in underdeveloped regions (e.g. Africa). Apart from mobile phones, other ICT applications, E-commerce, mobile commerce and other Web services are also being taken into poor communities across the world (Sherwani et al., 2009; Patel et al., 2009; Sherwani et al., 2008; Sicelo, 2007). These efforts in taking ICTs to rural underserved communities in Africa and other developing countries are made by research communities, government and non-governmental, for the purpose of socio-economic development and meeting the needs of underserved communities in developing countries.

ICTs have created positive socio-economic impacts that are felt by people across the regions and cultures where they have been deployed and used successfully. These technologies have changed interactions between people, between communities and cultures (Huang and Deng, 2008). For instance, the mobile phone has significantly affected people's social and cultural lives, the way they interact with one another and their environment at work, home and other places (Sato and Chen, 2008). New technologies bring added value to users and provide new

ways of information accessibility and socio-economic sustainability. Rural users can also gain access to information and sustain the socio-economic development of the area through information technologies. But several factors and conditions in rural areas still impede the development of ICTs. Factors like cultural barriers, poverty, poor infrastructural development and remoteness of some communities are common (Sood, 2002). Poor usability problems, as a result of user interfaces and applications that do not meet the needs, capabilities and cultural experiences of the people, also hinder ICT development (Lalji and Good, 2008; Medhi et al., 2006; Marcus and Gould, 2000).

Rural communities in developing countries are underdeveloped and their inhabitants face several challenges such as poverty, low levels of literacy, lack of technological literacy, and marginalization. These communities have abundant economic potential for ICT service providers and software designers to harness through products and services that will benefit the people both socially and economically, namely agriculture, tourism and micro-businesses. Due to high mobile phone penetration into rural communities, mobile applications and services have become viable tools for the socio-economic development of rural inhabitants and promotion of micro-business activities (Patel et al., 2008).

The use of mobile devices for electronic transactions is increasing as a result of the integration of mobile communication technologies and the Internet. The availability of mobile communication facilities in rural areas has introduced mobile and wireless Internet services to rural communities. However, mobile phone services are not fully utilized by rural users. The majority of mobile phone users limit the use of the device to making and receiving voice calls only. Several reasons can be attributed to the situation such as non-availability of other services that are perceived as useful to the people, low levels of education, technological illiteracy, and the cost of services and poverty. In order to make the mobile phone more useful and address some of the problems, service providers and designers need to provide services to rural communities with economic importance and value. If users perceive the service provided as useful, they will embrace it. Current Internet enabled applications such as e-commerce; e-health and other numerous applications on mobile devices are good examples for rural development.

Mobile commerce (m-commerce) is a mobility-based e-commerce transaction performed with a mobile device using wireless networks that include wireless LAN, 2G, 3G, and 4G telecom network, Bluetooth and infrared connections (Veijabinen et al, 2006; ITU, 2010b).

Mobile commerce gives organizations the competitive advantage over their counterparts. It provides added value and opportunity for location-aware services to consumers. The m-commerce influence on society in the near future will be overwhelming as it continues to provide mobile content and transaction services. Mobile commerce services include banking, shopping, entertainment and content download, amongst others. Mobile commerce transactions have a significant advantage over e-commerce, especially in rural areas, due to the possibility of performing transactions at any time and any place and media accessibility. In rural areas where wired Internet is scarce or desktop computers are few or not available, mobile commerce has the ability to overcome this deficiency. Mobile commerce is not yet fully adopted and practiced in developing countries; several lagging factors may be responsible, such as poor regulations necessary to protect consumers and business operators, lack of trust between the customers and business operators, and cost of using network facilities. The nature of the mobile device (e.g. small screen estate, low bandwidth, and small keypad) also hinders mobile commerce adoption. Users of mobile devices are, in most cases, in motion which is different from the desktop computer user's stationary condition; this makes the design of user interfaces for mobile devices more complex (Wang and Canny, 2006), and it impacts on the users' interaction experience.

However, mobile technologies present a variety of platforms and capabilities for interactions but, again, they impose new challenges to user interface and application designers (Seffah et al, 2004; Matt et al, 2003). The low level of computer literacy is another negative factor among rural people that mobile technology can help to overcome. The user interfaces and interaction techniques used for these applications will play a significant role in enabling rural users to adopt these technologies and overcome their deficiencies.

The user interfaces and interaction techniques for such application need to be intuitive, easy to use, localized to meet users' capabilities and cultural experience. Because the capabilities and expectations of rural users are different from people in commercial environment (Lalji and Good, 2008; Huenerfauth, 2002), there is a need to consider their social and cultural

context in the design of interfaces and interactions. These groups of users will require interfaces that will conform to their cultural preferences and experiences (Edim and Muyingi, 2010a). People in different regions and cultures perceive and use technology in different ways (Evers and Day, 1997). This is due to the differences in culture and preferences between different user groups (Barber and Badre, 1998).The socio-cultural environment influences an individual to manifest these differences in behaviours and motivations (Huang and Deng, 2008; Hofstede, 1997).

Adequate information about users' cultural backgrounds, value systems, perceptions and cultural experiences will improve user interface design and user experience (Huang and Deng, 2008; Shen et al., 2006; Evers and Day, 1997; Yeo, 1996). A usable interface is one that is simple to use and provides users with a natural sense of interaction with the technology. It identifies the users' context and meets the users' cultural preferences (Shen et al., 2006). Standardized user interfaces create usability problems for users of information technologies in multi-cultural societies (Marcus, 2001). Adaptation of user interfaces and interactions are necessary in order to meet the needs of individual cultures and to improve the interaction experience of users.

Different interaction techniques have been designed and implemented on both desktop PCs and mobile devices. Each interaction technique is an attempt to make interactions with the device intuitive, efficient, and to provide users with natural forms of interactions similar to human-to-human communications. The extent of use for many of these interaction techniques is still limited or restricted in the public domain and the mobile landscape. High capability phones that are enabled with sophisticated interaction techniques are costly and not widely used in rural areas (Edim and Muyingi, 2010d; W3C, 2009); they are mostly found amongst urban highly skilled technologically literate users. Every interaction technique involves the use of a physical input/output device to carry out a task through dialogue with the computing device. These dialogs can take different input/output forms that are described as interaction techniques. These include voice, keypad and screen, camera, touch, gesture, accelerometer and others.

Different mobile devices possess different capabilities in terms of the type of interactions that the user is able to use or experience with the device. Low quality brands of mobile phones are

commonly used in poor rural communities (W3C, 2009). These brands of phones offer limited interaction options in comparison to high quality phones used by highly literate users in urban areas with different interaction possibilities.

For rural or low-literacy users to effectively benefit from the vast potential of and have access to information provided by ICTs, user interfaces and interactions designed specifically for these groups of users will require user-specific input during the design process. A user-centred approach should be adopted (Cremers et al., 2008) to cater for the majority of mobile phone users in the target rural community (W3C, 2009). Rural users will use ICTs in ways different from users in commercial cities because their needs and expectations are different (Lalji and Good, 2008). The ICT application and service provided should also be perceived as useful to provide economic value and benefits to the people intended.

Efforts in providing useful ICT products and services that will add economic value to rural people has lead to the establishment of the Siyakhula Living Lab (SLL) in Dwesa community. The aim of the project is to empower the people for sustainable livelihood, both socially and economically. This study, which is part of the SLL project, specifically targets the same community.

1.2 Background of Study

This research was conducted in Dwesa, a rural community in the Eastern Cape province of South Africa. The community is, at present, experiencing different social and economic challenges. Its inhabitants can best be described as poor and are predominantly subsistence farmers with a few members also engaged in crafting. The area is also blessed with tourism potential through wildlife reserves and beautiful coastlines. This community is marginalized in terms of government programmes and development. The roads are un-tarred; electricity supply is limited to a few households who can afford it. Basic amenities are absent or not enough to cater for the entire population (Dalvit et al., 2007). The Dwesa population consists mainly of older adults and children of a school going age, while most youths have moved to urban areas in search of better job opportunities (Pade et al., 2009; Dalvit et al., 2007). A study conducted in Dwesa by Pade et al. (2009) identified areas for ICT intervention services in education, health care, tourism, micro-economy, farming, and government information and services for development. One significant problem in the area is a low level of literacy.

Through corporate intervention, the Siyakhula Living Lab (SLL) facility has been deployed in this community. The facility provides Internet services to the community and also serves as a platform for the design, testing and deployment of ICT related software projects with the aim of supporting the community with ICT services for social and economic improvement and better rural livelihood (Dalvit et al., 2007).

The objective for deploying the SLL is to provide ICTs for sustainable development and improving rural livelihood (Pade et al., 2009; Dalvit et al., 2007). The facility (SLL) has encouraged extensive research (Pade et al., 2009; Dalvit et al., 2007; Sicelo, 2007) in providing ICT services for rural development. Dwesa community has also witnessed a growing number of mobile phone subscriptions in recent years since the installation of mobile telecommunication facilities 5 years ago (Pade et al., 2009). This increase in mobile phone usage in the community has provided an enabling environment for mobile application designs to provide socio-economic benefits to the people (Edim and Muyingi, 2010b; Pade et al., 2009).

The community has several micro-business potentials to leverage the economy but poor social infrastructure stands as impediment to the growth of these economic activities. Poor road network and poverty in the area also limits these potentials. Movement in and out of Dwesa community is very difficult and time consuming as a result of limited numbers of commercial vehicles going in and out of the community in a day. The application of mobile commerce services in micro-businesses such as arts and crafts, farming, and animal production in Dwesa will promote their businesses beyond their local environment and market; thus enhancing income and quality of life. With mobile commerce, media accessibility problems due to limited desktop computers will not be a hindrance and the users can have access to the application at any time and any place.

The Dwesa community is actively involved and provides a conducive environment to support the various research activities. The community members' participation during research activities is encouraging. Community engagements or meetings are usually held to bring the stakeholders together (community people, the researchers and industry partners) and to give regular updates and educate the community about the ICT projects. It also encourages community members to learn and make use of the facilities for knowledge and economic

enhancement. Through the meetings, relationships of trust between the community and the researchers are strengthened.

1.3 Problem Statement

Rural second economy people, who are mostly low-literate and novice technology users, often find it difficult to use interfaces that do not conform to their socio-cultural experiences and context. Effective communication with the application or service becomes very difficult (Edim and Muyingi, 2010a) when using an interface designed in a language (e.g. English) different to the natural/home language of the target users; which affects the development of ICTs in rural communities (Kam et al., 2007). Different user interfaces provide different interaction techniques on mobile devices. Some of these interfaces and interaction techniques are difficult to use and, to a large extent do not meet the capabilities of the type of mobile devices and socio-economic experiences of the users in rural areas in order to add sufficient value for the users to embark on entrepreneurial activities by mitigating the level of illiteracy and increasing users' experiences.

Rural second economy people need interfaces and interaction techniques with contents that are localized to create a natural sense of interaction and understanding, and also motivate them to accept the technology (Kam et al., 2007) for socio-economic productivity needs. User interface for mobile applications that provide opportunities for economic gains, sustainable means of livelihood and poverty alleviation are required in rural communities.

This study focuses on investigating user interface designs for mobile application that harness the potential of ICTs to support rural micro-entrepreneurs for sustainable rural livelihoods.

1.4 Statement of Research Question

In order to empower second economy people who are semi-literate and illiterate users of mobile phones in rural communities, we need to develop interaction techniques that will meet their needs, capabilities and experiences. Users will also need to perceive the application as useful with added value so that they can accept it. Based on the above assumption this study aimed to answer the following questions:

(a) Current mobile user interfaces are less suitable for second economy people; – can we develop simple user interfaces on low end devices for a mobile service that will be:

- Accessible to semi-literate and illiterate users?
- Easy to use, understand and that will meet the target users' preference?

(b) How do we design user interfaces and interaction techniques that meet target users' capability and experience?

1.5 Research Objectives

The main objective of this study is to design user interfaces with potential interaction techniques suitable for low-literacy users' capabilities and experiences. Different user interfaces provide the users with different methods for input and output interactions with an application. Users of mobile devices in rural areas will require interaction techniques that are simple and meet their capabilities and interaction experiences. This experience represents the everyday interactions of users' within their cultural environment which can be transferred into interface designs for interactions with technology. The user interfaces that are provided for interactions with the selected mobile application were designed to conform to the context of use during this study.

The sub-objectives of this study are:

1. To investigate literature on mobile interaction techniques and the contextual and communication factors and preferences of the target users in a rural community. Cultural issues, which are an important factor that influences the way people perceive and interact with technology was considered in order to design usable interface components for the target group of users.

2. To design mobile application prototype for rural micro-entrepreneurs who have little or no previous experience with mobile commerce technology.

3. To evaluate usability and usefulness of the user interfaces and interactions and the integrated mobile commerce application. Rural users will need to perceive an application as useful so that they can accept and use it. An easy to learn and understand application has the potential to add social and economic value to their life.

1.6 Research Assumptions

This study relies on the following assumptions:

- The user interfaces designed in this work will be accessible by a good number of community members, whether semi-literate or illiterate, using low quality brand mobile devices.
- The interfaces designed during the study are usable in other communities with different cultures, but only after adaptation to culture has been performed.
- The user interfaces designed in this study will not narrow the local users' knowledge to the extent that they will not be able to use other user interfaces (e.g. Windows applications).
- Semi-literate and illiterate members of the community will be able to use at least one of the interfaces to interact with the mobile commerce application.

1.7 Scope and Limitations of Study

The study deals with the provision of a mobile service to micro-entrepreneurs in a rural community. The study is concerned with providing a useful application that will add economic value to users in a rural community. The mobile user interfaces that are designed will enable both the local users (shop-owners) and outside users (customers) to interact and perform transactions with the mobile application. The study considered the design of user interfaces and interaction techniques that meet users' capabilities and are adapted to the available mobile phones and other technological resources in the local community. Considering the local users' profile, both educationally and technologically, the study was an attempt to design user interfaces and interaction techniques that are usable by low-literacy users in the community. To this end we considered two interaction techniques common to the type of services we developed. These are the graphic user interface (GUI) for keypad interactions and voice user interface (VUI) for voice and dual tone multi-frequency (DTMF) interactions.

Localization of the GUI interface with ease of use and understanding was our target for the designs in order to meet the cultural preferences and experiences of local users (shop-owners). The GUI is localized with interface culture-components sourced from the users' cultural knowledge and environment. To achieve ease of use and understanding in the design of the localised VUI, the study looked at the use of two input techniques (voice input only

and DTMF input only) for two separate flavours of the voice user interface for community users. The goal here was to determine an interaction type that will enable the local users to achieve better results in terms of task performance.

On the customer's side, the study also provides two user interfaces (GUI and VUI) for interactions with the application. These interfaces provided standardized interactions and content in the English language.

This study is not meant to undertake a comparative experimental study of mobile phone interactions techniques in a rural community, but rather to design mobile user interfaces and interactions that meet the needs and experiences of low literacy users; with applications that will be useful to the community. And so, this study only considered GUI and VUI to meet the objectives of this research. Based on the available resources both hardware and software and the user profile (e.g. education, technology literacy) within the local community, other interaction techniques were not considered. Considering that, if a design is not usable by a majority of the target users then the benefits of the study, to the community, will be defeated.

During the study, getting access to local users was difficult due to the significant distance to the study area. The language barrier limited communication with the community members and also affected the process of data sourcing. On the design of the GUI, it was difficult to source information from the local users. Low levels of literacy and inadequate knowledge of the technologies involved (e.g. e-commerce, mobile commerce, computer literacy) were a problem. Translating computer jargon to a form that the community members would easily understand was difficult. This also affected the amount of cultural components (e.g. metaphors, icons) sourced for interface localization. Designing an isiXhosa (natural language of the community) voice recognition and synthesis engine was beyond the scope of our study. We used an English voice recognition and synthesis engine for the voice interface. IsiXhosa language clicks (phonemes) were also difficult to implement directly on an English voice recognition engine.

Conducting research in a remote rural community, such as is done by this study, where the researchers and the target users are separated by long distances, differences in language and culture was not an easy task. Direct communication with some participants in the community

in English language limited their responses and the use of a middleman or interpreter to overcome the situation also had its limitation. The interpreter may sometimes fall short of adequate explanation of statements to and from the community members.

Overall, conducting a user-centred design methodology for user interface design in the Dwesa environment was a big challenge. Local users hardly know what they want on the interface or how they want it to look. In many instances they found it difficult to express their views on particular issues and, as such, information needed from the community users became very tedious. The use of a concrete prototype to present practical explanation was an approach used to overcome some of these challenges.

Training of low-literacy users in remote rural areas for the purpose of using technology is tedious and costly due to so many factors. It is important to design user interfaces that are simple, easy to learn and use with minimal training. It will make information technology services accessible to all potential users in the target community. During design, the available technology within the environment is also an important factor to consider.

1.8 Significance of Study

Mobile phone devices are affordable and provide added value to the users above basic intrinsic (emotional, connected, security etc.) needs (Donner, 2004). Mobile services can contribute immensely to the rural economy and sustainable development. This study was conducted to provide a platform to showcase the business potential of rural micro-entrepreneurs and extend the market beyond the immediate environment. The product of this study will help to improve the product market of local entrepreneurs (e.g. crafted artefacts) to customers outside the community. Mobile commerce applications have the ability to take businesses to the outside world and attract customers from far and near. It is also a means for promoting trade and economic activities in the community.

In this study, we have designed user interfaces and interactions that are accessible by semi-literate and illiterate users in the Dwesa community. Through the user interfaces the online shop-owner in the rural community will be able access information from the application. People in the community will eventually benefit from the application. More trade activities

can be encouraged in the community and more people can be economically productive. It will also encourage low-literate and uninformed technology users to accept technology.

The main driver of the knowledge economy is the need for wealth creation. The wide spread and increasing use of mobile phones has made it the de facto media to reach the base of the pyramid of population. This study demonstrates how, if well designed and directed, some applications for mobile phones can contribute noticeably to create micro-business opportunities for second economy people.

This study is also an attempt to enhance usability and user experience through cultural adaptation of the user interfaces and interactions. The use of cultural knowledge or local experience of low-literacy users to design the interface will create easy understanding and motivate users. This knowledge represents the daily experiences of users as they interact with their environment. This cultural experience is common to any target user groups or cultural region and can be sourced and used to design user interfaces to make technology accessible to the people.

1.9 Definition of Terms

In this study we understand and use the following terminology as defined in this section.

Added value service: Services rendered through transactions made with the mobile device that have the potential to bring indirect or immediate income to the owner of the device and helps appreciate the usefulness of the device. Apart from using the mobile phone to make and receive calls, other services are provided; such as performing wireless transactions on the internet and having access to mobile content. These services bring added value to the device and users.

Culture dimensions: The measurable cultural attributes or traits of a group of people that distinguish them from another group.

Culture markers: Interface display components or elements unique or associated with a cultural group.

Cultural preference: Users' favourite or first choice, based on cultural experience.

Ease of use: The simplicity and effortlessness employed by the users of a user interface during interactions with the interface.

E-Commerce: It involves transactions such as displaying, advertising, buying and selling using stationary electronic devices namely desktop computers.

Interactions: Back-and-Forth communication between two entities such as a user and a computer device. Set of standardised dialog activities between the user and a mobile phone.

Interaction techniques: The different methods (e.g. touch, vision, pointing, gesture, voice, scanning etc) which the user of a mobile phone device can use for interacting with the device.

Intuitive: Easy to learn, understand and use with minimum cognitive experience. When applied to an interface, it will mean an interface that will not require too much formal intellectual training before it can be used.

Localization of interface: Adaptation of certain components or elements of a user interface to reflect the local human expression mode (verbal or non verbal) and culture of a specific group of users.

M-Commerce: An e-commerce transaction performed using a mobile communication device, namely mobile phone, to perform electronic transactions for the exchange of goods (e.g. crafted artefacts) and services.

Mobile content: This includes information from web pages downloaded into a mobile communication device e.g. textual information, messages, games, ring tones, graphics, etc.

Mobile device: A mobile communication instrument such as a mobile phone.

Personalization: Building or adapting a system to best meet user's preferences.

Rural community: A remote geographical location that is not easily accessible and underdeveloped; here the terms "second economy people" or "rural second economy people" will be used interchangeably.

Rural micro-entrepreneurs: Micro-business owners (e.g. crafters) in a rural area

Second economy people: People living in areas faced with multi-faceted economic challenges namely economic, social, and educational; representative of rural areas in developing countries.

Usability: The extent or degree to which users find the product or its interface usable.

Usefulness of application: An application that users perceive or feel is beneficial to them.

User Interface: The medium of interaction between the user of an application and the application.

User experience: The explicit or tacit skills or knowledge acquired by users as a result of using a system.

User-centred approach: A methodology that takes seriously the involvement of the intended person to use the system during the entire or major part of the system building.

1.10 Chapters Overview

In Chapter two, we present the literature review. This chapter gives a description of related work on mobile commerce, mobile phones interaction techniques and user interfaces. The chapter also discusses technologies for wireless mobile communications and user interface technologies. A critical analysis of the different interaction techniques in respect to users in a rural environment is presented. The chapter also presents a discussion of user interfaces and ICT applications and services that have been designed for the purpose of empowering semi-literate and illiterate rural users.

Chapter three discusses the state of ICT services. These include discussions on mobile commerce applications and the driving technologies for mobile commerce. The issues of culture and its implications for user interface design and usability are also presented. Cultural theories and models related to user interface development are also discussed. A user-centred design approach and methodologies commonly used for interface and application development are also presented.

Chapter four presents the research design and the methodologies applied in the study. The user-centred research methods are briefly described and their strengths and weaknesses are also stated. The research methodology for the design of the mobile interfaces and application, starting with the graphics user interface followed by the voice user interface, are presented. A detailed discussion of the methodology, processes, tools used and content of the research are presented.

Chapter five of this work presents the findings made during the study and results and data analysis from users interactions with the user interfaces. Here we have analyzed and discussed the data and results obtained during the study and discussed in Chapter three. The discussion is started with an overview of the research findings before the intervention of this study and what we have done in this study to fulfil the study objective.
Chapter six presents the research conclusions and suggestions for further research.

1.11 Conclusion

Information and communication technology is a viable tool for the socio-economic development of marginalized rural communities. Low levels of technology awareness, literacy problems and media accessibility have been an impediment to the development of ICTs in marginalized communities. Desktop applications and computers are not readily accessible due to a limited number of desktop computer facilities available in rural communities and the lack of computer skills needed to use desktop applications. Mobile phones are accessible and mobile applications can be used to bridge the gap. They provide easy access to information at any time and any place. Users of mobile applications will not need much training to use the device or applications even in rural communities. Providing ICT services to the rural community for social and economic benefits will only create the desired impact if the interfaces are accessible to everyone in the community. Rural communities need applications that are both socially and economically useful. This will encourage the acceptance and use of the technology in the communities where it is implemented.

We have presented in this chapter an introduction to the study. The discussions include the background of Dwesa, the area where we conducted this study. We have also stated the research objectives, the statement of research questions, delineation of the study and limitations. In the next chapter, we present a discussion of the existing literature related to this study.

CHAPTER TWO: BACKGROUND LITERATURE

2.1 Introduction

Research in the design of user interfaces and human-computer interactions has received a lot of attention in the research community. The main focus of these activities has been concentrated in providing systems in commercially established environments. Different interaction techniques and user interfaces have been developed; mostly for the highly literate societies. For low literate rural societies most of these interfaces and interaction techniques cannot be replicated due to the constraints and life experiences in these localities. The few attempts made to address the digital divide in developing countries are mostly found in Asia. Rural communities in Africa are yet to benefit to a significant degree from the research communities in terms of applications and interface designs needed to address their specific needs.

This chapter presents a review of the various studies on mobile interaction techniques and user interface designs. These interaction techniques include keypad interactions with graphics user interfaces, speech interactions with voice user interfaces, gesture interactions with gesture-based user interfaces, point and shoot interactions with point and shoot user interfaces, vision interactions with vision-based user interfaces, and multimodal interactions with multimodal user interfaces. An analysis of the interaction techniques with respect to this research objectives and the study area are discussed.

The part of this study that has been influenced by this review includes the research questions, and objectives that we seek to achieve. The literature has provided information on different interaction techniques and research efforts that have been made on ICT services and user interfaces designed for the development of underserved low literate rural people. This review has enabled us to identify the type of user interfaces and interaction techniques to implement for this study and based on the environment and resources available, in order to meet our research objectives.

2.2 The Siyakhula Living Lab ICT Project

Information and communication technologies (ICTs) provide a potential that could be harnessed for development and poverty alleviation in developing countries especially in rural underserved communities (Heeks, 2008; id21, 2007). The Siyakhula Living Lab (SLL) is an

ICT infrastructure deployed in Dwesa through the collaboration of Telkom Centres of Excellence at University of Fort Hare and Rhodes University and their sponsors that include Telkom South Africa, the Technology and Human Resources for Industry Programme (THRIP), COFISA (Cooperation Framework on Innovation Systems between Finland and South Africa), the Meraka Institute and Nokia Siemens Networks. The SLL project started in 2006 with the purpose of taking technological resources and training to the people in rural areas such as Dwesa. The objective is to enable rural people to have access to information and also bridge the digital gap in these areas (Pade et al., 2009; Dalvit et al., 2007). The aim of the project is to develop and deploy an ICT application and services for marginalised rural people in South Africa. These communities are large and represent a potential emerging market for suppliers and consumers. The SLL will, in the long run, promote socio-economic activities for a sustainable rural livelihood using ICTs. The collaboration of the Telkom Centres of Excellence in the University of Fort Hare and Rhodes University provide an active group of young researchers with technical expertise for project development and sustainability. In order to forestall failure, like most rural ICT installations that have closed down as a result of none sustainability mechanism e.g. the telecenters (Heeks, 2008), members of the group embark on regular monthly visits. These visits to Dwesa take a full week's stay in the community. The collaboration and visits ensure the sustainability of the infrastructure, build networks between the local people and the research students, boost trust and confidence, and ensure that the ICT equipment keeps running smoothly.

The SLL presently consists of five laboratories installed in five different schools within the Dwesa community. The schools include Ngwane Secondary School, Mtokwane Secondary School, Mpume Secondary School, Nqabara Secondary School and Nondobo Secondary School. The installion includes desktop computers with Internet access in all the Schools. All the separate units are linked together as a single unit through WIMAX connectivity. Figure 2.1 presents the structure of the SLL infrastructres in the five schools in Dwesa. Figure 2.2 shows the photograph of SLL in Ngwane Secondary School in Dwesa.

The SLL paltform supports the development of ICT applications in e-commerce, e-health, e-learning, e-government, entertainment and the training of local users to gain computer literacy skills to enable them to use the facilities. The focus of service delivery has recently moved from desktop computers and fixed line telephony to mobile phones. With the presence

of GSM networks and the increasing use of mobile phones in the community, voice services and SMS (Short Message Services) specifically designed and deployed for rural community users are now feasible (Pade et al., 2009).

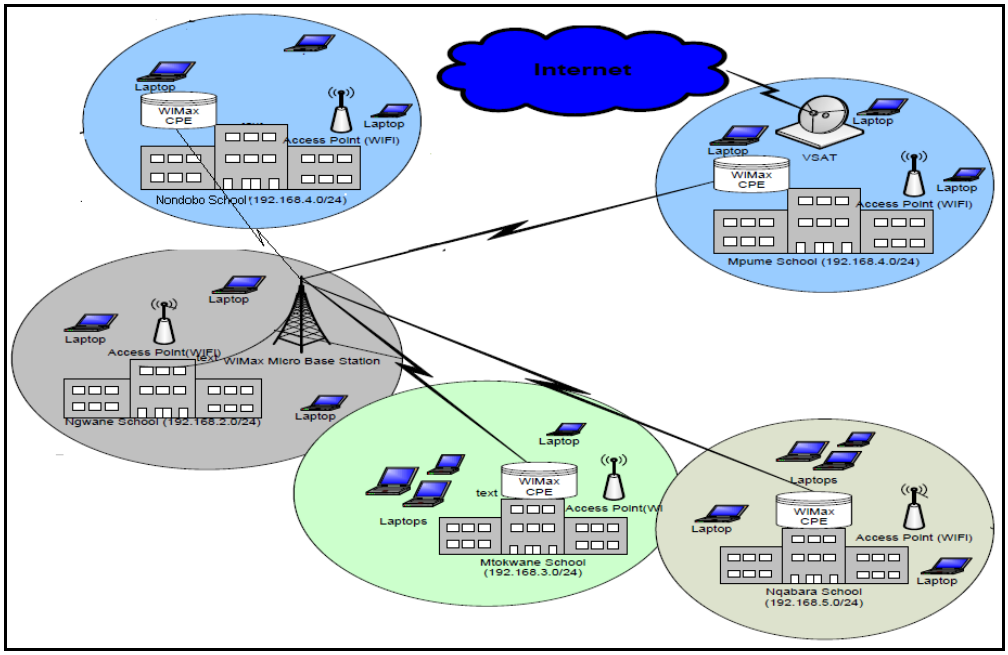

Figure 0.1 The Siyakhula Living Lab project structure in Dwesa (Ndlovu et al., 2009)

Figure 0.2 Photograph of SLL in Ngwane Secondary School

2.3 Significance of the Mobile Phone to African Small-Scale Entrepreneurs

The mobile phone is one of the most promising ICT tools for communication and delivering electronic services to micro-entrepreneurs in developing countries. Users are able to establish and sustain social and economic connections (Donner, 2004). Africa's micro-entrepreneurs

had experienced a significant impact from the introduction of mobile networks in their communities. Significant contributions from mobile communication to micro-enterprises include an increase in income, reduced cost, improved markets and encouraged production. Micro-entrepreneurs also use mobile phones to achieve faster and cheaper communication, improve their transportation system, as an extension of business networks, and substitution for journeys, brokers and intermediaries (id21, 2007; Duncombe and Heeks 2001). Mobile phones offer access to information for micro-entrepreneurs such as prices, weather related information to farmers and healthcare services (Idowu et al, 2003). The introduction of mobile technology in Africa has enabled several studies in different areas which explore how the new technology can best be applied to improve the social and economic livelihood of communities and micro-businesses.

Donner, (2004) discussed the usage of mobile phones among micro and small enterprises in Rwanda. He identified different mobile phone usage perspectives among small business owners as a convenient tool for improving their business, an instrument for meeting their intrinsic needs, and an indispensable tool used to enhance their productivity. These views indicate that mobile phones give the users satisfaction, help their business grow and add value to mobile phone use among micro-entrepreneurs and small business owners.

id21 (2007) presents discussions on Mobile phones and development, and also outlined the impact of mobile phones on micro-entrepreneurs in developing countries. An example is the informal textile industry in Nigeria where the use of mobile phones by micro-entrepreneurs has helped to eliminate the cost and time spent in travelling to gather information, as well as risk and reliance on middlemen. Mobile phones provide a means for increased awareness of trade opportunities, shorter time to fulfil orders, increased customer satisfaction and reduced communication cost in this informal industry.

The mobile phone is considered as more than a communication device, its use has other positive impacts – cheaper communication, and strengthening family relationships. In the banking sector, the mobile phone is used to offer financial services to poor mobile phone users in Zambia. Successful mobile banking services in Africa include South Africa (WIZZIT) and Kenya (M-PESA) (id21, 2007). Farmers in rural Kenya receive their insurance

payments through Mpesa on their mobile phones and this has eliminated the need for a middleman in the process of making an insurance claim (Dinfin Mulupi, 2010).

Mobile phones have enabled new micro-businesses to be established (Donner, 2007; id21, 2007), and also enabled micro-business owners to keep close relationships with family members and friends, as well as allowing them to increase their customer base and business network (Donner, 2006). SMS services are a popular and cheap means of sharing information and maintaining customer relationships.

Mobile phone enabled services and the mobile web are promising technologies for future emerging markets in developing countries (Boyera, 2007). The major issue of concern is whether the services that are provided will be able to increase mobile adoption for micro-enterprises by meeting the needs and expectations of users. It will require the design and deployment of services that take into consideration the social, cultural and literacy factors to provide the needed services for social and economic development.

2.4 ICT4D Research Approaches

The process for providing ICT for development services to rural communities involves the application of different research studies. The first step is to conduct a literature survey in order to collect information on current research knowledge and findings on a particular topic of consideration. The second step is to make a decision on suitable research approaches or methodologies for the study being undertaken. This depends on the environment where the research is to be conducted.

Different ICT for development studies have applied different approaches and methodologies in order to obtain their desired study outcomes. A Living Lab (Lb) approach encapsulates a variety of multi-disciplinary methodologies and tools in a user-centred context whereby all stakeholders in the project, especially the target group, are empowered through co-creation of ideas, solutions, innovations as well as their implementation and co-evaluation (Delvit, et al., 2007).

The objective of these studies has been to provide user interfaces and interactions that will enable low-literacy users to gain access to information for socio-economic benefits. Recent

studies indicate that ethnographic research methods that allow the target users to be fully involved in the study are commonly used. These research methodologies include on-site visits, surveys, interviews, focus groups, observations, contextual inquiries, participatory designs, and user evaluations to determine the usability, or non-usability, of the system.

We will leave out the discussions on methods applied in this study for the methodology chapter to avoid repetition. These include interviews, surveys, focus groups, on-site visits, literature reviews, and observations. And in this chapter other methods that were not used in the study design such as contextual inquiries, participatory designs will be discussed. All the research methods mentioned here have been applied in different studies meant for ICTs development in underserved communities.

2.4.1 Contextual Inquiry

Contextual inquiry is a design method that starts from the initial design stage, data gathering, and prototyping, evaluation and implementation of a new system. The contextual design process involves the users (15-20 participants) for data collection, system modelling and design processes (Wixon et al., 2002). This method combines and uses field design methods such as interviews, observations to gather information leading to the design of a system that meets user need. It provides a good avenue for performing user and task analysis together in low literate environments (Kam et al., 2009). Information gained from the users informs the entire design process. With contextual inquiry, data is collected and presented in a well organized manner (Xavier et al., 2001). Contextual inquiry is focused on both designers and the users.

In situations where the activities of users are not confined to a given location contextual enquiries become very difficult to implement. Also, where it is difficult to have access to the users for user and task analysis this may be difficult to apply.

Qualitative data is usually collected during contextual inquiry. The methods of data collection include field notes (Kam et al., 2009), video recording and others. Data analysis methods include descriptive statistics, regression analysis and others.

2.4.2 Participatory Design

In participatory design, both the users and the designers are regarded as co-designers. Users are fully involved in the design of the system. The participatory design approach has been

successfully applied in the design of ICT for development applications for low-literacy users (Patel et al., 2008; Cremers et al., 2008). Participatory design enables users to clearly state their perception and mental model of a system. This enables the designer to visualize the system under consideration based on the users' view. The outcome of the design may depict more of the users' view rather than the designers' views.

Participatory design has its drawbacks. Users may find it difficult to understand the language of the designers or may not be able to state, in concrete terms, what they visualize of the system (Abras et al., 2004). Cultural differences between designers and users can also arise and create communication problems during design. The designers can help users to overcome these problems by leading them through pre-defined steps that are open to the users, while also performing checks so as to prevent users from being lost, while stimulating creativity (Cremers et al., 2008).

2.5 User interfaces and Interaction Techniques

Different user interfaces and interaction techniques have been designed and implemented on both desktop computers and mobile devices. The goal of these designs is to make the devices more efficient and user friendly. Each of the different interaction techniques tries to take a form that is similar to human-to-human communication. These innovations take information and communication technologies to a greater level of intuitive interactions. The majority of these implementations are still focused on urban users who are highly skilled, technology literates in places where the facilities for implementation are available. Rural areas, in developing countries, are yet to experience these ICT innovations due to a lack of necessary skills and experience couple with non-availability of the necessary facilities needed to use these technologies.

This review on user interfaces and interaction techniques is neither exhaustive nor limited to a single interaction technique. We will not completely ignore the interaction techniques designed for the desktop computer as some of them apply to and can be implemented on mobile platforms. Reviews on interaction techniques have been presented in different domains of applications. Very few reviews cover a broad spectrum of interaction techniques on mobile devices. These reviews include hand gestures (Pavlovic et al., 1997) and taxonomy of gestures (karam and Schraelfel, 2007). Other reviews include vision-based interaction

technique and its application in human motion analysis (Gavrila, 1999; Poppe, 2007), in motion estimation (Erol et al., 2007), motion of the eyes (Duchowski, 2002), and facial expression analysis (Fasel and luetin, 2003). A review of user interfaces for vision-based interactions is presented in Quek (1995), as well as Kratz and Ballagras (2007). The speech-based interactions technique is discussed in Potamianos et al., (2004). Multimodal interactions or multimodal user interfaces on a single application have also received attention. Jaimes and Sebe (2007) presented a review of applications with multimodal interactions and user interfaces. On the design of user interfaces and interaction techniques, different authors have also proposed the use of human-centred design methods for effective user interface designs. Maguire (1999) presented a survey of the methods for support usability design in different situations and environments.

The next section presents a review of the different interaction techniques applied on mobile and desktop applications.

2.5.1 Graphical User Interfaces (GUI)

The graphical user interface has dominated interface technology and interactions on the desktop and mobile systems for a long time now. The popularity of the GUI has made it the traditional medium for the presentation of information in different computing platforms and applications. GUI is easy to understand and helps to remove complexities during task performance. Different interaction techniques often present information on the screen in a text and graphics format to enable the users to adequately visualize and understand output from the application. The graphic method of displaying computer output on the screen is very common with different user interfaces. The interaction technique used with the GUI may not be through the computing device's keypad/keyboard. It may be a combination of keypad and other input mechanisms.

The main modality for interacting with graphical user interface is the keyboard or keypad on mobile devices. Other modalities of interaction on GUIs are usually combined with the keyboard, such as the pen, stylus, touch screen, hand writing, and others. The objective is to provide effective interactions for the users. Different methods and models for GUI design have been presented by different authors. These include model-based design (Paterno and Santoro, 2003), unified interface design method (Savidis and Stephanidis, 2004), and pattern

modeling (Nilson et al., 2006). These models provide design guidelines and platforms for designing more user friendly graphical user interfaces. These models are focused on designing user interfaces for literate users in commercial environments. They are not yet tested in designing user interfaces for rural users.

The small QWERTY keypad on mobile devices is very cumbersome during interactions as a result of the size of the device. But, it is the main device used for interaction with GUIs. Research efforts geared towards reducing key presses during task performance on GUI had recorded successes. Several of these efforts or designs have combined key presses with other modes of interaction in order to reduce the difficulty users may face during interactions. Benko et al. (2006) describe a method where the finger is used for selection on a mobile device touch screen. Other examples include: finger touch interaction (Vogel and Baudisch, 2007), FluidT-mouse (Esenther and Ryall, 2006), "drag-and-pop and drag-and-pick" (Baudisch et al., 2003). The user interfaces mentioned above contain graphical presentations for visualization of output and user interactions. They also provide graphical icons to simplify understanding and ease of interaction. Although the mobile keypad used for these interactions is cumbersome, but it remains the most popular form of interaction with mobile devices found across different geographical regions.

Luoma (2003) describes "the symbol creator" application. The system enables the users to perform text entry with ease by using a GUI with minimum keypad input. In Balakrishnan et al. (2008), the keypad is combined with a pen rolling technique to interact with a pen-based graphic user interface. Stylus-based interfaces offer users ease and flexible interactions during text entry on mobile devices. The interfaces present graphical soft keypad interfaces on the screen for the users. Examples include Yatani and Truong (2007), Glyph (Poirier, 2005), and Edgewrite (Wobbrock et al., 2003).

Other forms of interaction modalities that were integrated with the mobile keypad to give users intuitive interactions on GUIs are discussed in Rekimoto (1996), Widgor and Balakrisnan (2003). Rekimoto (1996) described a tilt interface that enables interactions on small screen devices. The user tilts the device to the direction of an item that is targeted for selection on the screen. When the target item enters the focal point, a key press operation is initiated to achieve the selection operation. Widgor and Balakrishnan, (2003) presented a

GUI that allows the user to tilt the mobile phone to the direction of a character on the keypad and the movement is indicated on the screen. The desired character is then selected by pressing the key on the keypad that contains that character in its combination. The design reduces the number of key presses on the mobile keypad, especially if the desired character is the third on the key combination.

Medhi et al., (2006) show that GUIs are flexible and easy to use among different groups of users. This is demonstrated with a text free user interface (Medhi et al., 2006) that was implemented and used to assist illiterate and semi-literate users to search for jobs that are available on the Web and within their local community. The application proved successful since users were able to interact with the user interface with ease. A GUI on any application for rural people, together with the appropriate symbols that reflect the socio-cultural preferences and experiences of the users, would help to improve usability and acceptability of new technologies in the community.

Graphical user interfaces are popular and commonly found on different mobile applications. This makes GUIs ideal for rural users. A GUI is easy to implement and is compatible with the type of mobile devices commonly found among rural users. Low-literacy users favour the use of graphics on interface for visualization and easy understanding (Medhi et al., 2006; Medhi et al., 2009). This is an indication that if graphical user interfaces are designed with symbols that reflect on the knowledge of low-literacy users, their user experience and usability will be enhanced. Mobile phones common in rural communities will support graphical interfaces. Keypad input and screen displays are common input and output formats very familiar to semi-literate and illiterate users (Edim and Muyingi, 2010d).

Graphical user interfaces are simple to implement and are applicable to different mobile devices. They are suitable for the types of mobile phones used by low-literacy users in rural areas (Edim and Muyingi, 2010d) as a large number of users' devices can be accommodated. The design of user interfaces that provide keypad interactions on mobile devices in rural areas may not be too difficult for low-literacy users due to past experienced gained from using mobile devices and similar services. Localization of graphical user interface to provide the target users with interface elements that are familiar to the users will provide the users with intuitive and flexible interactions and will enable them to have access to information.

From the review of research studies on graphical user interface design, there is evident that were this interface and interaction technique have been implemented for low-literacy users, the target users have in most cases found it easy to recognise interface elements and interact with the application. This informed our choice of interface and interaction design for this study. The study here was to find a way to design and adapt the graphical interface to meet the capabilities and preferences of low-literacy users in Dwesa community. The approach in the study was to design a graphical user interface with graphics symbols (metaphors/icons for easy visualization, familiar to the environment and easy to understand and) similar to what was discussed in Medhi et al. (2006) taking into consideration the socio-cultural environment and experiences of the target rural users in order to meet this study objective. Methods and cultural design theories that lead to the elicitation of community users' design requirements and cultural preferences were applied in the process to design the graphical user interface.

2.5.2 Vision-Based Interactions

Advances in mobile technologies have improved the capabilities of mobile devices by introducing several new features and functionalities. These have increased the modalities of interactions and services available on the device. Mobile devices are now equipped with high resolution cameras, detachable large memory facilities and multimedia applications and functionalities. The high resolution cameras on mobile devices are used for interactions with vision-based interfaces and applications. The cameras are used to capture images of stationary objects or those in motion and process these as input to the application. Vision-based interaction is popular in desktop computer systems due to the hardware capabilities of personal computers (Martin et al., 1998; Letessier and Bernerd, 2004).

Vision-based user interface and interaction technique is also gaining attention in the mobile arena. The goal of the vision-based interaction technique is to increase user satisfaction and provide intuitive interactions. An application area where this interaction technique has been applied is mobile gaming (Capın et al., 2006). Vision-based interaction is considered a form of interaction that is synonymous with the natural human sight use for interaction with objects within the environment. The technique is a Human-computer interaction (HCI) process where the motion of the human body, object, or facial expression is captured and sent for recognition. The interactions are flexible and natural (Kjeldsen et al., 2003). A vision-based user interface on the device enables users to visualise the interactions and enable them

to communicate with the application. Kjeldsen et al. (2003) designed a vision-based interface to detect head gesture movement as input through the camera of a mobile phone. The head movements are captured and sent for recognition and the interpretations are then sent back to the user.

Reilly et al. (2007) described an application that used the camera of the mobile phone to read 2D barcodes attached to paper maps. The camera is placed at an acceptable range in order to produce a good resolution on the lens of the camera. In Reilly and Chen (2006), a vision-based interface is used to read tags on paper maps. The application uses the lens of the camera on a mobile phone that is also equipped with radio frequency identification (RFID) readers for reading the tags on a map. Mobile games are common applications on mobile devices, such as the ball in the maze game (Bucolo et al., 2005). This application uses the camera of a mobile phone to provide intuitive interactions to the user when playing the game. This is made possible through two different interfaces (translation and tilt interfaces). By simply translating or tilting the camera the interactions with the ball takes place. In motion estimation, the camera of a mobile phone is used to capture movement either by translation or rotating the device (Hannuksela et al, 2007). When the camera is moved by the hand (translation or rotation) the movement is measured and taken as input into the mobile device.

The advantage of vision-based interaction technique is its' simplicity and intuitiveness that it provide to the user. The successful implementation and the level of usability recorded by vision-based applications shows that this interaction technique meets different user groups' interaction experiences in mostly highly literate environments. Although the design of vision-based interfaces mostly did not depend on the users' input to the design process, but often depended at a greater extend on the designer. In low-literacy environments where users' input to the design process is very necessary for interface acceptance, the user interface may not conform to their knowledge and capabilities. How to adapt vision-based interfaces to meet the cultural knowledge of Low-literacy users was not mentioned or have never been considered in any the studies discussed above.

Mobile phones equipped with cameras are now very common and vision-based interactions will also become popular in the near future. The CAM application (Parikh et al., 2006) uses the camera of a mobile phone to read barcodes on paper documents. This application is used

to assist illiterate and semi-literate members of self help groups in rural India to collect data for financial assistance from corporate institutions. The CAM application is one of the very few applications where vision-based interface and interaction has been demonstrated with low-literacy users.

In rural areas, where the use of written text for communication is not very popular due to literacy challenges, vision-based interaction would provide the necessary intuition and simplicity for interaction with ICTs. For this to gain the required acceptance among user groups in rural communities, there is need to find a means of adapting vision-based interface and interaction technique to meet the capabilities and user expectations. Although in most rural communities, technology illiteracy, limited experience with mobile devices with cameras, non-availability of computing facilities, cost of implementation, as well as usage constraints still pose serious challenges to the use of this technology. Also, mobile phones with high resolution cameras and high memory capabilities are still not widely used in rural communities. The outcomes of input through vision-based interactions are mostly unknown which is a limitation associated with vision-based interaction. Meeting the user experience and preferences within low literacy environments which is part of the aim of this study may be undermined. Where the vision based interaction technique has been demonstrated in a low literacy environment (e.g. the CAM application), the implementation is narrowed to a specific application where the inputs are pre-determined and the designs are based on the designer's model. What is not stated is if the user interface to CAM did meet the expectations and experiences of the target users, since the design depended on how the designers wanted the interactions and interface elements should be. Access to CAM devices is limited to a few trained users which makes personalization of the device difficult.

2.5.3 Gesture-Based Interactions

Using gestures during oral communication is common amongst humans (Brewster et al., 2003). Gestures are carried out using different parts of the body. These include the head, hand, mouth, or eyes as a means of supporting and clarifying utterances or interactions for better communication. Using gestures for communication is a natural form of interaction between humans.

Researchers have applied gesture-based interaction technique for human-computer interactions. In this case, the computing machines such as desktop computers or mobile devices are the recipients during interactions. Natural gestures for interactions have been applied in various applications and services such as mobile and interactive games (Sato et al, 2006; Kratz and Ballaga, 2007), camera-based recognition systems (Pavlovic et al., 1997; Sato et al, 2000), and special input gloves and virtual reality (Wexelblat, 1995). Wexelblat (1995) describes a multimodal application that uses gesture interface and graphical interface and special input gloves for interaction on virtual environment. Vatavu et al. (2005) used gesture interactions as inputs to manipulate objects on a large virtual reality screen. Bretzner et al. (2002) describe an application that allows the users to use hand postures in front of a camera to control consumer electronics through a prototype gesture user interface. The above mentioned applications used high resolution cameras, large display screens and gesture interpretation servers for design and testing in controlled environments.

User interfaces for gesture-based interactions on mobile devices are becoming popular. An example is a gesture-based interface with a 3D audio pie menu for capturing head gesture (Brewster et al, 2003). The user points to the interface and then selects an item on the menu. The authors note that, with gestures on mobile devices, the problem of small screen size on the device could be overcome.

Long et al. (2000) describe a multimodal interface that combined gesture and pen for interactions on a pen-based user interface. Crossan and Murray-smith (2004) presented an intuitive technique in achieving gesture-based interactions through a combination of accelerometer and gestures on a gesture-based interface. Pirhonen et al. (2002) used gesture interactions to control the music player of a mobile phone. In the application, a mobile phone attached with the accelerometer is used to recognize when the mobile user shake or tap the device. Through these operations, a song is selected for filtering on the mobile music player (Crossan and Murray-smith, 2006). The authors found the interactions very easy and natural. These applications demonstrated the simplicity and intuitiveness involved when using gestures to interact with a device or application. For instance, in the case of using gestures to select songs in a mobile music player, the user does not need to read instructions, commands or click a button on the phone or interface before performing the operation. A simple wave/movement of the hand or body will activate a command and the task is performed.

Fohrenbach et al. (2008) discussed the use of gesture in manipulating inputs on large display systems. Hand gestures are used for pointing and selecting items on the large display system. The movement and tracking of the finger is also used as input into the large display system.

As a human form of communication that cuts across every society, this type of interaction technique could have some unique features among different groups and will be very intuitive during interactions, if properly adapted. Its implementation may be more difficult in rural communities due to poverty, illiteracy, non-availability of computing facilities, technological illiteracy. Non-availability of computing resources (recognition servers, cost of transmitting signals, mobile devices with capabilities) makes the gesture interaction technique difficult to implement in rural areas. It may be difficult to localize interfaces. Low-literacy users may require extensive training to use the application. Gesture interactions are yet to be tested with semi-literate and illiterate users and as such the technology or interaction technique is not yet accessible to technologically illiterate users (Parikh et al., 2009). And information pertaining to the design of gesture interactions for technology illiterate users is still illusive.

Gesture-based interaction is intuitive and flexible. But low-literacy users find it difficult to state their needs and preferences during requirements elicitation (Edim and Muyingi, 2010b). From the reviews presented on gesture interactions, we make the following observations: the process of gathering data about the unique gestures and interpretation common to the people may be difficult to actualize for design of gesture interface for rural, low-literacy users. And also, translating their cultural knowledge to meet up with their preferences may be difficult to achieve for different culture groups. Differences among individuals in a group may hinder uniformity on the acceptable data and hence affect the understanding of the interactions in general. It is also not yet known if gesture interactions are suitable and can meet user capabilities in low-literacy environments. This remains an issue that is not yet discussed in the literature so that gesture interactions can be implemented for low-literacy community users.

2.5.4 Point and Shoot Interactions

The point and shoot interaction technique offers an intuitive method of interaction for the users. It is flexible and similar to the human form of pointing to objects during interaction.

Handheld devices are pointed at another object for the exchange of information. Several studies of the point and shoot interaction technique has shown that the technique offers intuitive and flexible interactions using the mobile device as a pointing device on other objects (Rukzio et al., 2006). Ballagas et al. (2005) describe the use of a mobile phone to interact with large display systems. The mobile phone is pointed to a target area on the large screen and the target area is captured through the phone's camera as an input device to the screen of the mobile phone. Interactions such as select, rotate/drag are then executed on the target using the joystick of the phone. The testing of this application was conducted in a controlled laboratory environment.

Point and shoot interaction has also proved successful on mobile tourist applications. Madhavapeddy et al. (2004) describe a tourist application that enables the user of a mobile phone to read information from a world map. The user points the camera of the phone on a world map attached with visual tags on an active large display system. The interaction enables the phone to read information from the map through the tags. The information is then sent through a wireless network to a computer server which then helps the user to locate a city and/or airport. The application also assists the user to make travel arrangements, such as booking a flight or getting information about the city. Rukzio (2006) discussed an application that used the camera of a mobile phone to pick images of objects by pointing the camera to visual markers attached to another smart object. The information is then processed by the phone application for further interactions or the performance of other services such as phone browsing.

Valkkynen et al. (2003) discussed an application that uses a mobile phone that is attached to optical beams for interaction with other objects (e.g. poster). The application uses the optical beams to select a visual tag on an advertisement poster when the phone is pointed towards it at short range. Through the optical beams, the phone reads the URL of the tag for information relating to what is displayed on the poster through a shoot operation and then displayed on the mobile phone interface. This type of interaction technique comes with a lot of technological attachments to the mobile device.

The point and shoot interaction technique is very easy to understand and perform without much training. This interaction technique, due to its simplicity, may not pose much usability

problems for low-literacy users. Point and shoot interfaces are accompanied by several computing platforms or technology attachments on the mobile phone. This interaction technique is not widely used in the public domain. Its implementation in rural communities still remains a difficult task due to cost and non-availability of handheld devices with such capabilities. User interface design for point and shoot interaction will rely on the designers and not the users, because it will be difficult to elicit interface requirements from low-literacy users. The inputs to application are pre-determined and restricted. Personalization is difficult to implement with the point and shoot interaction technique.

The point and shoot interaction technique is simple and easy to use for interactions. It provides flexible interactions but it is not suitable for use during movement. This may contradict the mobility ways of life of rural dwellers that are not confined to an office environment. This type of interaction technique requires several technologies apart from the mobile phone in order to be implemented. The point and shoot interface and interaction technique is yet to be tested with low-literacy rural users to establish how this interaction technique can be designed to meet the expectations, experience and what is generally accepted among this group of users.

2.5.5 Touch-Based Interactions

Humans touch each other during communication if they are close to one another in order to pass information across nonverbally. Touch is a natural form of interaction during person-to-person communication or person-to-object interactions (Rukzio et al., 2006). In touch-based interactions, mobile devices are used to touch on other objects within the environment for the exchange of information. Mobile applications that use this type of interaction technique enable mobile phone users to interact with objects like posters, maps with radio frequency identification (RFID) tags, information kiosks, public display systems, and near field communication (NFC) enabled mobile devices.

Anokwa et al. (2007), Falke et al. (2007), as well as Hardy and Rukzio (2008) presented applications that used mobile devices equipped with NFC/RFID to interact with real world objects at short communication range for exchange of information. The applications provide users with intuitive and easy interactions with smart objects. Hardy and Rukzio (2008) also demonstrate similar implementation with large display systems and tourist application on

mobile phones. Riekki et al. (2006) describe the use of mobile phones enabled with RFID tag readers as touch devices to access data and information stored in RFID tags on another smart object. When the mobile phone is touched on the tags information is read from the tags into the mobile phone. Anokwa et al. (2007) also discussed a model of interaction where NFC enabled mobile phones are used to interact with physical objects at short range within the environment (e.g. interaction with movie posters). The combination of NFC technology and the touch-based interaction technique has also been applied in home care services for elderly people (Isomursu et al., 2008). The application helps elderly people to order their daily meals from a home care service provider right from their homes using an NFC/RFID enabled mobile phone to interact with RFID tags placed in the home and linked to a network computing infrastructure.

Hinckley et al. (2000) discuss a form of touch interaction technique where the mobile device itself is touched by the user, such as lifting it up with the hand. The touch sensors attached to the mobile phone send signals into the device as inputs to enable the phone to perform an operation.

Using a mobile phone as a touch device for information exchange is performed just like a typical Web browsing application (Rukzio et al., 2006). The interaction technique is easy and simple to perform without requiring much training or help from anyone (Isomursu et al., 2008). It is also intuitive to use. The inputs are pre-determined which narrows implementation to specific applications where the users are restricted to particular input and tasks. This is different from the mobile commerce application that this research focuses on. The inputs will vary based on what the users want.

This type of interaction technique is limited in use in a highly literate environment and has not been tested in low-literacy environments. The interaction technique comes with additional technologies to complement the mobile device. Mobile phones with the facilities for implementing this type of interaction technique in rural areas are still absent (Edim and Muyingi, 2010b). The design of touch-based interactions as seen in this review depended on the mental model of the designers eliminating the views or what the users will prefer on the interface. Touch is part of social interaction among low-literate people in rural communities during human to human interactions. But the objects of interaction in this case are the mobile

device and other objects. This phenomenon may convey a different meaning and as such low-literate users may not be able to relate this form of interaction with previous experience they have acquired from the natural form of interactions within their socio-cultural environment. This will limit its use to very few people within a community.

The touch-based interaction technique provides intuitive and flexible interactions for users where it has been tested. Among technology illiterate users, they may feel reluctant to use the system because it will fail to conform to their social form of interaction and experience. The use of additional technologies, together with mobile phones, for establishing interactions may further alienate low-literacy users from having access to information services. Above all this type of interaction technique is yet to be tested with low-literacy users and as such there is no information to establish how this interaction technique can be adapted to suit low-literacy users.

2.5.6 Speech-Based Interactions

Speech communication is an easy, natural and intuitive form of communication. Speech interaction is a common form of interaction among humans. The application of speech technology for human-to-machine interaction provides a natural sense of interaction to the users if properly adapted to suit the user environment. Several speech recognition and synthesis systems have been designed to aid speech-based interactions. Applications that use these technologies have demonstrated the potential of speech technology for communication between users and machines. One prominent advantage of speech interactions is its ability to accommodate a variety of users (Zhang et al., 1999) irrespective of educational level and technological literacy. Speech user interfaces provide a medium for users to interact with the application using natural language.

Speech-based interactions reduce screen presentation, and overcome the constraints imposed by a small screen and cumbersome keypad on mobile devices. Speech interactions are simple to use and conform to users' common form of communication.

Several attempts have been made to provide applications and user interfaces that will enable users to interact with computing devices using speech inputs. Zhang et al. (1999) developed a speech-based application that uses a speech recognition system to convert voice input data to

a form understandable by a computer machine. Tsai (2006) describes a speech-based user interface and application designed to provide users with intuitive and flexible interactions using voice inputs and getting voice outputs in return. The application provides Web services through a voice interface using the Mandarin language. The voice interface is a voicexml design that is connected to a Web service through a VoIP telephone service. Through Automatic Speech Recognition (ASR) and text-to-speech (TTS) synthesis, the user is able to access Web services through telephone lines using voice inputs and getting voice responses as output.

Zhang et al. (1996) discuss a voice interface that users interact with using either the Mandarin or English language. The user interface was designed to enable students to have access to the student's grading system through voice input and voice output. Every user, irrespective of educational level, will use the application provided that they understand the Mandarin language or English language. Pargellis et al. (2004) discussed a system that automatically generated dialogs and interacts with the user through voice output and user voice inputs. The application offers users a voice user interface that is intuitive and simple to interact with.

Speech technology in combination with WAP (wireless application protocol) provides access to Web services using voice inputs and outputs through mobile devices. A WAP-based information system (Lo and Meng, 2002) provides mobile device users with Web services through voice commands/inputs and voice outputs. The services provided by the system include the weather of a city, stock alert service and news. A Multimodal Web System (MWS) (Chang and Minkin, 2006) combine voice technology and visual display to enable the users to get information from the Web using speech and keypad interactions. Web access through speech interactions is a promising means to bridge the technology gap in low-literacy societies. For a mobile commerce application for low-literacy users which we have implemented in this study, speech interface will be able to provide the needed intuition and natural interactions with the application. The language of interaction is the natural and preferred language of the community.

Different mobile applications use speech technology for interactions. They include a database manipulation system using voice queries (Arons, 1991), an auditory interface for a driving simulator on mobile devices (Sodnik et al., 2008), a Web-based database system for voice

dialogs using different languages (D'Haro et al., 2006), a multilingual spoken dialog application used for online information browsing (Zue et al., 1996), and a spatial audio user interface on mobile devices for GPS (Global Positioning System) interactions (Holland et al., 2002).

Spoken dialogue systems provide easy and speedy transactions for users of mobile devices. Speech interactions enhance information access for all categories of users irrespective of literacy level or visual impairment (Tsai 2006). Speech dialogs make the users more relaxed during interactions. Speech interface provides flexibility in the way that users use their natural language during interactions (D'Haro et al., 2006). Natural language interactions are easy to "personalize" (Zadzrozny et al, 2000). Complex menus and commands are not needed for making queries or commands in commercial applications, but with simple spoken commands communication is established between user and application (Zhou, 2007).

Applications on mobile phones that use speech interfaces for interactions will enable mobile users to also engage in another activity while using their mobile device. Users with sight disabilities can be supported with speech interfaces to interact with computing devices (Holland et al., 2002). In a rural environment where educational level is low, natural language interactions will provide flexibility and easy interactions between the user and the mobile applications and services. Sherwani et al. (2007) describe a prototype that uses speech-based interactions to assist the semi-literate and illiterate users in rural Pakistan to access health information and services.

Speech-based interactions are suitable for implementation in low-literacy communities. Speech applications will not be costly to implement and use in poor communities. With speech interfaces, semi-literate and illiterate users in rural communities will be able to gain access to information and services. Speech user interfaces are easy to localize for any cultural group and will be able to meet the limited experience and preferences of low-literacy users. The users will be able to interact with the system using their natural language to access information. Mobile phones in rural communities do not need additional technology attachments to be able to operate speech interfaces. Literacy levels are not a factor for having access to speech interface. Applications such as e-health (Patel et al., 2009; Sherwani et al., 2009), advertisements, mobile shopping, entertainment and financial systems use speech

interfaces. E-health services, with speech interfaces for rural users (Patel et al., 2009; Sherwani et al., 2009), provide intuitive interactions for users. Speech user interfaces are applicable in different application areas including mobile commerce services for low-literacy users in rural communities (Patel et al., 2009).

The speech-based interaction technique provides intuitive and simple interactions that conform to socio-cultural form of interaction and experiences of target users. Speech applications are very easy to adapt to the culture and experience of the target users. Common mobile phones support voice interactions and can be personalized. With voice applications a larger population of low-literacy users in rural communities will be covered. The review on speech interactions has shown that speech interactions have been tested in low-literacy environments and also informed our choice of interaction technique in this study. What is now required is how we can adapt speech interactions to suit the capabilities of this group of users. In this study, we have designed a speech interface and tested two interaction flavours in attempt to address this study questions and objective.

2.5.7 Multimodal Interactions and User Interfaces

Multimodal user interfaces combine two or more modalities of interactions on a single application for users to communicate with an application. They can accommodate diverse users (e.g. the visually impaired and low-literacy users) since they provide more than one modality of interactions in different application domains.

Multimodal interfaces are common and suitable in different application domains. They are designed with the aim of enhancing usability of applications by giving users intuitive, flexible and efficient interactions through a combination of different communication features and channels for interactions.

Shneiderman and Plaisant (2005) discussed an intelligent multimodal interface that provides users with speech interactions and a graphical interface with limited key presses. The multimodal system provided users with interfaces that were easy to learn and use. Oviatt et al. (2000) describes the architecture for designing speech and pen-based gesture interactions as a multimodal user interface in a single application. Oviatt et al. also discussed a mobile

information service with a user interface that combined speech and graphical user interface for speech and keypad interactions, respectively.

In the virtual reality environment, Lotoschik and Wachsmuth (1997) designed a multimodal interface for a virtual reality application. The interface is a combination of speech and gestures for user interactions. Kaur et al. (2003) discussed a speech and gaze interaction system as a multimodal prototype application that uses speech and gaze to "select and move" an object on the computer screen.

A multimodal interaction system for the visually impaired (Bellik, et al., 2009) combines speech recognition and synthesis technology with keyboard and tactile (Braille) interactions to assist the blind to improve their mathematics skills. The system is an adaptive multimedia system for presenting mathematical expressions to visually disabled users. ELOQUENCE is a multimodal software platform designed to assist system designers in designing multimodal applications and interactions (Rousseau et al, 2006). A mobile museum guide application with multimodal interface was designed using the MUNDO system (Hartl et al., 2002). MUNDO is a software infrastructure for developing multimodal interfaces for mobile devices and applications such as mobile commerce.

Multimodal interfaces, depending on the type of interaction techniques employed, could be easy to localize. Multimodal interfaces are suitable for ICT applications and services targeting disadvantaged communities. A combination of speech and graphical user interface for eServices will improve users' experience and promote technology acceptance in rural areas. Also, such combinations will fit very well into the technology landscape or available computing facilities in rural communities. Low-literacy users will require minimum training to be able to use such a combination.

2.5.8 Summary of Interaction Techniques

A summary of the different interaction techniques based on interaction modalities, input and output mechanisms associated with the different techniques are presented in Table 2.1. The table gives a critical look at the different interaction techniques with regard to the conditions in rural communities. Also mentioned in Table 2.1 is the suitability/non-suitability of each of the interaction techniques for implementation for rural mobile phone users taking into

consideration factors such as low income, technological illiteracy, low-literacy level, availability of facilities and user capabilities and experience with new technologies.

Table 0.1 Summary of Interaction Techniques

Touch-based interactions	
Interaction methods	Instant or continuous touch on an interaction object with a mobile device for connecting the two together (e.g. Isomursu et al., 2008; Rukzio et al., 2006).
Application areas	Mobile tourist guide, home care services, advertisements, entertainment, museum guides, wireless services (e.g. Hardy and Rukzio, 2008; Isomursu et al., 2008; Falke et al., 2007).
Input Mechanisms & facilities	Mobile devices enabled with NFC, RFID readers, Bluetooth, sleep/active mode display, (e.g. Rukzio, 2008; Isomursu et al., 2008).
Output Mechanisms & facilities	Mobile device screen, large display system/dynamic display system (e.g. Hardy and Rukzio, 2008; Isomursu et al., 2008).
Use During movement	Interactions performed when stationary
User requirements (illiteracy; less training; intuitiveness "localization")	Less pre-knowledge of displayed options required; intuitive, difficult localization/personalization; rural user will require much training to use.
Implementation in a rural community	Facilities not available in a rural community. Low brands of phones in rural community. Not yet suitable for implementation.
Gesture-based interactions	
Interaction methods	Movement of human body parts, camera movement, image capturing on camera (e.g. Sato et al, 2006; Kratz and Ballaga, 2007; Pavlovic et al., 1997 & Sato et al, 2000).
Application areas	Interactive games, virtual environments, control of music players, camera-based recognition systems (e.g. Pavlovic et al., 1997 & Sato et al, 2000; Pirhonen et al., 2002);
Input Mechanisms & facilities	Mobile device camera, sensor-enabled mobile device, accelerometer, input glove, (e.g. Wexelblat, 1995; Pirhonen et

	al., 2002; Crossan and Murray-smith (2004).
Output Mechanisms & facilities	Mobile device screen, large display systems, virtual reality systems (e.g. Pirhonen et al., 2002; Fohrenbach et al., 2008).
Use During movement	Some implementations are suitable for use during movement.
User requirements (illiteracy; Less training; intuitiveness "localization")	Intuitive, unknown outcome of input; requires knowledge of possible input, difficult localization and requires extensive training of users.
Implementation in a rural community	Lack of facilities, low quality brands of phones amongst rural users, difficult for implementation and not yet suitable in rural areas.
Vision-based interactions	
Interaction methods	Instant or continuous movement of camera on objects, image capturing with camera (e.g. Kjeldsen et al., 2003; Reilly et al., 2007; Reilly and Chen, 2006).
Application areas	Mobile games, tourist guide, advertisements, video mails (e.g. Capın et al, 2006; Bucolo et al., 2005; Reilly and Chen, 2006).
Input Mechanisms & facilities	Mobile device camera, data gloves, NFC/RFID reader (e.g. Capın et al, 2006; Hannuksela et al, 2007; Kjeldsen et al., 2003).
Output Mechanisms & facilities	Mobile device screen, virtual reality display systems (e.g. Hannuksela et al, 2007; Kjeldsen et al., 2003; Pavlovic et al., 1997).
Usage during movement	Some applications may not be suitable during movement.
User requirements (illiteracy; Less training; intuitiveness "localization")	Unknown outcome of input; requires knowledge of possible input, difficult localization.
Implementation in a	Limited number of mobile phones with capabilities. Non-

rural community	availability of required software and hardware. Costly to use by rural users. Interaction complexity, technological illiteracy.
Point and Shoot interactions	
Interaction methods	Point and shoot; mobile device is pointed to object of interaction, selection or clicking an item (e.g. Rukzio, 2006; Valkkynen et al., 2003)
Application areas	Tourist guide, Web services, Advertisement, games (Madhavapeddy et al., 2004; Rukzio, 2006; Valkkynen et al., 2003).
Input Mechanisms & facilities	Mobile device camera, optical beams/light beams, laser pointers (Rukzio, 2006; Valkkynen et al., 2003).
Output Mechanisms & facilities	Mobile device screen, large display systems (Ballagas et al., 2005; Rukzio, 2006; Valkkynen et al., 2003).
Usage during movement	Interactions not suitable during movement; would require concentration at a static position.
User requirements (illiteracy; Less training; intuitiveness "localization")	Unknown outcome of input; requires knowledge of possible input, difficult localization; users would require training to use application in a rural area.
Implementation in a rural community	Lack of facilities in a rural context, technological illiteracy, costly to implement and use. Low quality brands of phones that will not support such implementation in a rural area for now.
Speech-based interactions	
Interaction methods	Spoken dialog or voice commands (e.g. Lo and Meng, 2002; Arons, 1991; Pargellis et al., 2004)
Application areas	Wide range of application, games, Web services, database queries, tourist guide (e.g. Zhang et al., 1996; Lo and Meng, 2002; Arons, 1991; Pargellis et al., 2004).
Input Mechanisms & facilities	Mobile device microphone or mouth piece, headset (e.g. Lo and Meng, 2002; Arons, 1991; Pargellis et al., 2004; Tsai, 2006).
Output Mechanisms & facilities	Mobile device screen, speaker, earpiece or headset, VOIP phone (e.g. Sherwani et al., 2007; Lo and Meng, 2002; Arons, 1991).

Usage during movement	Suitable for use during movement.
User requirements (illiteracy; Less training; intuitiveness "localization")	Intuitive, illiteracy is not an impediment; linguistic localization very easy; users will require minimal or no training to use.
Implementation in a rural community	Suitable for implementation in a rural area.
Graphic User interface	
Interaction methods	Keypad pressing, finger touch, stylus, pen interactions (e.g. Benko et al., 2006; Luoma, 2003; Balakrishnan et al., 2008),
Application areas	Wide range of application, games, Web services, database queries, tourist guide (e.g. Widgor and Balakrishnan, 2003; Benko et al., 2006; Luoma, 2003; Balakrishnan et al., 2008).
Input Mechanisms & facilities	Keyboard/keypad, touch screen, stylus, pen, soft keys (e.g. Medhi et al., 2006; Benko et al., 2006; Luoma, 2003; Balakrishnan et al., 2008).
Output Mechanisms & facilities	Mobile device screen (e.g. Medhi et al., 2006; Benko et al., 2006; Luoma, 2003).
Use During movement	Cumbersome and diverts attention when use during movement. Often used with conflicting attention.
User requirements (illiteracy; Less training; intuitiveness "localization")	Intuitive; not much impediment with low literacy factor, less training for users, ease cultural localization.
Implementation in a rural community	Suitable for implementation in a rural area, but with minimal key presses and localized static graphics on display.
Multimodal interactions/User Interfaces	
Interaction methods	Keypad/button pressing, pointer selection with narrator interaction, different combination of interaction modalities (e.g. Lotoschik and Wachsmuth, 1997; Bellik, 1997; Kaur et al.,

	2003).
Application areas	Wide range of application, games, Web services, database queries, tourist guide (e.g. Bellik, 1997; Kaur et al., 2003; Oviatt et al., 2000).
Input Mechanisms & facilities	Help desk; narrator or screen navigator; combination of different input devices (e.g. Kaur et al., 2003)
Output Mechanisms & facilities	Mobile device screen text; screen narrator, virtual reality screen (e.g. Lotoschik and Wachsmuth, 1997; Kaur et al., 2003).
Usage during movement	Less conflicting attention with narrator, a combination of other modes with gesture or speech will enable user to interact with the phone during movement.
User requirements (illiteracy; Less training; intuitiveness "localization")	Depending on the type of interaction combination, localization is possible with speech or graphics, intuitive, may ease cultural localization.
Implementation in a rural community	Suitable for use in a rural community with a combination of the right interaction techniques.

The reviews show the several efforts that have been made to improve user interactions with computing devices among literate and low-literacy users. Due to cost of resources and the difficulties associated with the development of ICTs in rural communities, very few of these researches have benefited users in rural communities. With the high penetration of mobile phones into rural communities, mobile application such as mobile commerce is a good example of ICT service that can be developed for rural users. The user interfaces and interaction techniques discussed above in the review will require a proper design presentation that will suit the particular rural environment if the target users are to experience the required level of usage. Simply replicating user interfaces and interaction technique designs meant for highly literate users in rural communities will be difficult to use by low-literacy users. User interface adaptation is very important in this regard in order to meet the users' experience and expectations. The discussions on the various user interfaces and interaction techniques helped us in identifying the user interfaces and interaction techniques (GUI and VUI) that we chose to implement in attempt to address the research questions in this study.

2.6 ICT Services and UIs Design for Low-literacy Users

ICTs are rapidly becoming the driving force for sustainable development in the 21st century even in developing countries and penetrating every aspect of human life (Heeks, 2008). The rural communities in developing countries are not left out. Studies have shown that ICTs have impacted significantly on economic growth in developed countries where they have been deployed and used successfully in businesses (Dedrick et al., 2003). The majority of ICT development efforts are concentrated in urban centres (Batchelor and Scot, 2005). The rural areas are perceived as risky markets and are still unexplored, to a large extent (Heeks, 2008).

With the growing demand for mobile telecommunication, mobile networks have penetrated several rural areas in developing countries providing connectivity to rural dwellers (ITU, 2007). Africa has the highest growth rate in terms of mobile phone subscription (World Bank report, 2009), narrowing down gradually the digital gap that has been created due to the absence of digital media for accessing information e.g. the desktop computers. Mobile phones have the capability to access information from the internet (WAP and HTTP enabled mobile phones). Rural and marginalized communities can be provided with ICT services that are accessible through the mobile phone for economic improvement, access to education, government services and health information. User interfaces that takes into consideration the knowledge of the target users and what conforms to their socio-cultural environment will help to improve access to these services.

Several efforts have been made to use ICTs in supporting the low-literacy and poor people in developing countries by different research studies, but mainly in Asia. These efforts include computer literacy training programmes and skills acquisition and software applications development. Efforts in software applications and user interface designs for low-literacy users are yielding good results. For instance, the texts free interface on desktop computers for semi and illiterate domestic labourers in rural India (Medhi et al., 2006). A voice user interface on mobile devices enables rural India farmers to share farming information among themselves (Patel et al., 2008). An online desktop computer application prototype (Sherwani et al., 2007) assists rural and low-literacy community health workers in Pakistan to access health information from the Internet. The Internet based application enables rural health care workers to deliver improved health care services to rural community people. This

implementation is restricted to very few utterances from the users, which makes it different from our study. A desktop-based e-commerce application for rural micro-entrepreneurs in the Dwesa community is presented in Sicelo (2007). The application helps to advertise products from micro-entrepreneurs in a rural community for sale to customers on the Internet. The user interface was not localized to enable low-literacy rural users to effectively use the application. The user interface did not address what the users preferred or meet the capabilities of the local users. In order to address these challenges, this study chose to implement the design using the mobile platform and develop interfaces that are based on what the community users want and meet their cultural experiences.

Gosh et al. (2003) discussed a user interface that was design to help community-based microfinance groups in India to manage their finances. The users were semi-literate rural Self Help Group members collectively engaged in saving and lending money to themselves. The application was for economic purposes but not many users in the rural area will be able to afford mobile devices with the capabilities demanded by the interface. Personalization of the user device was impossible. The application also provided pre-determined inputs and restricted user inputs. This is at variance to a mobile commerce application where the inputs depend on the different users. Cremers et al. (2008) study user-centred design processes with the involvement of illiterate persons using user interface of ATM machines. The study provided information on the techniques that will allow adequate participation of semi-illiterate persons during design and meeting the requirement for designing user interfaces targeting semi-illiterate persons.

Kam et al. (2009) describes a digital videogame application for low-literacy rural children in India. The authors studied 28 village games and designed a user interface for the games. The users found the interface intuitive and entertaining. Here, ethnographic studies were conducted to elicit the tasks requirements for the games and the interface interaction requirements were based on the decision of the designers. Medhi et al. (2009) conducted studies to determine the type of mobile user interface that will be most suitable to help illiterate and semi-illiterate users to access financial services. They reached a conclusion that this group of users preferred spoken dialog interfaces to text-based interfaces. They also concluded that the users performed very well with multimedia user interfaces.

Patel et al. (2009) describes a study that design and tested speech versus Dual-Tone Multi-Frequency (DTMF) input voice interface. The study result shows that users perform better with DTMF input than voice inputs. The implementation here is similar to what we have done in this study but in a different environment/user group and application area. And also, the inputs and interactions demanded from the users in this study are not limited to few utterances as the case in Patel et al. (2009).

Medhi et al. (2007) conducted a study to determine user interface representations that could help speed up comprehension of health information among illiterate and semi-illiterate users of computer. The study concluded that subjects' comprehension is better when presented with voice annotations and hand drawn graphics. This study has similarities to our work in terms of the characteristics of the target users, type of user interface and interaction technique applied. The differences are on the type of application, cultural group and what we did to answer this research question. Kam et al. (2007) discussed the PACE (Pattern-Activity-Curriculum-Exercise) framework for rapid design of localized language learning applications and interfaces on mobile devices for children. The framework was helpful in designing the mobile game and user interface for children who were learning the English language as the second language in rural India.

The CAM (Parikh et al., 2006) user interface on mobile phones enables semi-illiterate users in rural India to capture data from documents using the camera of their mobile phone. The user interface, through the phone camera, is able to read visual codes from the paper documents to give financial details about the individual. The evaluation of the interface shows that it was easy to use by most of the participants. The CAM application is intuitive and flexible for interactions. The user interface is difficult to localize and user preferences are not taken into consideration. The inputs to the CAM application are pre-determined, while this study is focused on a domain where the users are not restricted to a particular set of inputs. Semi-literate users will require much training to use since output from inputs are unknown and may not give the expected results.

Sherwani et al. (2009) developed and compared speech versus touch-tone user interface for low-literacy community health workers in rural Pakistan. The study shows that participants performed better with the spoken dialog interface than the touch-tone interface. All the

studies mentioned above have demonstrated the potentials of ICTs for socio-economic development of low-literacy people and rural communities. With mobile technologies (e.g. mobile commerce), rural people and communities can be empowered both socially and economically.

The research efforts made so far in using ICTs for empowering low-literacy users in developing countries have shown significant successes. Much is still desired to enable the vast populations of users in rural communities to have access to information. User interfaces designed for this purpose are very important if the goal of providing information to the poor and people with low literacy levels is to be achieved.

2.7 Wireless Application Protocol Programming Model

The enabling technology for the delivery of Internet data and content on mobile devices include Wireless Application Protocol (WAP) standard specified by WAP FORUM (WAP Forum, 2008) and i-mode Internet enabled mobile devices. The WAP programming model is shown in Figure 2.3. In the figure, the phone user sends a request for information from a Web server through the mobile communication network to the internet and then to the Web server. Along the line, the WAP server acts as a translator between the WAP device and the Web server. The Web server identifies the request and gives the appropriate response to the mobile device traversing the same route back. WAP (Wireless Application Protocol) facilitates Web/Internet connectivity with mobile devices. WAP was pioneered by Motorola, Ericson, Phone.com and Nokia, providing an open connectivity protocol for wireless applications. It combines both wireless communication and the Internet for mobile device accessibility.

WAP has been at the forefront of providing the technology for mobile commerce application using its XML based document type language (wireless markup language). WML offers platform independent applications (Hampe et al., 2000) for different types of devices. The latest standard, WAP 2.0 supports client-side scripting languages such as the wireless markup language and scripting (WML), extensible Hypertext Markup Language Mobile Profile (XHTML MP), and Wireless cascading stylesheet (WCSS). The WAP standard is also based on the Internet standards (HTML, XML and TCP/IP). It is a platform for developing applications that are suitable for thin client devices such as cell phones, PDAs (Personal

Digital Assistants), and pagers. The availability of 3G technology allows clients with this technology to access the same Internet content with the desktop computers. The only difference is how the content is rendered on the browser of the client device. Other technologies such as Java Micro-edition also developed for resource starved devices such as mobile phones enable connections to the Internet through HTTP protocol connections. The devices are Java enabled phones for providing Internet services such as mobile commerce, chat rooms and others. Technologies such as X-HTML, WCSS were used in designing the graphic user interface. Although with X-HTML, connecting the user devices to the Internet is through the HTTP with recent mobile devices. These technologies provided the flexibility needed to add graphical symbols on the interface and to provide the target users with adequate visuals for interactions.

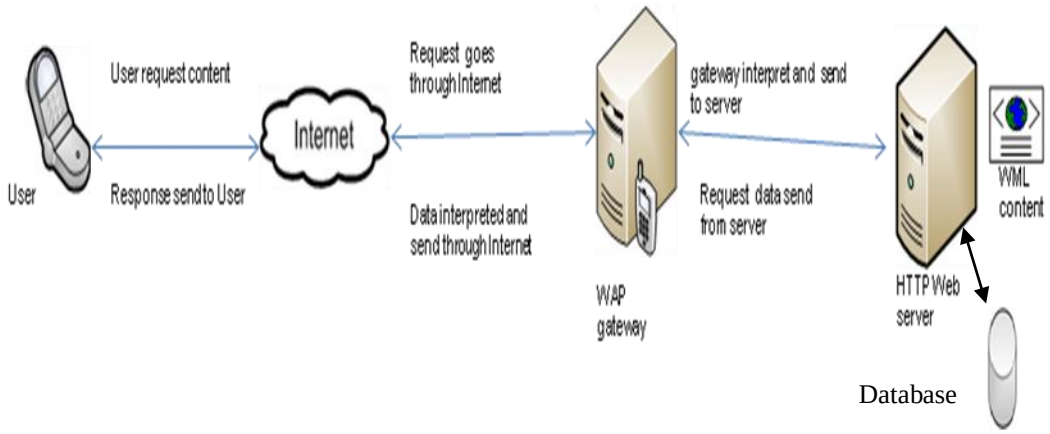

Figure 0.3 The WAP Programming Model (adapted from: Routt, 2004)

2.8 Conclusion

The review has shown that several attempts have been made to provide intuitive and easy to use user interfaces both in highly literate and low-literacy environments. More successes have been recorded among users in highly literate environments (Rukzio et al., 2006; Kjeldsen et al., 2003; Reilly et al., 2007; Reilly and Chen, 2006, etc.) and very few successes in low literate communities (Medhi et al, 2006; Patel et al., 2008; Sherwani et al., 2007; Kam et al., 2007). The majority of ICT development innovations have concentrated on the highly educated in urban centres and the user interfaces and interaction techniques provided has helped in enhancing ICT development in these areas. With the growing debate on ICT for development in rural communities across different cultures, there is need to carefully consider the design of these user interfaces and interaction techniques for different user

groups in low literate communities such as in Africa. However, the studies on user interfaces and interaction techniques, and also studies on ICT services for low-literacy users did not provide adequate information on how to adapt these user interfaces and interactions or did not point out how to design these user interfaces and interactions so that the experience and cultural preferences of low-literacy users in rural communities can be included in the design in order to influence their perceptions, enhance interaction experiences and interface acceptance. Low-literacy people in rural communities are mostly technology illiterates, low level of education and lack the experience to interact with new technology (Lalji and Good, 2008).The natural experience and preferences of technology illiterate users in rural communities will make the user interface and interactions to conform to what the users want and improve interaction experience. Rural communities are underserved in terms of technology resources and hence rural dwellers have limited experience with information and communication technologies. Lack of awareness of users' experience and preferences of low-literacy users during user interface design will create usability problems and hinder successful development of ICTs in rural communities. User interfaces that are designed with the highly literate users in mind are usually very difficult to use by low literate users in rural communities (Edim and Muyingi, 2010a). This is because they lack the skills necessary to use these interfaces. User interfaces that are tailored to cater for their behaviours and natural abilities will help to promote ICTs development in rural communities.

CHAPTER THREE: STATE OF DESIGN OF ICT SERVICES FOR DEVELOPMENT

3.1 Introduction

The advent of ICT provides an enabling platform for addressing the socio-economic needs of underserved communities (Donner, 2007), by providing useful eServices. But the user interfaces that provide the medium of interaction between the users and services need to also address the social and cultural specificities of the target users (Boyera, 2007). This will improve the usability of the services, and reveal the expected result.

Mobile applications such as mobile commerce provide added value to users even in rural communities and as such are easily accepted. The user interfaces and interaction techniques that are provided for user interaction with this services still hinders successful ICT development in rural communities.

Usability problems are not limited to one category of users and user interface design. These problems are still denying users the much needed satisfaction irrespective of physical abilities, educational background and environment (Cremers et al., 2008). To design suitable user interfaces for ICT applications and services for rural users, one will need to understand the users and their socio-cultural environment. The socio-cultural environment influences the behaviour and natural experiences of the people as a result of their daily interactions within their environment. Taking these users' cultural experiences into user interface design will promote acceptability and use (Yeo, 1996; Shen et al., 2006). Culture influences users' behaviours and motivations, which in turn have effect on their interactions with technology. Several researches indicate the importance of cultural inclusion in user interface design. In this study, we have emphasized the elicitation of culture related data to design user interfaces and interaction techniques for Dwesa low-literacy users.

This chapter discusses mobile commerce and its enabling technologies. The chapter also presents discussions on technologies for VUI and GUI Design for Web Applications. Some of these technologies we have applied in this study in attempt to address this study concerns. The chapter further describes the user-centred design approach and the cultural model and

theories we have adopted for this study. This study objective and research questions has influenced what is presented in this chapter.

3.2 Mobile Commerce

ICTs offer new markets and business opportunities for design professionals, ICT vendors and service providers to explore (Heeks, 2008). For the users, they bring added value and promote micro-businesses. The new markets and opportunities also come with new challenges that require different views and approaches in proffering solutions. Harnessing the potentials of ICTs for assisting underserved communities in developing countries requires understanding of the changes and challenges in the new environment. In rural communities there are micro-businesses that ICTs could affect positively in promoting their businesses. The spread of mobile phones to rural communities makes it a good platform to provide services that will assist rural micro-businesses to improve their economy. Mobile phones can be used to overcome non-availability of desktop computers in rural communities, make information accessible and encourage local productivity.

E-commerce platforms on desktop computers and wired Internet have been a driving force for business activities in developed regions (Molla and Licker, 2005). But due to affordability and sustainability problems e-commerce is yet to create a similar impact in underdeveloped communities (Molla and Licker, 2005). M-commerce has a wider reach and can help leverage the socio-economic challenges faced in the rural areas. Mobile commerce provides added value services and satisfaction. It is ubiquitous and reaches the users anywhere and at any time (Pousttchi et al., 2002).

M-commerce is e-commerce on the mobile device platform. E-commerce provides innovative and timely business services to consumers and business operators. These include e-shopping, business to business (B2B) services, business to commerce (B2C) services, and government to business services through the Internet. Han and Han (2001) point out that "the value customers receive from e-commerce is much more than what conventional businesses provide". In developing countries, e-commerce is still not well developed due to some constraints that need to be addressed so that both buyers and sellers are protected (Molla and Licker, 2005). The extension of E-commerce from wired Internet to wireless Internet or mobile Internet gave birth to m-commerce. E-commerce transmitted through the mobile

Internet and transactions done using the mobile device is considered mobile commerce. It involves mobile communication technologies on the one hand and the wireless internet on the other hand.

Mobile commerce services not only provide the benefits of e-commerce but surpass them by giving customers and businesses other benefits like ubiquitous services, flexibility of interactions and user convenience (Mahatanankoon et al., 2005). M-commerce services include entertainment, social networks, mobile chat rooms, news, advertisements, mobile banking, reservations, and ticketing (Wu and Wang, 2006). M-commerce provides space for the personalization and customization of products and services that are accessible with ease and flexibility at any time and place (Keng et al, 2001; Pousttchi et al., 2002). These potentials of m-commerce coupled with easy affordability of mobile devices in rural communities make it a good technology platform to meet ICT for development goals.

Mobile devices, when compared to the desktop computer, pose some constraints that affect the smooth operation of m-commerce. These include low computing capabilities, small memory to hold data, small screen size that reduces the amount of information displayed at a time or reduced form factor, cost, small data bandwidth and poor adaptation for different mobile devices (Pousttchi et al., 2002). But customization can help to reduce the negative impact experienced by users (Pousttchi et al., 2002). Customization of the user interfaces is very important in this study and we have made serious effort in applying it in the design.

Mahatanankoon et al. (2005) identified content delivery and transaction as two modes of m-commerce operations. Content delivery involves the provision of web information services (e.g. weather information, financial news, sports news, social network interactions and games). On the other hand, the transaction mode includes business transactions between businesses and customers, where the customers carry out business transaction activities online (e.g. purchases of items from online shops). The mobile commerce application designed for this study is a transaction oriented application that will enable users to perform transactions on it.

Molla and Licker (2005) investigated factors that affect e-commerce adoption in developing countries and developed a decision tool to help manage risk in organization for e-commerce

adoption. Molla and Licker (2005) also pointed out the driving forces for bringing e-commerce nearer to the customers in developing countries. These include users' perception, users' satisfaction and adoption. Wang and Liao (2007) describe an M-Commerce User Satisfaction (MCUS) model to help developers built and test mobile commerce applications and promote users' acceptance. A model for identifying users' needs when developing an m-commerce application also listed factors to consider during the process (Wu and Wang, 2006). These factors include assurance, the needed products and enabling functions. Buyukozkan (2008) studied existing literature on m-commerce and applied the analytical hierarchical process (AHP) to analyze the data derived. He formulated a hierarchy of m-commerce user requirements that will help designers to develop acceptable and satisfying m-commerce applications.

Konstantina et al. (2006) discussed an m-commerce museum shop for selling museum artefacts. The application provided a graphical user interface for users to browse through products of museum artefacts. The application enhanced the museum system and enable customers to visit the museum through the Web. Yousif and Abid (2005) discussed a WAP-based course registration system for undergraduate students. The application presented the students with a graphical user interface on their mobile device to perform transactions. It enabled the students to carry out course registration, adding and dropping courses, check results and transcript. The application enhanced the students' registration process as it took less time to register, and was also found to be very efficient when compared with the manual system of registration.

The studies described in the last two paragraphs on mobile commerce research activities provided vital information and insight on some of the operations and functionalities found in a typical mobile commerce application which we have incorporated into our design. The applications described here are similar to some extend to the mobile application we have developed during this study. What differentiate our work and the ones discussed here include the user interface, and the additional traditional business tasks that have been added into the application designed to address this study objective.

Sicelo (2007) designed and deployed an e-commerce platform for rural users in Dwesa. This electronic shop is intended to aid the rural people within this community to engage in trade

activities for sustainable development by helping them to sell their products on the Internet. The application allows the administrator/shop owners to upload their products into their virtual shops using the desktop computer. With this application, being a desktop application, the target users were confronted with several hindrances. These include lack of computer literacy and skills, technology illiteracy, limited number of desktop computers in the community, centralized computing and Internet facilities that made it difficult for micro-entrepreneurs to have access to the application. The distance of facilities from the users and time also hindered local users from exploring the potentials of the application. The user interface for local users was not localized and hence made it difficult for community members to use the application (Edim and Muyingi, 2010c). In order to overcome these challenges experienced by the local users, we decided to design a mobile commerce application and also focused on the user interfaces and interactions provided to enable the community users to be able to use the application. Mobile applications have ubiquitous advantage over desktop applications and this fit very well in Dwesa rural community where the settlements are sparsely located.

The proliferation of mobile phones also implies that the added value services provided by m-commerce will also spread and reach everyone irrespective of their geographical location or literacy level. A lot of users with different capabilities, needs, experience, culture, and literacy will also be part of the added value services provided by m-commerce. The opportunities provided by these technologies (the mobile technologies) present several challenges to system designers as they try to include every category of user into the mobile world. With the growing concern for helping the underserved and marginalized communities, it is necessary to include rural dwellers in the added value chain. Mobile applications with user interfaces and interaction techniques that will enable low-literacy users to carry out transactions freely at any time and place and for economic benefits is a step in the right direction. The opportunity to adapt Web technologies to support the second economy people in rural a community was explored in this study. The challenge here was to provide mobile user interfaces with interaction techniques that are intuitive, easy to use and accessible to low-literacy users. To achieve this, the users' natural knowledge gained from their socio-cultural environment and their preferences were major concerns we considered during the design process. These factors will enable local users to perform transactions on the mobile commerce application with ease and accept the interfaces as their own.

3.2.1 Special Features and Attributes of Mobile Commerce

Mobile and wireless communication enable mobile commerce customers to experience special features that are not available on fixed or wired e-commerce. Such features include ubiquity, convenience, location-awareness, customization, and adaptability (Mahatanankoon et al., 2005; Tsalgatiduo and Pitoura, 2001).

Ubiquitous services: Users of handheld devices through mobile communication maintain connectivity at any place and time. Customers of mobile commerce services can initiate and conduct transactions at any place and time. For instance, mobile phone users get notification of account updates or perform mobile payments anywhere and at any time. For rural users who are in locations far from urban centres where banks and other financial houses are, using mobile applications that enable them to make transactions such as buying of electricity for domestic use. It will add value to mobile phone usage in rural communities as a result of the ubiquitous nature of the services provided.

Convenience: Mobile commerce applications provide convenience to its customers by providing services at anytime and anywhere. Customers are not restricted by any condition that will cause them to make transactions when it is not convenient. They could also decide to perform transactions on their mobile phone while engaged in other tasks like reading, movement and taking a rest. The restriction in movement imposed by wired e-commerce is eliminated. In rural communities where desktop computers and the wired Internet are limited or nonexistent, mobile networks and applications are most convenient. Users will not need to travel long distances to cities before they perform any transaction such as making payments for services.

Location-awareness: Mobile networks provide location aware services to customers. These are mobile commerce services that are offered to customers based on their physical location at any given time. The mobile network operators are usually aware of a cell phone within their network. With this information services such as advertisement, taxi/car hire services, vehicle tracking can be offered to the customers based on his/her location and the service nearest to him or her (Zhang et al., 2002). In rural areas, services such as weather and agricultural information, government programmes and extension services, healthcare and health risk information (e.g. outbreak of epidemics, immunization programmes, and

agricultural extension services) in a given locality can be provided to local communities through their mobile phones as a means of alerting the people and enhancing rural livelihood.

Customization: A common strategy for business growth is to maintain a business relationship with users or customers. When users are provided with relevant services and information based on their current location or lifestyle, their morale and trust is enhanced for the service provider. Mobile device users, due to the constraints of the device, are not willing to receive or interact with services that do not meet their present requirements. For instance, users of mobile phones will be happy to receive information about current events such as latest scores for soccer fans, weather forecasts in the morning for the working class (Kim, 2006). A careful understanding of the pattern of life and local activities for a particular rural community will help to identify what information needs are particular to the people and subsequently supplied through their mobile phones.

Adaptability: Adaptation of mobile commerce services to the needs of the people (social and economic needs), their devices and user capabilities will create the desired impact on the users. For instance, if mobile commerce is to be successful in rural areas; the services provided must be in line with what the users in these locations seriously needed, services that will be of low cost to them when compared to the urban centres, and services that will meet their experience and capabilities. Also, the type of mobile phones used in rural areas are not of as high quality as those of urban users, thus mobile applications can be adapted to meet the capabilities of these devices.

3.2.2 Types of Mobile Commerce Applications

There are several mobile commerce applications and they include customer services, organizational services and enterprise markets. These applications and services provide high quality data transmission and communication among participants (Kim, 2006). Mobile commerce applications have been categorized into (Mahatanankoon et al., 2005; Zhang et al., 2002; Hampe et al., 2000): content delivery, transaction-based, location-sensitive, emergency-sensitive, and entertainment applications.

Content delivery applications: These types of applications provide the mobile user the platform to be able to receive or send messages through his/her mobile device. Examples of

content delivery services include searching the Internet for information, message services (e.g. prepaid service notification, transaction notifications, sending and receiving SMS, e-mails, MMS), dictionary services, directory services (enquiries such as prices, telephone, booking information, Google search), subscription content delivery (e.g. news services, weather news), chat rooms and social networks and others (e.g. religion readings).

Transaction-based: These are applications that enable the mobile user to perform business transactions using the device. These include bank transactions (account enquiries, transfers, payment of fees, bills), placing orders (e.g. buying of goods), ticketing (e.g. bookings, ticket enquiries), service payments (payments to service providers, buying of airtime, buying of electricity, data rates). The mobile commerce application designed for the purpose of this study is a transaction-based application.

Location-sensitive applications: These applications enable businesses to send location-based services to potential clients or existing clients within the business location. Through technologies like the geographic positioning systems (GPS) locations are identified. Mobile devices within the given locations are captured and relevant information can be send to the clients. Application areas include advertisements, weather forecast, driving directions, nearby restaurants, and alerts from travelling companies.

Emergency-sensitive services: These applications help mobile phone users receive timely information and also help users seek emergency assistance when such a situation arises. For instance, clients can receive timely stock prices, flight status, SMS, weather forecast. Mobile phone users can report an emergency situation for assistance; for example, a crime incident, accidents, emergency health-care service, and roadside assistance.

Entertainment service: These applications are relevant to mobile users as necessities that are needed during certain times (e.g. playing and listening to music to keep ones' mind busy while on transit). Other mobile applications this category include playing games and music, and educative games on the Internet.

3.2.3 Underlining Network Technologies and Standard for Mobile Commerce

Mobile commerce applications use wireless network technologies and the Internet for transactions with mobile devices. The development of these technologies has evolved from one generation to another. The major mobile commerce actors include the telecommunication network providers, the users of the services, the mobile network operators, content providers, Internet service providers, the portal providers, financial institutions, phone software providers, the delivery service operators, and also the product manufacturers for tangible items (e.g. phone), and other equipment manufacturers (Veijalainen et al., 2006).

The enabling technologies started with the 2G networks standards such as TDMA, GSM, and CDMA for providing both digital and cellular connections (Coursaris and Hassanein, 2002). The 2.5G networks provided improvements on the 2Gs with technologies such as HSCSD, GPRS, and EDGE (Peck, 2001). These technologies provide the users with higher data exchange rates. The present 3G mobile wireless network technologies provide high speed and quality data transmission such as video and audio data. These technologies include wireless LANs, GPS, CDMA W-CDMA, UMTS, cdmaOne (Grami and Schell, 2004; Peck, 2001), Wi-Fi, and WiMax. IMT-Advanced (or 4G) is a new mobile network technology approved by ITU and is hoped to be in the market before the end of 2010 (ITU, 2010b). IMT-advanced is expected to perform better than the 3G, and will provide wide range of data services to include high-speed and quality multimedia, packet-based data transmission for both fixed and mobile networks (ITU, 2010).

Hampe et al. (2000) categorized the mobile networks providing mobile commerce enabling environment as either global (satellite based) or terrestrial (micro or cellular). These technologies use different media infrastructures and wireless communication standards such as the global satellite, 3G, Bluetooth, Internet platform and IEEE 802.11a/b. The GSM and SMS technologies are the most widely used of all the mobile technologies and have reached so many rural areas enabling mobile phone users in these communities to maintain communication with relations and friends in different parts of the world. With this infrastructure in place, more people now have personal GSM enabled devices.

In the SLL in Dwesa community, the enabling technologies for mobile commerce include the GSM networks, WIMAX and WIFI technologies connecting the network of computers to the Internet. The mobile commerce application designed in this study will be accessible by local community users through the GSM network platform.

3.3 Technologies for VUI and GUI Design for Web Applications

3.3.1 Voice User Interface Technologies for Mobile Web Applications

Voice technology is powered by voice recognition and synthesis systems. The voice recognition system provides an engine that translates spoken words into a digital form that a computer can understand. The voice synthesis system translates text messages from the computer to voice signals (such as voice prompts). The former is an Automatic Speech Recognition (ASR) system and the latter is a Text-To-Speech (TTS) engine. These voice technologies provide a platform for speech application development. There are several speech recognition and synthesis systems for voice user interface design. A few notable examples include the Java speech API, the Microsoft speech API version 5, sphinx an open source platform, IBM via voice, dragon natural speaking, nuance, lumenvox, cepstra, festival lite (TTS), asterisk PBX, and voxeo ASR/TTS speech server. Telephony interfaces include both hard and soft IP phone for interactions with the interactive voice response systems. An example of a soft phone is the open source exten-xlite softphone, a SIP phone for testing voice applications. The Microsoft windows XP and vista O.S. contains both speech recognition and synthesis (text-to-speech) systems for developing voice applications.

Technologies for designing voice enabled interfaces include SpeechXML, Java speech markup language (JSML), VoiceXML and others (Abram et al, 1999). VoiceXML provide voice-enabled interfaces for accessing web services.

The following technologies were used to design and test the voice user interfaces developed during this study: VoiceXML technology, Asterisks PBX, Voxeo speech server, exten-xlite SIP phone to design and test the voice user interface and to demonstrate part of this study intentions. The voice user interface interacts with other web technologies in the mobile commerce application to give the users the needed satisfaction.

3.3.2 GUI Technologies for Mobile Web Applications

The WAP standard and its wireless markup language (WML and scripting) are strong tools for developing GUI for M-commerce applications. WML is also compatible with other Internet standards such as the javaScript, URL, HTML, XML, and TCP/IP. Mobile devices equipped with WAP browsers use the WAP open architecture for Internet access. WAP-enabled phones use WML, an XML language meant for resources starved wireless devices for displaying Internet content on the browsers. WML provides flexibility and efficiency for mobile applications and interactions (Swallows et al, 2007). WML is organized in cards defined as documents and provides users with graphical user interface to interact with the application.

Mobile Web offers users of mobile devices (e.g. PDAs, mobile phones) access to Web services using the device web browser. Apart from the WML, new mobile devices support other enhanced technologies. Platform-specific mobile technologies include symbian, BREW/uiOne, J2ME, and adobe flash lite. The technologies that are platform-independent include WML, XHTML-MP (extensible hypertext markup language mobile profile), WCSS (wireless cascading style sheet). The technologies mentioned above are well enhanced to meet the W3C Web development standard. WML used the WAP gateway to connect to the Internet, while other technologies use the hypertext transfer protocol (HTTP) to connect to the Web.

Several Web service applications have been designed for WAP enabled devices. Lo and Meng (2002) discussed a WAP-enabled application for browsing Web content. The application combines speech spoken dialog interface and WAP to provide users with information on the weather of a city and stock alert services. The Rapid Serial Visual Presentation (RSVP) is a tool for design mobile browsers on WAP devices (De Bruijn et al, 2002). The method seeks to enhance Web browsing on handheld devices. Chittaro and Cin (2002) studied WAP interfaces and presented guidelines for the design and evaluation of user interfaces on WAP devices. Holland et al. (2002) developed an auditory interface for a GPS receiver. Rist and Brandmeier (2002) tested a number of image transformations on small screen devices including WAP phones in an attempt to solve the problem of image presentation on them.

Kaasinen et al. (2000) developed a proxy server to convert HTML web pages to a form that a WAP browser could read as WML. The system enables WAP phones to access and read content rendered in Web HTML and originally meant for the desktop browsers. Maglaveras et al. (2002) used WAP technologies to design an application that enables users to have access to health care information from the Internet. The prototype user interface was designed using WML for WAP terminals.

New mobile devices provide new colour display types as well as extended keyboards and pen inputs to provide mobile commerce clients a better experience. Recent mobile devices use browsers that are different from WAP browsers. Mobile devices with 3G technology use extensible hypertext markup language mobile profile (XHTML-MP) and wireless cascading style-sheet (WCSS) for presentation and rendering on mobile browsers. The technologies are very similar to desktop browsers and with high quality display graphics. With new Web technologies or languages, the same Web page can be view both on the desktop and the mobile device browsers. XHTML-MP and WCSS combines with server side technologies such as JavaScript, PHP, JSP, or ASP to provide data driven and dynamic content to the client device.

For this study, the server side technology we applied includes open source PHP, MYSQL, and Apache server, to design dynamic content and the database for the mobile commerce application; while the client-side technologies used for designing the GUI uses X-HTML-MP and WCSS. The client can establish connection with the Web server through the HTTP protocol. These technologies provided the needed platforms for designing and testing the application for this study and means of meeting the study objective.

The advancement in mobile technologies has enabled the mobile web to adopt web standards. Both mobile and desktop computing platform devices are able to access the same application and content from the Internet. Web standards (e.g. cascading style sheets (CSS), JavaScript, PHP, MYSQL, etc.) are now portable onto the mobile Web. The two Web technologies have converged to a common point enabling content rendered on mobile devices in the same way that it would be rendered on the desktop browser.

3.4 User-Centred Design Approach

The user-centred design approach provides design guidelines and principles for usability design. The emphasis is on users' involvement during design. This is to enable the designers to make the right decisions and gather empirical data needed for the design. Through adequate user involvement, the designer will be able to meet users' expectations and satisfaction (Xavier, 2001; Huenerfauth, 2002). ICT applications and services designed for rural users can be described as lightweight systems that require ethnographic research methods (e.g. focus groups, interviews) to enable the users to participate effectively and for data collection.

Users should be at the heart of the design process in building usable interfaces. The design should focus on the users, their capabilities, expectations and needs. The process of involving the users will only be successful if the right methods are applied during the design process. The methods must be the type that the users will be comfortable with and participate in with ease. Usability is crucial to the development of any system and the use of user-centred design approach and appropriate design methods will help the designers to develop usable user interfaces (Costabile, 2001). The design of user interfaces for users in, as yet, unexplored rural communities is a huge task that is costly and time consuming (Huenerfauth, 2002). For these groups of users, applying a user-centred design approach and methods that will enable the users to participate effectively will be most beneficial to the designer and the users. The designer will be able to identify their needs, abilities, and environment (physical, social and cultural environment). The users will develop confidence and trust in the design process and participate effectively during design (Wixon et al., 2002).

Effective user participation depends largely on the methods used due to cultural differences (Vatrapu, and Perez-Quinones, 2006). A user-centred design approach (Johnson et al., 2005; Xavier et al., 2001; Costabile, 2001; Shneiderman, 1998) includes the following steps:

- Analysis of the intended users to identify user characteristics and the environment where the system will be implemented.
- Users' tasks analysis and scenario design – tasks analysis is performed to identify the tasks involved and the procedures for performing the tasks and then scenarios of the user tasks are designed.

- Design of prototype – iteratively develop tangible prototype to enhance users' understanding of the proposed system and then customize into local culture to enhance usability.
- Evaluate the prototype with the users to determine whether the prototype meets the design requirements.

The different methods for collecting users' data include observation, being direct, shadowed or under cover from the users, focus groups meeting, interviews, and surveys (Peleg et al., 2009; Xavier et al., 2001; Costabile, 2001; Kinzie et al., 2002). On environmental analysis, techniques such as ethnography, site visits, interviews, and surveys can be applied. For user tasks analysis, one may use methods that include observation of users while they perform their tasks, scenarios, interviews, questionnaires, flow diagrams, and use case diagrams. Prototyping methods include paper prototype, wizard of Oz, storyboards, scenarios, and emulators (Xavier et al., 2001). Usability evaluation methods include expert and user based methods. Expert based evaluation includes heuristic evaluation, cognitive walkthroughs, and inspections (Nielson, 1995). User based evaluation includes think aloud technique, observation, focus groups, interviews, and surveys (Xavier et al., 2001; Costabile, 2001). The use of the above mentioned user-centred approach will provide valuable qualitative and quantitative data that will aid the design of the desired user interface that meet users' needs and expectations.

We adapted the user-centred design approach discussed above to suit this study environment and to systematically interact with members of the community for the purpose of designing the user interfaces and application. This designed approach ensured that the intended low-literacy users in Dwesa participated in the design process to bring about interfaces that met their requirement. The phases outlined above ensured that we were able to keep track of the data collection and the design of the user interfaces processes. We made necessary addition, that is, introduced an additional phase so that we could apply methodologies that helped us to interact effectively with the community members and collect the required data to aid the design of the user interfaces and application. The additional phase is presented in the research design. In the next sections, we present detail discussion of each phase of the user-centred design approach outlined above.

3.4.1 User/Environmental Analysis

A user analysis is crucial for user interface design. It involves a careful investigation for an understanding of the users and environment for a successful design process (Helms et al., 2006; Johnson et al., 2005; Huenerfauth, 2002). Understanding the target users will lead to the design of a successful and usable system. User needs will be identified (Thursky and Mhemoff, 2007), their characteristics and capabilities with technology, and the nature of the environment where the system is to be deployed will be investigated and determined (Costabile, 2001). Information concerning the users in terms age distribution, education, technology literacy, cultural inclinations, skill levels and experiences of the users will be determined (Johnson et al., 2005).

Several methods are used for user and environmental analysis. These include ethnographic studies, where the researcher visits the work place and study the users in the work environment (Bossen, 2002), surveys, interviews, focus groups (Thursky and Mhemoff, 2007; Johnson et al., 2005; Xavier et al., 2001; Huenerfauth, 2002; kinzie et al., 2002; Costabile, 2001; Shneiderman, 1998). The environmental analysis also includes the social and cultural aspects of the environment as they influence the daily life of the users. The types of conditions that surround the user environment (noisy, quiet) where the system will be deployed are important factors that will determine the type of interface and interaction that will suit the users in this environment (Johnson et al., 2005; Shneiderman, 1998). Availability of technology tools that will be used to support users' tasks will also be determined at this level of design.

3.4.2 Task Analysis and Scenarios Design

Task analysis is a process that is used to identify the various tasks that the users will need to perform in order to achieve the set down goals. During the process, system functions, user information and tasks capacities are indentified (Kinzie et al., 2002). Task analysis also identifies input and output requirements and formats for the system as well as the constraints that users may encounter during interactions (Zhang et al., 2002). Tasks analysis takes into consideration the experience and capabilities of the users, necessity and accuracy of a task (Zhang et al., 2002). Different methods can be used for analyzing users' tasks. These include ethnographic studies (Johnson et al., 2005; Bossen, 2002; Shneiderman, 1998), interviews, observations, documents study, and questionnaires (Johnson et al., 2005).

The information that is gathered is analyzed and presented using different techniques such as flow diagrams, scenarios, sequence diagrams, hierarchical tasks tree and tables (Shneiderman, 1998). For users in the rural communities who are new to ICTs and services and with little experience in the tasks domain, the designer may have to supplement the data collected about users' traditional tasks activities with extensive study of similar applications and literature materials in the domain in order to collect data about additional tasks. The users will be presented with the information through tasks scenarios/prototype for their contributions and further analysis of the issues that might arise in the process.

Scenarios are simple and provide a means of engaging the users early in the design, for their input. Scenarios provide a good means of presenting design decisions to the users even in a rural context. In rural areas where the literacy level is low, oral presentation is common and easier to understand. Through scenario narratives and stories, information is passed easily. The designers could use the process to elicit requirements and understand users' cultural context (Huang and Deng, 2008). A scenario sketch represents a prototype of an activity (Rosson and Caroll, 2002) which can be presented in the form of a story. Scenarios show the decomposition of tasks into activities. They are also useful for describing the interface elements needed to perform each activity and the sequence of interactions. Scenarios include activities, tasks information, and interactions.

Scenario discussions with users could provide a means of gathering data meant for application database design. Scenario designs also include user actions, screens, menus, icons, labels, navigations, and plans for achieving user goals. The evaluation process is formative at this level and criticism from participants are taken for interface design. In a rural context, focus groups are very effective for data gathering and evaluation. The method is synonymous with the way of life of the people.

3.4.3 Prototyping

Prototyping is a useful technique in software design. Prototypes provide a tangible system for introducing a new application to the users (Shneiderman, 1998), including users that are new to technology. The prototype aids the requirement gathering process even in low-literacy environment (Medhi et al., 2006). It helps users to understand the system even at an early

stage of the design (Scacchi, 2002). Simulated prototypes are used to communicate design ideas to the users and may be developed into the needed system (Xavier et al., 2001).

Different prototyping techniques can be employed in the design process. These include paper mock-ups, wizard of OZ technique, story boards, and high fidelity prototypes such as system emulators, or program codes (Helms et al., 2006; Xavier et al., 2001). Prototyping is an iterative process where the designers and the users are fully involved. At each prototype cycle, the designer and the users evaluate the system against the design specifications and the process continues until the system meets its target.

3.4.4 User Evaluation

Evaluation of an interface or software is important to ascertain the usability of the product. User evaluation is a process by which the users test and evaluate the design to judge whether it meets the requirements previously specified. Several evaluation techniques can be applied to this process. One method is the think aloud protocol where the evaluator talks as he uses the system in a controlled laboratory set up (Costabile, 2001; Abras et al., 2004; Thursky and Mahemoff, 2007). The process and the outcome are recorded for future analysis. Another method is the heuristic evaluation method where experts in usability will examine an interface using their experience or usability guidelines to ascertain whether the guidelines have been followed during design (Nielsen, 1995; Shneiderman, 1998).

Other forms of evaluation methods include walkthroughs, and inspections (Nielsen, 1995; Xavier et al., 2001). One effective way of evaluating a design is to use the actual intended users in the environment where the system is to be put to use (Costabile, 2001). User evaluation is the most common method and it is capable of exposing potential problems that expert evaluation may easily ignore (Shen et al., 2006). In situations where there are no usability experts or laboratory facilities for the evaluation, user evaluation becomes the most effective method. During user evaluation, the processes are carefully observed and recorded on paper or videotaped. The data is then analyzed and used to review the design (Xavier et al., 2001). Post-test interviews or questionnaires can also be used to collect users' feedback and the result of the analysis is then used to update the system (Peleg et al., 2009; Shen et al., 2006).

All the design phases discussed above were duly applied in the course of this study and user interfaces design. The research methodologies outlined in each of the design phase were selected with regards to the study environment. This helped to provide a good avenue for Dwesa community members to participate effectively during data collection.

3.5 Enhancing User Interface Usability through Customization

New technologies usually pose usability problems to the users even among the highly educated. User interfaces are often designed in a way that users will need to conform to the interfaces in order to use them (Marcus, 2001). Such situations may prevent low-literacy users from reaping the benefits of new technologies that drive the adoption of information technology (IT). Customization of these technologies (software) to reflect the cultural experience and preferences of the target users or community is therefore required to present an artefact that will conform to the users' interaction expectation. When the user interfaces and software are properly adapted to the culture of the target user group, the system will be intuitive to the users and useful. A user interface is meant to provide users with simplicity and a natural sense of interaction; taking into consideration the context in which it is being used, and adequately dealing with the users' cultural issues and the required added values (Shen et al., 2006).

In order to enhance the development of ICT and record the desired success in rural areas, the user interfaces where the users interact with ICT products and services should be adequately adapted to meet users' preferences and provide the needed intuition and ease of use (Yeo, 2001; Shen et al., 2006). User interface adaptation implies design that takes into consideration the culture and real-world experience of the users. In rural areas, the users' real-world experiences are connected to their everyday living and their interactions with their socio-cultural environment. If we design user interfaces that are meant for rural low-literacy users and adequately adapt the interfaces to reflect on their culture and real-world experiences, then we will be able to provide interfaces that will be intuitive, easy to use and meet the experiences of low-literacy users.

Three steps identified for user interface or web interface development and adaptation include globalization, internationalization and localization (Yeo, 2001; Al-Badi and Naqvi, 2009).

3.5.1 User Interface Globalization

Globalization is the process in which product designers seek to accommodate culturally diverse users by designing user interfaces that offer every user the same satisfaction through a user interface that is not tailored to any specific culture. Yeo (2001) views globalization as comprising of internalization and then localization processes. Through the globalization process, a product or user interface is created for users with different cultures but making provisions for adaptation to local markets or cultures.

3.5.2 User Interface Internationalization

Internationalization is a process through which a software or interface is designed for a global market, and then customized to a specific local market. At first, the designer creates a base design that is devoid of any single culture, but that can be modified in future to suit different cultures through customization. The base design provides a platform for adaptation to multiple cultures. The goal of internationalization is to design for international markets (Yeo, 2001). Initially, the designer applies his own culture or the culture of origin of the software or the user interface, and then the culturally specific elements of the product are identified and translated to a target culture(s) in future (Russo and Boor, 1993). Fernandes (1994) identified issues (e.g. nationality, language, social context, time, currency, units of measurements, cultural values, body positions, symbols, and aesthetics) that could create user interface design difficulties since they vary between different regions and cultures and it is noted that a careful understanding and selection is required to implement the best solutions.

3.5.3 User Interface Localization

Localization of an interface involves adaptation or customization of the interface designs to meet the cultural preferences of a particular cultural group. A localized user interface will reflect the language, text, layout of interface elements (e.g. menu, label), colours, metaphors, sounds, the look and feel as well as the social context of the target culture (Tong and Robertson, 2008; Yeo, 1996; Russo and Boor, 1993). Other markers such as time, dates, currency, number format, address format, dialogs, error messages, and navigations will also carry the cultural preferences of the target users. Localization makes user interface elements become culture sensitive to a target culture (Yeo (2001). When information is localized, it becomes accessible, easy to understand and useful to the users (Cyr and Trevor-Smith, 2004). A localized user interface will provide a natural sense of interaction, ease of use, and meet users' cultural preferences.

The user interfaces and interactions developed in the course of this study had followed the two steps stated in Yeo (2001). That is, at the first step we designed none customized interfaces, then we performed the second step which is the customization process by collecting culture related data or requirements and then gradually turned the user interface to culture sensitive interfaces.

3.6 Culture and Technology Acceptability

Several factors influence how technology is perceived and used in different regions and cultures (Evers and Day, 1997). One of these factors is the culture which differs among users across different regions. Cultural differences also make users differ in their preferences (Barber and Badre, 1998). These differences emanate out of the individual's socio-cultural context and the environment in which they live (Huang and Deng, 2008). Apart from technology illiteracy, rural people in developing countries are deeply rooted in their cultures and belief systems. It makes their needs and preferences different from those of people living in cities. This implies that adequate knowledge and understanding of the perceptions and cultural values of the target users, during design, will make the user interface accessible, improve usability and quicken the acceptance of ICT products and services (Yeo, 1996, Evers and Day, 1997).

ICTs are important instruments for socio-economic development of all regions especially the underserved regions. These technologies bring positive impacts that are felt across these regions and cultures, for example the impact of mobile phones in developing countries (id21, 2007). Cultural behaviour such as communication is also affected as a result of the influence of technology on users (Huang and Deng, 2008). The added values that ICTs bring to the people are enormous. Despite some usability problems experienced in different regions and cultures, users continue to embrace these technologies and services. The Internet and mobile communications have influenced people to act or behave in a different manner at home or elsewhere (Sato and Chen, 2008). Usability problems across different cultures can be reduced by designing a user interface which is culture sensitive (Sato and Chen, 2008; Shen et al., 2006; Marcus, 2001). It will enable the users to interact with technology more naturally with ease and with a sense of belonging (Yeo, 1996).

Due to the influence that culture has on technology users, it has received much attention from the research community both in the social sciences and computer science. Among the several definitions of culture, this research considers Geert Hofstede's definition of culture which states that "culture is a collective programming of the mind which distinguishes the members of one group or category of people from another" (Hofstede, 1997). Culture affects the mindset of an individual which is manifest in the individual's behaviour, interaction with the environment, beliefs, values and the way information is perceived and processed. It also affects the way individuals interact with and use technologies, as well as the design process for these technologies (Yammiyavar et al., 2008; Vatrapu and Perez-Quinones, 2006; Marcus, 2002). Hence, the concerns regarding user interface usability have been extended to include cultural issues in system design and use (Barber and Badre, 1998; Yeo, 1998). This implies that when designing an ICT product, the culture of the target users should be given serious attention during the design process so as to present an acceptable interface that conforms to the people experiences. This is what this study intend to pursue in order to meet our research objectives.

Apart from cultural behaviours of a people, other noticeable or tangible cultural elements or markers include numbers, language, text, layout, colours, symbols, icons, metaphors, sound, image, patterns, frames positioning on screen, navigation control. These user interface elements also need to be identified and incorporated in the design (Tong and Robertson, 2008; Smith et al., 2004; Marcus, 2001; Kang and Corbitt, 2001; Yeo, 1996).

A number of cultural models have been identified and used to assist developers in designing user interfaces. Marcus and Gould (2000) and Marcus (2001) investigated Hofstede's five culture dimensions (Hofstede, 1997) to determine their influence on user interface and web interface design with regard to users' cultural preferences. Marcus (2001) pointed out that with a concrete understanding of the culture dimensions and the transformation of significance and meaning to appropriate interface artefacts (user interface components), designers will be able to built user interfaces that will meet users' needs and preferences for the target culture. This implies that with a culture sensitive user interface designers will be able to provide good interactions, simple and clear navigations, and good visualization of information for the users (Shen et al., 2006). These requirements can be actualized through a careful analysis of the culture dimensions as well as the cultural environment and a

transformation of the information gathered into user interface culture-components for the target users.

A culture user-interface for a target cultural group will reflect the "language, cultural conventions, race, shared activities or workplace" (Yeo, 1996) of the people. This will require an understanding of their perceptions and cultural values. The required simplicity and intuition of a user interface and the interactions thereof will manifest if the cultural identities of a target group are added to the design, then the users' experience will also be enhanced. This will mean the culture related artefacts of a user interface will be taken care of during design and the problems associated with interface localization will be addressed. In this study, we have made effort to address these culture issues to design useful interfaces for low-literacy users in Dwesa community.

3.6.1 Application of Cultural Issues in User Interface Design

In order to design a culture user interface that meets the cultural preferences of the users, cultural issues must be identified through investigation of the users' socio-cultural environment. These cultural issues are then analyzed and further evaluated with the assistance of experts who are computer literate and knowledgeable in that culture (Yeo, 1996). The theories and cultural issues relating to the design of a culture sensitive user interface include those presented in Sato and Chen (2008), Marcus (2002), Marcus (2001), Kang and Corbitt (2001), and Hofstede (1997). Marcus (2002) demonstrated the relationship between the culture dimensions of Hofstede (1997) and user interface components and cultural markers also presented in Yeo (2001), Marcus (2001), Kang and Corbitt (2001) and Tong and Robertson (2008). We considered Hofstede's dimensions of culture and their relationship with interface components as presented in Marcus (2001) in this study with regard to the isiXhosa culture in Dwesa community.

Hofstede's culture dimensions include (Hofstede, 2005):

Power Distance (PD) - the extent to which the second class citizens of a society react to their leaders or authority as a result of visible signs of social and economic inequalities due to class differences.

Individualisms vs. Collectivism (IC) – A collectivist society is one in which the members of the society consider themselves as a group and each member shows responsibility to the

group. Emphasis is on group responsibility. An individualistic society refers to a society in which each person only shows responsibility to oneself. Emphasis is on individual responsibility.

Masculinity vs. Femininity (MF) – A society in which gender roles are separate is regarded as masculinity society. The general behaviours are assertive in nature. Gender roles and responsibilities are not distinct in a femininity society. Roles overlap within genders.

Uncertainty Avoidance (UA) – the extent to which the members of a society believe in the supernatural or what is unknown as opposed to the extent to which they believe in concrete evidence or known facts.

Long-term vs. Short-term orientation (LT) – long term orientation emphasizes living a virtuous life. Members of the society are expected to have patience and perseverance among themselves. Short term orientation emphasizes on beliefs, truthfulness and divine or miraculous achievements.

Marcus (2002) identified user interface entities and attributes that are uniform across all platforms (mobile or desktop applications) and they include: *metaphors, mental models, navigation, interaction, and appearance.* Marcus believes that these entities and attributes relate to the dimensions of culture and contribute to user interface usability and aesthetics if properly understood and transformed to user interface interaction elements.

According to Easton et al. (2003) South Africa is a relative power distance society. In the urban centres, individualistic life dominates the way of life and in the rural communities a collective way of living dominates. South Africa is a masculinity culture in some communities and feminine culture in others; depending on the community, in addition to which South Africa is moderate on uncertainty avoidance (Easton et al., 2003). South Africa is a multi-cultural society which clearly gives rise to the differences noted by Easton et al. and points to the variations in cultural behaviours.

The studies discussed above all indicated the influence of culture during design and user interaction with user interfaces. In the design of user interfaces for ICT services meant for low-literacy users, the user interface design culture theories and models if also applied during user interfaces design, it will definitely help in producing interfaces that will meet the cultural requirements and experiences of these groups of users in different cultural regions. In the course of this study and user interfaces design, we have considered the issue of culture

inclusion in the interface design. And as such, we looked at different culture related issues outline in the literature, and applied them in this study for user interface customization. For instance, Hofstede's (Hofstede, 2005) culture dimension model was applied to collect data used to deduce user interface design implications and user preferences (Marcus, 2002) and structure the interfaces to meet the expectations of the target community. The research studies and information on culture markers (Shen et al., 2006; Yeo, 1996) helped us to identify the type of interface elements/culture components that are within the space of the cultural knowledge of the target community. We elicited culture component data and markers suggested in different studies (e.g. Chen (2008), Marcus (2002), Marcus (2001), Kang and Corbitt (2001) but which are found within Dwesa cultural environment in order turn the user interfaces to culturally sensitive interfaces during this study.

3.7 Conclusion

User interfaces and interaction techniques are now focusing on making the mobile device more users friendly. The complexity of the user interface imposes usability problems for the users. This becomes more obvious if users are illiterate or semi-literate. In rural underserved communities such as Dwesa, the users of ICTs are novice and will require user interfaces and interaction techniques that are simple to understand and meet their capabilities and cultural experiences. Users' devices in these communities are low brands and applications targeting these users must take into consideration the technology landscape in these communities so that a good number of people will be able to use the services with their personal device.

Culture influences the learning ability and usability of user interfaces. Several studies on culture, user interface design and user perceptions have stressed on the importance and influence of culture to the users of technology artefacts. And also, not only does culture influence usage of technology artefacts, but also the way the target users respond or participate in the design processes of these artefacts. Studies on culture have identified models and theories that can influence user interface design for different users groups. Adaptation of the user interface to suit a particular cultural environment will require understanding theses cultural issues pertaining to the specific cultural group in order to improve user experience when they interact with the interface. With this, the users' behaviours, expectations and users' cultural preferences are taken care of during design. Although the discussions presented above were mostly applied for addressing the interface

needs of literate users. In this study, we have tried to apply these culture issues in designing user interfaces for low-literacy rural users and to address this study questions.

Low-literacy users in rural communities have their own interaction experience gained from their interactions with their socio-cultural environment. A user-centred design ensures user participation during application design. In this study, we applied the user-centered design approach discussed earlier to elicit users' requirements necessary to design user interfaces and interactions in attempt to meet the capabilities, preferences and expectations of users in Dwesa rural community.

CHAPTER FOUR: RESEARCH METHODOLOGY

4.1 Introduction

With the increasing efforts focusing on socio-economic sustainability in rural communities, through the use of ICT products and services, the usefulness and usability of these services are very important if the goals are to be achieved. The design of user interfaces for rural users requires the adaptation of the design approach and techniques that will enable target users to effectively participate in the design process. For rural application design, the environment is different from commercial settings where accessibility of the users is not in doubt and the literacy level is equally high (Lalji and Good, 2008). Direct involvement of target users, through design methods that motivate the rural users to effectively participate in the design will yield the expected usability and encourage users to accept the system (Medhi et al., 2009; Lalji and Good, 2008).

This chapter starts by describing the research design that includes the research questions and the user-centred design approach adopted with an outline of the various research methods used in this study to address the objective. The study area where this research was undertaken is also described. Next, the research methodology is presented using the research design framework and connected to the theoretical framework of this study. Within the research methodology, the discussions of the various studies applied are presented in a logical order using the phases of the approach presented under the research design. These includes a discussion of the research methods and motivations for selection and the description of the data collection activities and the explanation of how the data was analyzed during each data collection process. This study applied appropriate research methods in order to aid the local community to be actively involved in the design process.

4.2 Research Design

This study looks at designing user interfaces and interaction techniques on a mobile commerce application for rural micro-entrepreneurs. The aim is to design user interfaces that are usable by taking into consideration the experience and preferences of low-literacy users.

This study was undertaken to address the following research questions which have been indicated in section 1.4, and are repeated below for the reader's convenience.

(a) Current mobile user interfaces are less suitable for second economy people; – can we develop simple user interfaces on low end devices for a mobile service that will be:
- Accessible to semi-literate and illiterate users?
- Easy to use, understand and that meets the target users' preference?

(b) How do we design user interfaces and interaction techniques that meet target users' capability and experience?

In order to address the research questions stated above, we reviewed existing literature and adopted a user-centred design approach that is divided into five phases with research activities that are user-oriented. A description of the study phases (user-centred approach) will be used to outline the study process and the discussion of the research activities that include: interviews, focus groups, surveys, etc., are presented in the methodology subsections. The user-centred approach is described next.

4.2.1 The User-Centred Approach

In order to adopt appropriate and practical way to help local community members to participate effectively and to logically keep track of the design and data collection processes, the field study was planned to have five consecutive and iterative processes over the 3 years study period. The phases are iterative and design oriented a s the activities and findings of previous phases provided data/information for the design of the next phase. This approach helped to make the research process appropriate and encouraged the participating community to be involved in the study.

The description of the phases is presented below.

- **User/environment study** –

  Analysis of the user and environment profile involves activities that will aid the designers to understand the users and environment during system development (Johnson et al., 2005; Huenerfauth, 2002). Here, the emphasis is on the identification of user needs, their characteristics and capabilities with technology, and the available resorces required for development and implementation of system (Costabile, 2001).

  This phase was conducted to investigate the user environment in the target community (Dwesa). The objective at this stage of the study was to understand the user characteristics in terms of age distribution, education, technology literacy, technology

landscape, cultural inclinations, skill levels and experiences of the users, and the micro-business activities in the community (Huenerfauth, 2002; Thursky and Mhemoff, 2007).

During the user and environment study, the following research activities were conducted:

1. On-site visits and informal interviews with community members;
2. Survey for user/environment data collection;
3. Facilitated focus groups to understand the user problems and business environment.

The discussions on how these activities were performed and the composition of the participants are presented in the research methodology section (section 4.4.8.1 – 4.4.8.5).

- **Tasks analysis and scenarios design**

Task analysis helps to identify system tasks as well as interface activities. Here, system functions, tasks capacities (Kinzie et al., 2002). Input and output requirements and formats for the user interface and user interactions are also specified (Zhang et al., 2002). User experience and capabilities are usually considered, as well as the necessity, simplicity and accuracy of tasks (Zhang et al., 2002).

We conducted tasks analysis to identify system functions, user information and tasks capacities to aid the application design process. We conducted an audit of similar applications (Smith and Dunckley, 2004) and reviews to gather data about application tasks. Other task data was also collected from the community during the user/environment study. Tasks data was then used to design task scenarios. The tasks were separated into two sets of tasks; the customer tasks and the shop-owner tasks meant for micro-entrepreneurs in the community. The scenarios were presented for formative evaluation in the community through focus groups and data was collected.

Research activities during tasks analysis and scenarios design include:

1. Literature reviews on mobile commerce applications and tasks data collection.
2. Audit of similar application for tasks and user interface data collection.

3. Informal interview with community members on traditional business processes and the environment in Dwesa;
4. Design of application tasks and scenarios design, and held focus groups for formative evaluation scenarios and crafted artefacts data collection from community members.

Details of these activities are presented in the research methodology section (section 4.4.10 and 4.4.10.2).

- **Prototype design**

Early prototype provides a tangible system that aid in further discussions and requirements from the target users (Shneiderman, 1998). A tangible prototype at the early phase of system design can help novice users of technology to understand the research intention early and aid data collection process (Medhi et al., 2006). The simulated prototype will be refined or developed to a full system that meets the user requirements (Xavier et al., 2001). It was necessary to design a tangible prototype to further explain our study intentions. The design of the prototype has followed an iterative process. The tasks analysis and scenarios design processes provided the needed data to start the design of the mobile commerce application. The application provides standard user interfaces for interactions, that is, the customers' interface and the shop-owners' interface. We also needed to adapt the shop-owner interface to the local culture of the target community. Steps were then taken to get feedback from participants in the community and redesign the application. In order to improve participation and contribution from participants, the prototype was always used as an illustration to prompt discussions and facilitate user interface data elicitation.

1. Prototype design.
2. Held focus groups with community members for the formative evaluation of the prototype and further collection of data about crafted product and user interface preferences.

The details of the focus groups are also discussed in the research methodology section (section 4.4.11.2).

- **Cultural adaptation of the shop-owner interface**

Customization of user interface helps to adapt the system to reflect the experience and preferences of the target users (Yeo, 2001). This process involves internationalization, then localization to reflect the cultural expectations of the users (Yeo, 2001). And so the prototype that was developed in the prototyping phase served as the input or tool needed for this development phase. This process of cultural adaptation produces a user interfaces that is culturally sensitive, easy to use and meet the cultural experiences of the target users. With this, the context of used will be addressed and resolving with the users' cultural issues required for understanding and effective interactions with the system (Shen et al., 2006).

Customization of the shop-owner user interface (GUI) to the cultural preferences of the Dwesa people was an important aspect of the design that was given serious attention. Customization improves user interface usability and acceptance by users (Shen et al., 2006; Marcus, 2001; Yeo, 1996). In order to adapt the shop-owner user interface to a culture sensitive artefact, we considered and applied culture design principles and suggestions identified in Shen et al. (2006), Marcus (2001), Yeo (1996), Hofstede's culture model (Hofstede, 2005) and a field study of the environment. With the information from the literature, we identified the elements/components on the GUI that needed to be customised as suggested by Yeo (1998). The cultural adaptation process required both qualitative and quantitative data. We conducted field studies such as:

1. Facilitated focus groups meetings with community members for culture preferences data.
2. Interviews with community members for culture markers data collection.
3. Surveys with culture experts for cultural data (culture markers data) collection.
4. Audited the cultural/physical environment for cultural components data (interface metaphors/icons).
5. Consult computer literate/culture experts for validation of culture related data.

The discussions of the methodologies are presented under the cultural adaptation of user interface section (section 4.4.13, and 4.4.14).

- **Design Evaluation**

Evaluation of a system is important to determine whether the system meets the requirements and objective set out for the design. User evaluation involves the target users testing and evaluating the design to know if the interface or system meets the requirements previously specified. During user evaluation process, the users are carefully observed and what is observed is recorded on paper or videotaped for analysis and upgrading of the design (Xavier et al., 2001). Interviews or questionnaires may also help in further gathering user feedback that will serve as input for subsequent system improvement (Peleg et al., 2009; Shen et al., 2006).

The evaluations of the prototype shop-owner interfaces (GUI and VUI) were done through focus groups and single user evaluations, while the customer interfaces were done through single individual evaluations. The use of real users for the process of evaluating a system is the most common method of evaluation and has the advantage of exposing hidden errors that are not commonly noticeable through expert evaluations (Shen et al., 2006). The evaluations also provided data that lead to the improvement of the prototype. The activities conducted at this phase include:

1. Conduct a pilot test through focus groups for formative evaluation sessions and redesign of the shop-owner interface.
2. Held focus groups with community members for user evaluation of interfaces (GUI and VUI);
3. Held single user evaluation of interfaces with community members (GUI and VUI);

In the evaluation processes, two experiments were conducted on the shop-owner interfaces (GUI and VUI) at different times. The first experiment was to determine how easy it is for users to understand and learn the shop-owner interface by looking at the tasks performance time and error rate during consecutive trials. The second experiment was to determine users' perception about the shop-owner interface and application for the GUI and users interaction preference for the VUIs.

Details on how these methods were applied are presented in section 4.4.15.

The diagram (figure 4.1) below shows a graphical presentation of the research design approach, the activities conducted and the methodologies used in the design processes.

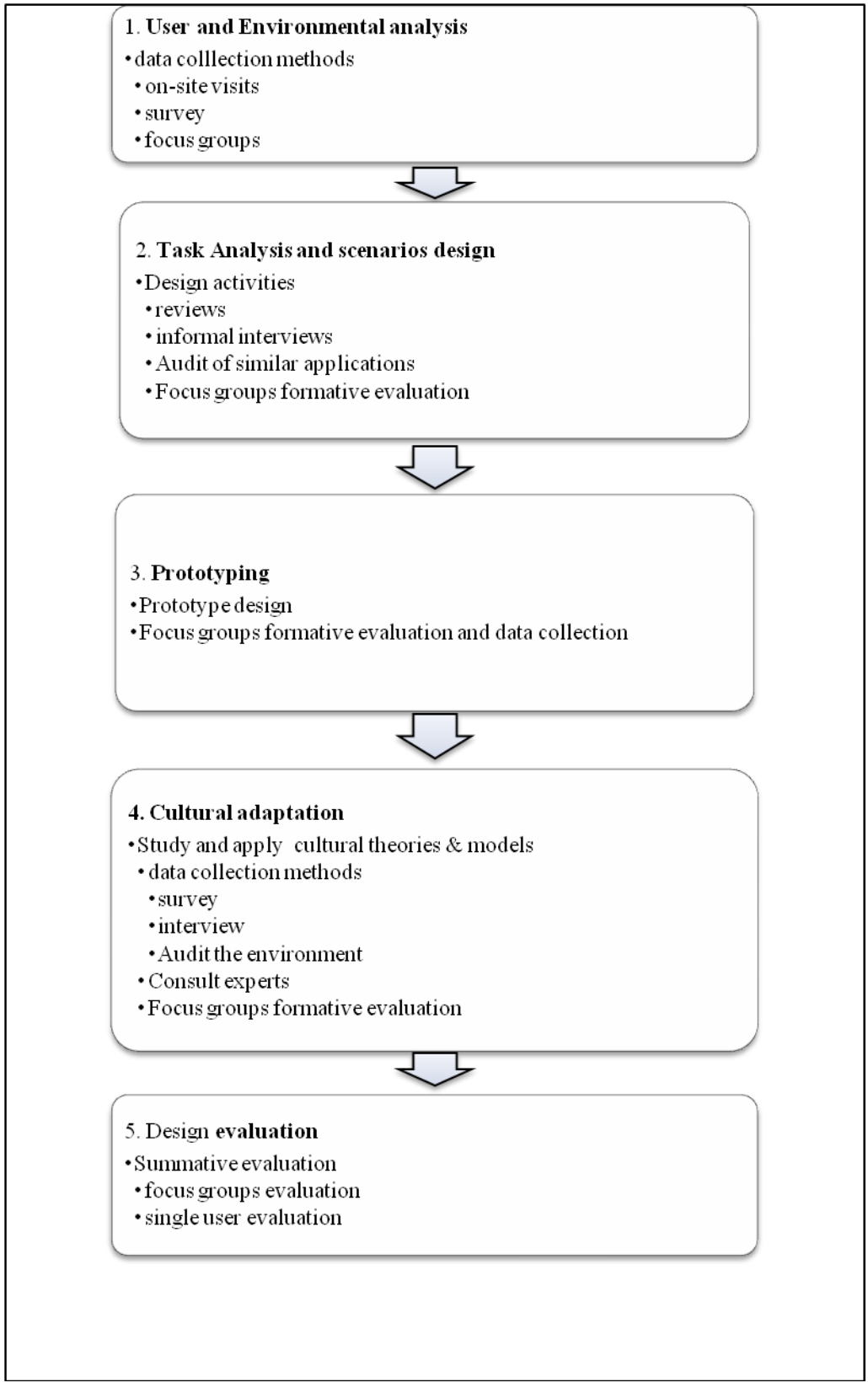

Figure 0.1 The research design phases

4.3 The Study Area - Dwesa Community

The community is a rural area located in the Wild Coast region of the Transkei in the Eastern Cape Province of South Africa. The nearest urban town to Dwesa community is Willowvile, which is 50km away from Dwesa. This region is well known for its impoverished conditions due to the deplorable state of its infrastructure and socio-economic status compared to other provinces in South Africa (Pade et al., 2009). The Dwesa–Cwebe community lies between the Nqabara and Ntlonyana rivers in the Transkei region. The community has vast potentials in agriculture due to abundant rainfall in the area during most of the year and the nature and marine reserve covering large forest areas, grasslands, and its shoreline. According to Pade et al. (2009) the area is inhabited by 15 000 people within 2000 households covering eight local villages within the community.

Demographically, the community can boast a few youth or middle aged adults due to migration to urban areas for jobs and better economic prospects. This has left the community with a greater number of adults over 65 years and children under 15 years with the female population being the largest. There are very few vacant jobs in the community; offered by the local municipal and provincial government. More than 90% of the inhabitants are unemployed and more than half of the population rely on pensions, social grants and support from children and relatives living in urban areas (Pade et al., 2009). Apart from the high unemployment rate, other problems such as poor infrastructural development (e.g. bad road network, lack of electricity), low levels of literacy, poor income, poor health services, alcohol abuse and diseases are confronting the people. Culturally, the people value their customs, family values and extended family support. Dwesa people speak the IsiXhosa language which is one of the 11 recognized languages in South Africa. Subsistence farming is the primary occupation in this community, together with a few people engaged in crafting as the traditional occupations in the area. Less than 7% of the inhabitants who are not currently attending schools have completed grade 12 in senior secondary school which, by extension, points to the level of illiteracy in the community (Pade et al., 2009). Figure 4.2 shows the geographical map of the Dwesa-Cwebe district and the study area (little black spot in the circle) shown in the lower right hand corner of the map of South Africa.

Figure 0.2 Geographical Map of Dwesa-Cwebe District (Dalvit et al., 2007)

4.4 Research Methodology

This study was conducted using different research methods to engage participants in the community. The schools and other community centres were used as venues for engaging and interacting with community members during the study. Regular site visits to the community were conducted in the course of the study. These took place at least once or twice a month or as the need arose. The visits to the community usually take an entire week's stay in the community so that we could have enough time to conduct any planned research activity or conduct computer skills training for community members. Similar research methods were used during the design of the GUI and the VUI in some instances but different data was collected.

Ethnographic research methods enable application designers to know the target users both socially and culturally as they interact with the users in their environment. They also enable the active involvement of target users together with the designers during the application design process (Sherwani et al., 2009). Ethnographic methods have been used extensively for collecting both qualitative and quantitative data for designing applications and user interfaces

for low-literate users (Gosh et al., 2003; Cremers et al., 2008; Kam et al., 2009; Parikh et al., 2006; Sherwani et al. 2009). The qualitative methods used in this study include literature study, on-site visits, interviews, focus groups, audit of similar applications and the environment. The quantitative method includes surveys. These methods were used within the research design approach that includes user/environment analysis, tasks and scenarios design, prototype design, and design evaluation.

The various methods were applied based on the characteristics of the user group identified in this study. Each of the methods was used at various stages of the user interfaces and application design process.

In some instances, a combination of these research methods ensures that their weaknesses are mitigated (Adams et al., 2007). Since some of the research methods were used more than ones and to collect different set of data at different phases of the design process, the discussions and justifications for these methods will be presented first. The detailed discussions on how we applied the methodologies will be presented were we have used these methods at the different phases of the user-centred design approach we adopted in the research design.

A description of the various research methods that were used during the field study are presented in the next subsections of the research methodology to state the justification for using these methods. Later, descriptions of how the different research methods were applied are presented following the order outlined in the five study phases in the research design. This is because some research methods (e.g. focus groups, surveys) were used to collect different types of data (qualitative and quantitative data) in more than one phase of the study. We will start with the discussion and motivation for literature review.

4.4.1 Literature Study

A literature study outlines the current issues and scholarly developments in the domain and forms a basis for further research. A carefully structured literature study provides updated information on the domain of interest and enhances the formulation of research goals (Denzin and Lincoln, 2000). The study outcome is a report on existing knowledge and enables the researcher to draw up a road map for the study. The outcome also exposes ideas and issues, and gives information that enables the researcher to take decisions regarding which approach to use during ICT for development research.

The first step in this study was to carry out extensive literature study to understand current research on ICT for development, mobile interaction techniques and user interface designs. Through the literature study, we were able to identify and classify different mobile interaction techniques as well as chose the user interfaces to implement in this study. The literature study also provided information on user-centred design approach, cultural theories and models which were adapted to suit our design environment and be able to address the study concerns. Information obtained through the literature study lead to the formulation of research ideas and design decisions. In this study, we conducted literate review at the beginning of this study and also during tasks analysis. At the tasks analysis phase, literature on mobile commerce applications and mobile user interfaces design were studied.

Based on the user profile and environment for this study, we identified the keypad interactions on graphical user interface and voice interaction on a voice user interface for implementation.
We also identified different ethnographic research methods commonly used for ICT for development research and made decisions on the research methods to apply in the study.

4.4.2 On-Site Visits

An on-site visit is a process that involves the researcher visiting the study location where the outcome of the research is intended to have a direct impact. During ICT for development projects in rural communities, on-site visits are used for on-the-ground assessment of socio-cultural practices, physical environment, and context (Parikh et al., 2003; Medhi et al., 2006). It is a means for engaging and interacting with the target users in their natural environment with the aim of creating an enabling relationship with the target users. It is also an avenue for knowing who the users are, studying and collecting data on available resources and aiding the process of drawing up a research plan early in the study (Abras et al., 2004; Maguire, 2001). The on-site visits we conducted help to establish and strengthened relationship and communication and also to build the confidence of community members during the study. This method was costly and time consuming because the study area (Dwesa) is remote or located very far away from our institution. The advantage we had was that our sponsors took charge of the cost aspect of the research and regular visits and long stay in the community did not pose many problems. The discussions on the activities performed during on-site visit is

presented in the research methodology section under the user/environment study phase and subsection (section 4.4.7.1.1)

4.4.3 Surveys

A survey is a good method that is widely used for gathering data from a sample population or sample of stakeholders. Surveys are very useful for gathering quantitative data from a large population of respondents and may sometimes involve qualitative data too. During system development, surveys are used to collect data like user demography, user needs, tasks analysis, and evaluation of prototype (Patel et al., 2009; Medhi et al., 2007; Abras et al., 2004; Maguire, 2001).

A survey may ask respondents to give responses concerning facts, motivations, attitudes or perceptions and understanding of issues on a new system (Maguire, 2001). Survey questions could consist of questions that were closed-ended where the respondents gave fixed responses in order to minimize misunderstanding and reduce writing for respondents with low levels of literacy (Williams, 2006). Surveys could also consist of open-ended questions which allow respondents to give details or descriptions when answering questions.

Surveys are very easy to administer and can provide a large amount of data to enhance the quality of outcome due to the possibility of reaching a large number of participants (Blaxter et al., 2007). One disadvantage of a survey is that respondents may be limited or feel constrained by writing down their responses. For this reason and because of the environment or literacy constraints, we adopt closed-ended questions in most cases to help the respondents and eliminate lengthy writing. There were cases during surveys where some respondents lacked writing skills due to low levels of literacy, and as such, not everyone was able to return their responses. In this situation, the surveys may limit the amount of data collected or the extent to which the respondents express their understanding of the issue under consideration, as indicated by Denzin and Lincoln (2000). In order to improve on the amount of data collected through surveys, we did a follow up to assist participants who had writing skill problems. Also, surveys are not always possible to verify respondents' responses or determine a general opinion as a result of not discussing the responses with the respondents (Xavier et al., 2001). In each case we tried to gather large amount of data to overcome this constraint and be able to draw up a general consensus. In a rural community like Dwesa

where the settlements are sparsely located, it usually took a lot of effort and time to distribute the questionnaires, but a longer stay in the community help us in reaching and obtaining adequate responses from the participants. The surveys applied in this study were randomly distributed for every sample population identified for each survey.

Data collected during surveys were studied and analyzed using different analysis methods. These include descriptive statistics, t-Test and others. In this study, we applied different methods to analyze survey data. These include textual analysis and statistical analysis (e.g. measure of dispersion, value survey analysis and paired t-Test analysis) depending on the type of data collected. This is indicated at each data collection and analysis sections at the discussions on the activities and methodologies in the different phases of the research design and where surveys were applied for data collection. Details of survey field studies and discussions are presented in user/environment phase (section 4.4.7.1.2), cultural adaptation of user interface design phase (section 4.4.7.4.1.1 and 4.4.7.4.1.3) subsections in the research methodology

4.4.4 Focus Groups

Focus groups are a common research method that involves a group of participants who come together for discussions and give their personal views and experiences on the issue being discussed (Gosh et al., 2003; Xavier et al., 2001). During discussions, areas that need solutions are made known and the method is commonly used during requirements gathering for a new application (Maguire, 2001). Individuals in the discussion group express their understanding and experience of an issue that forms the focus (e.g. user requirements for a new system) and several viewpoints can be obtained during the discussion (Cremers et al., 2008; Xavier et al., 2001).

Focus groups are less intimidating and a good source for collecting data for system design, especially with low-literate participants (Cremers et al., 2008). The focus group is similar to the everyday way of life in rural communities, where social gatherings and word-of-mouth communication are common methods used in passing information to community members (Denzin and Lincoln, 2000; Pade et al., 2009).

During focus groups discussions we adopted an open-ended interviewing approach to capture participants' views. This approach helped us to understand how the participants perceived the

issue under discussion (e.g. culture markers, interface preferences). Shared understanding of participants' contributions was necessary in order to understand their perspectives and concerns. We were always concerned about participants clarifying the meaning of their responses when the need arose. As the discussions progressed, other issues that came up as a result of the interactions were thoroughly discussed as addition to the initial questions. With the assistance of a facilitator it was very easy to moderate, while listening and recording how participants make sense of the discussion, including their perceptions and contributions to the subject under consideration during the meetings.

An imbalance of contributions during the focus group is a common feature because some participants normally become reluctant to give their views thus allowing the discussion to be centred on a few active participants who monopolise the discussions (Isabirye and Flowerday, 2008; Silver and Wood, 1995). We notice this situation during focus groups discussions, so there was need to moderate and create room for less active participants to make contribution while at the same time try not to discourage the active ones. However, some participants were able to help to motivate others to become active and build confidence. During focus groups, participants can support others with ideas and also argue with others until a consensus is reached (Maguire, 2001). This creates differences and consensus of opinion in the focus group which is its strength as stated by Gibbs (2008).

Focus groups provided a lot of valuable data and were less costly process when compared with individual interviews (Denzin and Lincoln, 2000). This method was very easy and effective when we engaged low-literacy participants for data collection in rural community, as also noticed by Isabirye and Flowerday (2008), Cremers et al. (2008).

The following criteria were used for participants grouping: occupation, literacy level and size of the group. We did not consider gender because it was difficult to get a sizeable number of male participants to constitute participants within some of the occupation groups indentified during the study.

Detail discussions on focus groups field studies held during different phases of the study are presented under the user/environment (section 4.4.7.1.3), tasks analysis (section 4.4.7.2.2), prototyping (section 4.4.7.3.1.1), cultural adaptation of user interface (section 4.4.7.4.4) and design evaluation (section 4.4.7.5.1 and 4.4.7.6.1.1) subsections under the research methodology.

Depending on the stage of system design and the type of data required, different methods could be applied for data collection during focus groups. The characteristics of the users also determine the best method we adopted for data collection. Qualitative and quantitative data can be collected and analyzed. Data collection methods include field notes (Patel et al., 2009), video and tape recording. Qualitative data analysis includes transcription of recorded data, textual analysis, content analysis and others, while quantitative analysis includes descriptive statistics (Medhi et al., 2009), regression, factor analysis and so forth.
In this study, field note was used for writing down responses during each focus group meetings. Textual analysis was performed on notes, while quantitative data collected during focus groups was analyzed using descriptive statistical analysis (e.g. measure of dispersion, paired t-Test analysis).

4.4.5 Interviews

The interview is a common technique used to elicit the requirements or needs of users in relation to a proposed system. Interviews are commonly used for eliciting requirements from low-literacy users (Medhi et al., 2006; Medhi et al., 2009; Cremers et al., 2008; Patel et al., 2009). Interviews are very useful in different phases of system development including requirements elicitation, task analysis, and evaluation. During interviews the designer interviews users in order to gather data and understand their reactions to issues concerning the system under consideration. Interviews are used in instances where the information needed requires participants' opinion and level of understanding of the subject and the ability of the participant to communicate adequately is not in doubt (Adams et al., 2007).

An interview with users on an individual basis is usually a face-to-face interaction process. It involves a series of questions that need adequate explanations from respondents (open-ended) in one instance and those that require a fixed answer from respondents (closed ended) in another instance. A mixture of structured and unstructured interviews was applied in this study. In the structured interviews, the range of outcome is pre-determined to facilitate and simplify participants' responses while the semi-structured interviews gives the respondents room to express their understanding and opinion in more detail (Maguire, 2001).

In an interview, the questions are read by the interviewer to the interviewee whose responses are recorded by the interviewer using notes or a recording device. Interviews can provide detailed information and a wide range of opinions on the subject matter through face-to-face conversations. Poor communication, as a result of low levels of education, as is evident in the case of rural participants can sometimes hinder a successful outcome from interviews. As a result of this, one-on-one interviews were held with educated members of the community who could interact with us fluently and did not need a third party or interpreter. Some interviewees could be reluctant to speak or naive on certain issues during interviews, or they lack experience and the ability to verbally express their opinion. This was not the situation in our own case since focus groups through the assistance of facilitator were conducted with community members who had literacy problems and interviews were conducted with participants that we could communicate directly with. We also prepared initial interview guidelines consisting of open-ended questions to use in initiating a conversation with the interviewees. More issues were raised and discussed during the sessions. This approach also helped the interviews to be focus and create understanding on how the interviewees view the issue under consideration. Questions were also asked repeatedly in different ways in some cases and for in-depth responses. It also helped the participants to explore their responses thoroughly and helped us to properly understand the participants' beliefs and assumptions. Valuable information was obtained to strengthen the data collected during focus groups and surveys. Participants selected for interviews include community members that were educated and could interact directly with us without the assistance of a third party. Detail discussion of interview field study session and the activities held during interviews are presented under the cultural adaptation of the user interface phase in the methodology section (section 4.4.7.4.3).

During interviews, data collection and analysis can be carried out using similar methods to those presented section 4.4.3 and 4.4.4. In this study, field notes were used to collected data from the participants. The notes were read repeatedly and textually analysed or categorised into themes depending on the type of data (e.g. camera images, numeric data) collected at a particular time in the study.

4.4.6 Observation

In the observational method, the system designer observes the users as they carry out their tasks in their work environment. The observational method is popularly used for collecting

data from users during system design such as user, tasks and evaluation data (Abras et al., 2004; Maguire, 2001, Xavier et al., 2001), even in low literate environments (Patel et al., 2009; Cremers et al., 2008; Kam et al., 2009; Medhi et al., 2009; Parikh et al., 2003). Observation could be direct where the designer is present as the user performs his/her tasks or indirect where the tasks are recorded through video footage and the data can be viewed at another time. The designer is able to gather data from the primary source and gain experience on how the tasks are performed. The observational method can yield a large amount of data for system development.

The observational method can be challenging and, at times, users may fail to give detailed information to the observer because they may assume that the observer already has that information (Wixon et al., 2002). Having access to the participants could be difficult and users may find it difficult to allow the researcher to carry out observations on them. Some users may not like being watched or feel shy and may not be fully committed to performing their tasks under observation. During design evaluation we noticed that some of the participants felt shy being observed alone and were reluctant in performing the test, so we had to put them in groups for each member of the group to participate one after the other. This arrangement boosted their participation and good amount of results were obtained. Initial trial of the think-aloud method did not yield good outcome because the participants who were tested with this method found it difficult to interact or perform tasks on the system and at the same time speak out what they were doing. We observed that they were not familiar with the method and it seem unnatural to them. They were also constraint by the language of communication (English) and since we do not understand their native language without the help of an interpreter, we could not continue with the think-aloud method.

Data from an observational study could be collected and analyzed using quantitative methods presented in section 4.4.3 and qualitative methods presented in section 4.4.4. Discussion on observational field study is presented in section 4.4.10.3. Both qualitative and quantitative data were collected through observational method during the study. Field notes were used to collect data and analysed textually after careful reading and observing themes in the data, while quantitative data was analysed using descriptive statistical method (measure of dispersion).

4.4.7 Study Design Phases and Research Activities

A description of the activities performed during field studies are presented within the five phases of the study, starting with the user/environment analysis phase.

4.4.8 User/Environment Analysis

The research methodologies applied during this phase in the study process include on-site visits, surveys and focus groups discussions. The details of the activities for each research method are presented next.

4.4.8.1 On-Site Visits and Data Collection

On-site provides valuable information needed to influence the methods adopted to interact and conduct this study. We conducted on-site visits to Dwesa community at regular basis. The visits were, for the most part, to interact with the community and provide training for computer literacy skills development. These visits and training were organised at regular intervals and research activities were interwoven with the training programmes.

The purpose of the training to the community was to enable them to use computer facilities provided in the SLL and to prepare and enable them for the use of ICT services that are designed and deployed for the community. It is only through this that the community will be able to understand the value of ICTs product and services in the community. Five schools within the community host the SLL facilities (computers and software).

Training sessions were usually held in the computer laboratories in each of the schools. Training materials, in the form of printed notes, were organised as handouts and used during training. Participants include school learners (grade 3 to 12), and clerical staff of schools (functionally literate and semi-literate), crafters and other community members (mostly semi-literates with educational qualifications not higher than grade 12). Participants were usually put in groups, and each group is trained according to the three categories of skills that were designed. Participants were expected to complete one level before moving to the next level of training. At the completion of each level of training, they are assessed in order to know their level of improvements in the use of computer programs (e.g. operating system, Internet and web browsing, word processing, spreadsheet applications, typing skills programs and other educational programs depending on the user group). Small groups were also identified in the

course of these interactions and were the first point of contact during subsequent exercises or research activities.

The education and computer skills training programme is meant to help community members to acquire the necessary skills that will enable them to use ICT services (Kam et al., 2007). The regular trainings enhanced our relationship with the community and created the atmosphere for other interactions during the research. The community developed trust and confidence in the activities which enabled them to participate in the different research activities. The significant aspects of the visits and training are that they helped us to gain an understanding of who the target users are, in order to understand social interactions in the community, build confidence amongst and a relationship with the people. This process motivated the community to participate effectively and to embrace new technologies. We were also able to understand the challenges associated with the use of ICTs in the community.

4.4.8.2 Survey for User/Environment Data

As a follow up to the findings on the literature study and on-site visits, we needed to find out the user profile, technology profile in the target community, understand the mobile phone interfaces and interaction modes that rural users are conversant with and the available resources in the community. The goal of the survey was meant to collect a substantial amount of quantitative data about user characteristics and the technology landscape in the community. The survey (Appendix A) consists of closed-ended questions in the first part and Likert-scale questions in the second part. The combination was used due to the problem of limited access to users and the distance from the community. The closed-ended questions consist of predetermined responses that seek demographic information and technology landscape. The Likert-scale questions enable the respondents to give subjective responses (Sherwani et al., 2009) on computer, Internet and Web application literacy. The participants responded to how strongly they disagree or agree with a statement on a 1 to 5 point scale to choose from. Apart from the demographic information, all the questions are closely related and border on the technology literacy of the community. Due to constraints such as a low level of literacy and time, closed-ended questions were considered most appropriate so that we could gather more data from a large population sample.

The questionnaire was distributed in the community to a random population sample in three villages (Mpume, Ngwane and Nqabara) with the hope that we would be able to reach out and get responses from the different age groups and occupations in the community. In order to facilitate and obtain a substantial amount of data, a follow up was carried out to assist in explaining the questions to some of the respondents and to encourage them not to discard the material as a result of poor understanding of questions or lack of motivation to participate.

4.4.8.3 User/environment Data Collection

The data collected through the user/environment survey provides the demographic information of the community. A total of 120 respondents completed and returned the questionnaire. The amount returned was substantial enough to provide the necessary quality for the analysis and interpretation as well as the provision of reliable information. The data included the literacy levels, sex and age distribution and the occupational distribution of the area. The data has direct impact on technology use, as well as the people who will benefit from this study. Other data include technology literacy, mobile phone ownership and use, awareness and use of ICT technologies such as e-commerce, mobile commerce, Internet and web browsing, and mobile phone technologies (multimedia message service, short message service).

The data about the technology landscape in the community provides an indication of the technology literacy level and how the people interact with these technologies.

4.4.8.4 Survey Data Analysis Tools

The user/environment survey data collected was first studied and grouped into demographic sets, educational literacy, ownership and use of mobile phones, modes of interaction with mobile phones, use of mobile phone technologies, in addition to ICT awareness and its use in the community. We then entered the data into a Microsoft Excel 2007 spreadsheet for analysis. We then applied descriptive statistics methods (measure of dispersion) to analyse the data into numeric results and graphical presentations to give meaning and for ease of interpretation. The results obtained from the analysis were then interpreted

4.4.8.5 Focus groups for User/environment study

At the early stage of the study, we conducted focus groups with community members. The participants include crafters, educators and clerical staff in schools. The different groups were made up of participants with similar characteristics in order to encourage equal participation as stated by Adams et al. (2007). The data we needed at this stage included marketing processes and business activities in the community, constraints limiting business growth and suggestions on ways of improvement. We also needed information about computer literacy and use of ICTs. From the crafters, we began the process of collecting data about crafted products – products images, local names, prices, description and others. This data formed part of the application database design. The participants include crafters, educators and clerical staff.

The discussions with educators and clerical staff were held separately inside the school environment (the school's computer lab). Arrangements and approvals were made through the principals of the schools (Mpume and Ngwane secondary schools) the day we arrived in the community. The educators (n = 11) were participants who were functionally literates and they consist of 7 females and 4 males. The educators were between the ages of 28 and 45. The clerical staff (7 females and 3 males) are the administrative staff in the schools mentioned above. Their ages were between 26 and 39. All the educators and clerical staff owned and used mobile phones with different capabilities that include the ability to send and receive SMS, MMS and browsing the Web.

Discussions with crafters were held in one of the art and craft centres in the community (Ngwane Art and Craft centre). The meeting with the crafters was pre-arranged through a facilitator in the community. The facilitator has been appointed by the SLL project group and serves as a link between researchers and the community. She was very helpful in interpreting and explaining the questions and contributions using the local language to and from the crafters due to the communication barrier crafters had. 12 crafters took part during the discussions. Their level of literacy was very low (level of education not greater than grade 12 in school for all the crafters) and, at best, semi-literates and illiterates. The age range of the crafters was between 46 and 56. The facilitator assisted us during the discussion due to the language gap between us. Among the crafters 8 owned mobile phones and only two have relative familiarity with computers and operations.

The issues for discussions were prepared in the form of open-ended questions before the visit to the community. At the start of each of the discussion sessions we made introductions and stated the reasons for the discussions. Participants introduced themselves and the discussions followed.

We moderated all the sessions and took field notes. All the sessions lasted between 50 minutes to 1 hour.

4.4.8.6 User/Environment Data Collection and Analysis

Analysis of the field notes actually started in the field as indicated by Gibbs (2008). We performed textual analysis on all the field notes collected during focus groups. At first, the written notes were carefully read, modified and then summarised. The summarised information was read through and further modifications were made. They were then extracted and grouped into categories that included the demography of the community users, awareness and use of ICTs, business constraints and traditional business processes.

4.4.9 Tasks Analysis and Scenarios design

The research methods used during this phase of the study include audit of similar applications, focus groups. Details of the methodologies are discussed next.

4.4.10 Audit of Similar Applications

According to Smith and Dunckley (2004), an audit of similar applications is a practical approach involving the study of the characteristics of similar applications within the domain of the intended new system under consideration. This method was used to gather qualitative data during task analysis, user interface interaction elements and information flow and feedback during interactions. This process was very useful in supplementing the limited data we obtained from the community users for task analysis and interface design. In situations where the target users are not easily accessible for data or are not adequately technology literate and there is limited information from users on tasks analysis and interface designs this method will help to provide adequate information for the design of the application and interfaces (Smith and Dunckley, 2004). This technique is easy, cost efficient and fast in gathering data for system development (Edim and Muyingi, 2010d). Its drawbacks include the inability to get firsthand information from users concerning the system under consideration. The designer may rely too heavily on the mental model of other designers

instead of that of the intended target users of the proposed system (Smith and Dunckley, 2004).

The tasks data collected from the community on business processes were very few and needed to be incorporated in other processes to enhance transactions in the application. These include tasks or transactions that will enable the buyer and seller to effectively communicate through the Internet, that is, where the parties are not in physical contact with each other as is the case with conventional or traditional business transactions in Dwesa. These tasks enhance the business process for both the customer and seller on the mobile commerce application. In order to do this, we conducted further tasks analysis by auditing similar applications.

We studied e-commerce and mobile web applications (six e-commerce web applications and three mobile web applications). In some of the studied applications (e-commerce web sites), we carried out transactions to purchase items. This provided inside information on tasks and information flow, interface activities, navigation, and interface structures. In the application, transactions will involve the customer and the shop-owner or seller. Other literature also provided useful information on mobile commerce activities and value chain. Data about customer tasks and shop-owner tasks were collected and analyzed.

4.4.10.1 Tasks Data Collection and Analysis

We recorded the tasks data on notes. Two sets of task data were collected involving the customer on one hand and the shop-owner or administrator on the other. The customer tasks include activities to complete a purchase transaction, while the shop-owner tasks consist of activities which manage online shops and maintain customer relations. The tasks data provided the needed information to design the system functions and other user operations in the application. Other data collected during the audits include user interface interaction elements, menu layouts, interaction activities and information flow.

The collected data was carefully studied and hierarchical task trees were designed for the customer and the shop-owner tasks and system functions. A further transformation of the shop-owner tasks into scenarios design was done to enhance presentation and evaluation with participants from the community. The designed scenarios also marked the beginning of prototyping of the application and user interface design.

4.4.10.2 Focus groups for Evaluation of Scenarios

The tasks analysis process provided information that lead to the design of scenarios. We felt that presenting a hierarchical tasks tree to the community may not give a clear picture of our design intentions. The scenarios designed served as a simple prototype we could present to community members for evaluation and data collection. The scenarios contained narratives of the different activities for a shop-owner. We intended to further collect data from the crafters. The data included images of crafted products, local names of products, in addition to prices and data about the producers of the artefacts for application database design.

We conducted focus groups in the community and presented the scenarios for formative evaluation and data collection. The scenarios designs include scripts of different tasks and diagrams of user screens and menu (Appendix B). The process of presenting scenarios to the community was meant to educate the participants about the design and get their input early in the design process.

The sessions involved two focus groups at the Ngwane (n = 13 crafters) and Mpume (n = 9 crafters) art and craft centres respectively. The process was facilitated through the help of the SLL community facilitator. All the participants ranged from 43 to 56 years old.

In each session, we started with an introduction and the participants gave information about themselves. We then introduced the application and then followed with an explanation of the different scenarios tasks and other information. During the presentations we made the participants understand that the design was a prototype which would transform into a program that will be accessed through the mobile phone. Participants were able to make very few contributions and were eager to see a real program. The sessions took between 3 to 3.5 hours.

4.4.10.3 Data Collection and Analysis

Scenarios data- The textual data obtained from the crafters (artefacts and others) were reviewed and structured into database tables and entities. The artefact images were extracted from the digital camera and appropriate information was attached to them and then added to the database. The other data about interface elements and sketches was carefully studied to

identify the type of menu system and interface elements that the participants are familiar with. We then used the information as a basis for structuring the shop-owner user interface.

4.4.11 Prototyping

The GUI and the VUI prototypes were designed iteratively through a process of design, test redesign and finally evaluated. In this section, we will first present the design and formative evaluation of the GUI and then later, the design and evaluation of the VUI.

4.4.11.1 Design Tools for the GUI

Mobile web and server-side technologies were used in the design process. Apache WAMP server (Meloni, 2008): The Apache WAMP server is an open source web server consisting of independently designed programs for the Microsoft Windows operating system. The Apache WAMP server consists of a web server, MySQL open-source database system for relational database design. MySQL database management system was used to create the relational database for the mobile commerce application. Also included is PHP scripting language that is used to manipulate the data stored in the database engine and dynamically generate web pages. The PHP language was used to design the server-side program functions. The system also provides a graphical user interface called phpMyAdmin for managing MySQL database. The system is flexible, easy to install and use. There are other alternative apache web servers for other operating systems such as XAMP for Windows and other operating systems, and LAMP for Linux machines.

Openwave phone simulator (Openwave, 2009): This software simulates a mobile phone platform that allows calls to be made to the Web through hypertext transfer protocol (http) connection. It contains a handy browser that enables the testing of Web applications developed for mobile phones and other mobile terminals. The browser supports the rendering or display of HTML/XHTML and CSS, MMS and WAP 2.0 content. The openwave phone simulator was used during design and testing of the application. The extended hypertext markup (XHTML-MP) and the wireless cascading stylesheet (WCSS) scripting languages (Routt, 2004) were used to design the client-side interface. The application is designed for XHTML-MP compliant mobile devices. We also used WALL (Wireless Abstraction Library) open source tool to adapt the interface to suit WML (Wireless Markup Language) and Compact HTML (cHTML) compliant devices (Mehta, 2008).

The prototype system architecture is presented in Figure 4.3. The figure shows the customer user interface and the shop-owner user interface. The customer and the shop-owner will interact with the application using the respective user interfaces (on mobile phones) to send and receive responses from the application hosted on the Web server. The web server also uses the program functions to interact with the database management system to access the application data based on a user request.

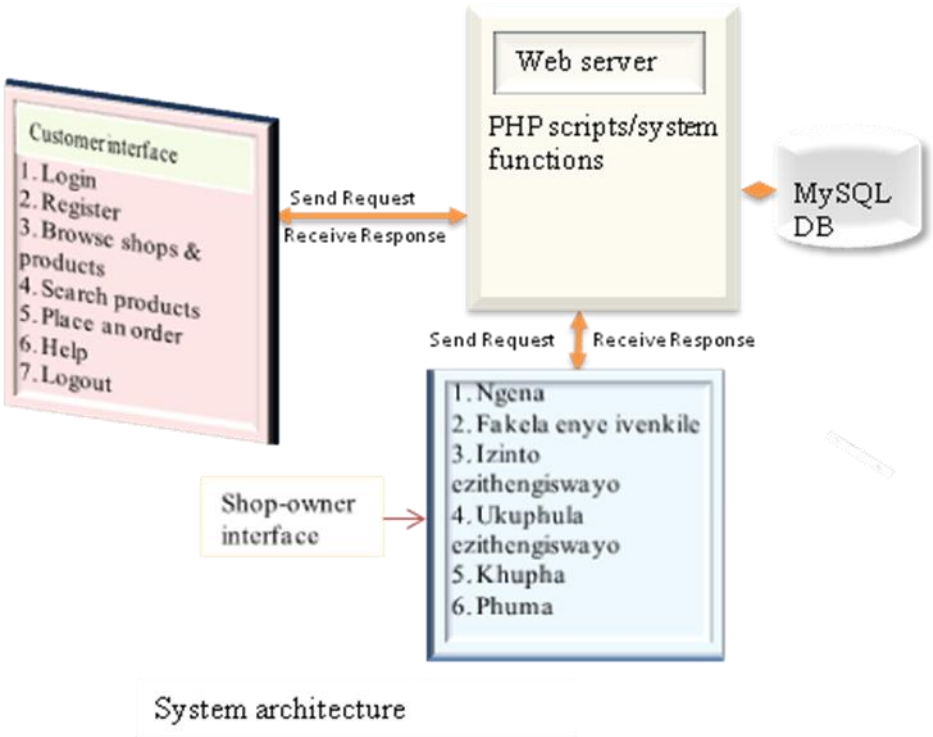

Figure 0.3 GUI System Architecture

4.4.11.2 Focus Groups for Formative Evaluation of GUI Prototype

The first iteration of a tangible program was designed and used to conduct formative evaluation using focus group for further data collection and upgrading of the GUI.

We held focus groups (three sessions) in the community to present the GUI prototype and to elicit data from the participants. The intention was to use the prototype to further explain the intentions of the study and to use it as a means to collect more artefact data and users' interface preferences. The artefacts data includes camera images and other attributes of the

products (local names, prices, descriptions, uses and other details) and data about the producers (names, contact information and description of online shops and other details). The data was used to upgrade the application database and the user interface.

The participants include crafters (n = 13) at the Ngwane art and craft centre, school learners (n = 15) and educators (n = 8) from two secondary schools in the community (Mpume and Nqabara).

The sessions with crafters were held at the art and craft centre. The crafters were women who were semi-literate and illiterate and were between the ages of 43 and 56 years.

The school learners were in grades 11 and 12 and between the ages of 15 and 21 years. Approval for school learners' involvement was sought through their principals in the schools. The discussions were held in the school computer laboratories.
The educators were functional literates and were between the ages of 28 to 42 years. Discussions with the educators also held in the school environment (computer laboratory).

In each of the session, we started with an introduction stating the reasons for the meeting. Participants were then asked to introduce themselves. The discussions were centred on the designs using the list we prepared prior to the journey to the community. The list provided a guide to the discussions pointing out issues to dwell on during the interactions. A detailed explanation of the different interface screens was made and participants were asked to study the different interface screens and point out any observations. They evaluated the menu layout, text, button positioning and size, amongst other details.

Participants who owned and used mobile phones were also asked to visualise the phone interface and make a sketch of the menu and the steps to perform tasks such as sending a text message to a friend, storing a new phone number, and deleting an old text message from the inbox. These tasks are synonymous with some tasks in the proposed application. They also made hand-drawn sketches of phone interface elements (e.g. ok, send, save, call and other buttons). This was done to help participants visualise their mental models of simple phone interactions. We also asked the participants to state their preferences for user interface

elements. The evaluation lasted for 1hour to 1 hour 30 minutes. The data collected was used for further iteration of the interface design and the first step towards interface adaptation.

4.4.11.3 Data Collection and Analysis

We demonstrated the prototype to the participants and raised questions that were discussed in the different groups. Textual data using field notes were collected. Additional images of artefacts (crafted products and cultural markers) were also collected using a digital camera.
The data collected was analyzed textually such as the cultural markers to determine where best to apply them on the GUI, while the images of crafted products were added to the database of the system.

4.4.12 Voice User Interface Prototype Design

4.4.12.1 Design Tools for VUI

The following design tools were used for the VUI design: VoiceXML for developing content and dialogs logic for interactions between the user and the system, and Voxeo speech development platform (Voxeo, 2009) for speech interface design. The voxeo speech platform consists of Automatic Speech Recognition engine (ASR), Text-To-Speech (TTS) engine and a Web server. The voiceXML application connects to the mobile commerce application database through PHP scripts by making calls or using http connections to the same PHP functions that were designed for the graphical user interface.

The Voice user interface was designed to perform the same function as the graphical user interface for both the shop-owner and the customer. We translated the various interface tasks, information displays and other user actions on the graphical user interface into voice user interfaces for the customer and the shop-owner respectively. The customer and the shop-owner will be able to interact with the mobile commerce application using voice and dual tone multi-frequency (DTMF) input in return to which the application gives feedbacks with voice output. DTMF inputs are numbered key presses that the user sent to the voice recognition system for interpretation. The expected action will then be executed in the application based on the recognition outcome.

The customer voice interface was designed to allow the customer to interact with the application using a combination of English voice and DTMF inputs and the user receives female voice output (English) feedbacks from the application.

The shop-owner voice user interface was localized and content adapted to local dialect, usage pattern and terminologies. The shop-owner GUI content (menu text, commands, display information and other text materials) was used to develop the shop-owner voice user interface. Voice prompts in the Xhosa language were recorded in the computer laboratory using a professional female voice personality. The pre-recorded prompts cover words and statements containing phonemes with click consonants that are difficult to implement in English-based automatic speech recognition (ASR) engine. Other prompts that allow for the smooth flow of interactions with the application using speech were also recorded and used to design the voice interface. The Isixhosa language contains complex cultural clicks and consonants that the voice engine is unable to utter in appropriate sounds or pronunciation for easy understanding by the local users.

The content of the shop-owner voice interface was presented in two separate flavours, one with voice input only and the other with DTMF inputs only. This was done for the purpose of determining users' interaction preferences with user interface flexibility. The DTMF and the voice input menus provided the user options to choose from (e.g. DTMF -"cofa wani" meaning "press 1 or 2...", and voice - "bisa wani" meaning "say 1 or 2...").

4.4.13 Cultural Adaptation of the User Interface

The shop-owner side of the GUI and VUI were adapted to culture sensitive interfaces using the natural language and other data (metaphors and icons, cultural markers, preferences) elicited from the community. As already stated in VUI prototyping section, the shop-owner voice user interfaces were adapted to the local language of the target community (Dwesa) using isiXhosa female voice prompts.

The cultural adaptation of the GUI necessitated the application different research methods to gather the data required for this process. These include surveys, audit of the environment, focus groups, and interviews. Details of these methodologies are discussed next.

4.4.13.1 Surveys for Culture Data Collection

Two surveys were conducted – survey on culture dimensions and survey on culture markers validation.

4.4.13.2 Culture dimension survey

In order to further the shop-owner user interface design iteration, a survey was conducted to determine the culture dimensions of isiXhosa culture in Dwesa. The goal of the survey was to determine the culture dimensions and then map the result to user interface preferences such as interface appearance, navigations, metaphors, interactions and mental models (Marcus, 2002). We adapted the value survey module (VSM), a questionnaire proposed by Hofstede et al. (2008), to suit the target local environment. The value survey module consists of Likert-scale questions (see Appendix C). The value survey module is widely used for investigating culture dimensions in different culture for the purpose of comparing user interface culture preferences between different cultural groups (Marcus and Gould, 2000, Smith and Dunckley, 2004).

The questionnaires were distributed by random sampling to educators and clerical staff in the five secondary schools in the community. All the participants in the survey are isiXhosa people by culture and live within this environment. The culture dimensions data include power distance, masculinity vs. Femininity, collectivism vs. Individualism, and uncertainty avoidance. We decided to distribute the questionnaire only to people who are gainfully employed within the community and with functional literacy due to the demands in the questions and ability to understand and adapt to the respondent's situation. The data needed from this survey would help in determining user interface requirements and cultural preferences for this user group (Dwesa people). The results were used to deduce the interface requirements, local user preferences and subsequently designed the shop-owner interface according to the findings.

4.4.13.3 Culture Dimensions Data Collection and Analysis

46 questionnaires were randomly distributed and 42 were completed and returned. Quantitative data was collected from the value survey module questionnaire. The data represents respondents' ratings for the culture dimensions. They include scores on power

distance, individualism vs. Collectivism, femininity vs. Masculinity and uncertainty avoidance.

The culture dimension data that was collected was entered into Microsoft Excel and grouped based on different culture dimensions. Calculations were done using the index formula designed for analysing the value survey module (VSM 2008) (Hofstede, 2008) and then the scores for each dimension were determined. The results were interpreted and used to deduce interface requirements and users' preferences.

4.4.13.4 Culture Markers survey

We also conducted a survey with 15 undergraduate computer science students for the purpose of collecting data to adapt the shop-owner interface to the target culture. 15 questionnaires were distributed randomly to students who share the same culture with the Dwesa people and are residents of the same province. The questions contained interface elements that the respondents were asked to translate to the local culture, give similar culture markers with the same meaning or usage in the local culture as the meaning of the interface elements presented on the questionnaire. The questions also asked the respondents to give names and sketches for such items identified. The questionnaires were completed and returned.

4.4.13.5 Culture Markers Data Collection and Analysis

15 questionnaires from students containing qualitative data on cultural markers were also collected. The cultural marker qualitative data collected was carefully studied and analyzed. The data was then selected and grouped into categories. The selected ones were then discussed and validated with postgraduate computer science students who have an IsiXhosa cultural background.

4.4.14 Audit of the Physical Environment

This technique involves a probe of the physical environment to identify artefacts within the environment that can aid cultural adaptation of the user interface (Shen et al., 2006). The technique is easy to implement and could be complemented with interviews for collecting adequate data and validating the data. The method is also useful in a low literate environment

where the users often find it difficult to understand computer jargon. The technique could be time consuming, and requires a long study period in order to gather sufficient data.

A study was conducted in the community to elicit cultural data or artefacts within the socio-cultural environment. We visited the community and moved round the environment and visited some community members in their homes to collect user interface data for further customization of the shop-owners' interface. We prepared a list interface metaphors, icons, and other items to search for within the Dwesa environment. We felt that the items found in the environment and some cultural artefacts that are used in the home are what the people in the community are familiar with and if sourced and used to design the GUI, community users will not find it difficult to identify and understand the actions and meaning they represent (e.g. road signs, local huts, gates, domestic instruments and others). During the process, we visited 6 homes in the community with the assistance of an interpreter. We had short interview discussions with the people we visited. We took photographs of artefacts from the homes we visited and from the environment as we moved around the community (e.g. road signs, huts/home, local baskets, colour artefacts, local fans, tables with items for sale and others).

The images were taken so that we could produce sketches or static hand drawn representations to depict the items. The hand drawn diagrams are used as user interface elements in the form of metaphors, icons and navigation signs. Since these items are common within the cultural environment of the community, it will be easy for local users to understand and interpret the actions which these items represent on the shop-owner interface.

4.4.14.1 Data Collection and Analysis

Field notes were used to collect responses from the people visited. We used a digital camera to capture images of artefacts from the homes and environment.

We studied and summarised the notes. The images were carefully studied and sketched out as hand drawn diagrams. The picture images and hand drawn diagrams that represented the expected user action or meaning on the interface were selected and validated.

4.4.14.2 Interviews for Culture Data Collection

Interviews were conducted with participants in Dwesa community, as well as undergraduate and postgraduate computer science students. The first interviews were conducted in the community to elicit cultural data for shop-owner user interface customization. These include information related to social and cultural issues, the environment, beliefs, values, working relation and culture components data. The list containing semi-structured questions used for culture components data elicitation during focus groups was also used to interview the educators in the community.

The participants were 10 educators (6 females and 4 males) in Ngwane and Mpume secondary schools in Dwesa. Their ages were between 26 to 47 years and 7 of them were average computer users, while 3 were not computer literate at all. The interviews were held in the educators' offices and the computer labs.

We started each interview session with an introduction. The interviewee was then introduced to the prototype and one or two tasks were performed to demonstrate how the prototype and the user interface worked. The interview sessions took between 45 minutes to 1 hour.

As part of the customisation process, interviews were also conducted with postgraduate and undergraduate computer science students who share the same culture with the Dwesa people (3 females and 5 males). They were between the ages of 22 to 25 years. All participants were familiar with the user interface design processes and have good knowledge of mobile commerce and mobile applications. We considered the interviewees as experts as recommended by Yeo (1996).

An interview guide (similar to the one used in the community) contained semi-structured questions to elicit interface culture components.

The interview sessions were held in the postgraduate computer laboratory and at different periods chosen by the participants. In each session, we introduced the application and participants were allowed to study the questions and then we discussed the questions. Each interview session lasted for 45 minutes.

4.4.14.3 Interview Data Collection and Analysis

Data was collected using field notes written during discussions with community members and students. Hand drawn diagrams made by participants to represent interface cultural elements were also collected.

The notes were carefully studied and textually analyzed to identify basic themes. The hand drawn diagrams were also studied and compared with one another. We then made selections. The data was then presented to post graduate computer science students for verification and validation.

4.4.14.4 Focus groups for Culture components Data Collection

We needed to adapt the shop-owner user interface to cultural preferences of the target users. We held separate focus groups sessions with community members. They include crafters, school learners, educators and clerical staff.

A list of semi-structured questions that consisted of the interaction elements of the shop-owner user interface was prepared and used as a guide during the focus groups discussions. The data we looked for include text format and translation, numbering format, menu layout preferences, colour markers, buttons and other cultural components that may be used to represent navigation, actions, metaphors/icons with local meaning, and images.

Arrangement for meeting with crafters (n = 14) was through the regular facilitator who has been assisting in previous engagements. The crafters have been part of our previous focus group interactions and they were semi-literate and illiterate women. They were between the ages of 43 and 56 years. The sessions with the crafters took place at the Mpume and Ngwane art and craft centres. The facilitator also served as the interpreter during discussions.

19 school learners took part in the discussions. They were in the 12^{th} grade and their ages ranged from 16 to 21 years. The approval for school learners and other school employees' participation was obtained from the school principals. 5 educators who were between the ages of 28 and 45 years, and literate, took part. 12 clerical staff consisting of semi-literates and literates also took part in the discussions in separate groups. The discussions with the school learners, educators and clerical staff were held in the schools' computer laboratories on different days.

At this stage we were familiar with the participants and a good relationship had been established and so the motivation and level of participation was better than the previous meetings. We started each focus group session with introductions. It was then followed with an introduction and demonstration of the prototype to educate the participants on its functions and what it is designed to accomplish. We then asked questions and discussed the issues on the prepared item. All the sessions with the different groups took between 50 minutes to 2 hours to conclude.

4.4.14.5 Culture components Data Collection and Analysis

The data collected during the process of interface adaptation (culture components and preferences, images) was collated and categorised into the different cultural markers, metaphors and other markers. We then held discussions regarding them with postgraduate computer science students who share the same cultural background as the community; for verification and validation of the most appropriate ones.

4.4.15 Design Evaluation

Evaluation was conducted for both the GUI and the VUIs using focus groups and single user evaluations. For the purpose of clarity, we will discuss the methodologies separately under GUI evaluation and VUIs evaluations.

4.4.15.1 Focus groups for GUI Evaluation

We conducted a pilot test and two separate experiments through focus groups to evaluate the shop-owner user interface.

The pilot test was conducted with 3 crafters in Ngwane art and craft centre and 3 clerical staff members of Mpume secondary school. The aim of the test was to perform a quick assessment of the shop-owner interface and make modifications prior to engaging more people in the community for extensive evaluation.

The crafters were semi-literates, while the clerical staff were literate participants. In each of the session participants were introduced to the interface and tasks were performed as a demonstration what the shop owner will do with the application. The evaluation at this stage was formative and we thus asked participants to use the interface and point out their

observations and areas where improvements were needed. We observed as they used the interface.

Experiments1:

The first evaluation experiment involved 14 school learners (7 males and 7 females), 9 crafters in Mpume art and craft centre and 10 clerical staff of Mpume and Ngwane secondary school (7 females and 3 males).

The school learners where between the ages of 15 to 22 years and were in 11^{th} and 12^{th} grades. The clerical staff were between the ages of 27 to 39 years and consist of literates and semi-literates participants. The test was conducted with the school learners and clerical staff in the school computer laboratories in separate sessions.

The crafters were between the ages of 46 and 56 years and semi-literates. The session with the crafters was held in the art and craft centre.

In each session, we made introductions and also introduced the application and interface and performed some of the tasks in the application. The participants were then asked to carry out two assigned tasks on the interface. We observed the participants and guided them as they performed the tasks. We recorded the task completion time and error rate for each participant. The tests took between 2 to 3 hours to complete a session depending on the number of participants in each group.

Participants were also selected at random from each group and scheduled for another evaluation test at a separate date. The purpose was to determine if the participants were able to learn the shop-owner interface when repeating the tasks on the interface at different times. We met again with 20 participants selected in their different groups. Each of the group members performed two tasks at three different times. The process took two days to complete.

Notes were taken for each task's completion time, each error encountered and the number of completed tasks. The data collected was used to determine task completion time and error rate, for the two tasks.

Experiment 2:

The second experiment was conducted at a different date in the community. The test was for the purpose of determining users' perception about the shop-owner user interface. The focus groups for evaluation consisted of 5 different groups. The groups include crafters (n = 8) in Mpume art and craft centre, school learners (n = 13), and clerical staff (n = 7) from Nqabara secondary school.

Among the school learners, 8 were in grade 12 and 5 were in grade 11. Their ages were between 15 to 21 years. 11 of the school learners owned mobile phones and all have been participating in the computer skills training programmes. Approval for school learners' participation was obtained from the school principal. The school learners were organised into 3 groups consisting of a mixture of males and females. The test was conducted in the computer laboratory.

The test with clerical staff was also held in the computer laboratory (Nqabara secondary school). All the clerical staff owned mobile phones and 3 were semi-literates while 4 were functional literates. Their ages were between 27 to 45 years. We obtained permission for their participation from the school principal since the exercise was conducted during working hours. The test was also conducted in the computer laboratory.

The test with crafters consists of those who had participated in the previous evaluation process. They were all semi-literates. Among them, 5 owned mobile phones. The sessions with the crafters were held in the art and craft centre (Ngwane).

We started each evaluation session with introductions. The application and the selected tasks were introduced. We then performed tasks to show the participants what they are expected to do. Each participant in each group was also allowed to perform the two selected tasks consecutively. We observed the participants and gave them assistance whenever the need arose.

Post test questionnaires (Appendix D) were given to each participant to complete after performing the tasks on the interface. In the questionnaire, we adopted the technology acceptance model (TAM) (Aggelidis and Chatzoglou, 2009; Davis, 1989) to test participants'

perception of the interface. We also interviewed the participants to get their views of the application and interface. Each group session took 1hour to 2.5 hours depending on participants' level of performance and the number of users in the group.

4.4.15.2 Focus groups Evaluation Data Collection and Analysis

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During design evaluation, we recorded each participant's performance data and interview responses on filed notes. Quantitative data was collected using the post-test questionnaire.
Quantitative data collected during focus groups (e.g. design evaluation) were first entered into Microsoft Excel data sheets. We then analysed the data using descriptive statistics (measures of dispersion) to obtain percentages, mean scores and standard deviations. We also produced graphical charts from the analysis. The results were then interpreted.

4.4.16 GUI Single User Evaluation

Single user evaluations were also conducted with community members and students using the shop-owner user interface and the customer user interface respectively.

9 educators in Mpume and Nqabara secondary schools participated in the exercise and among them, 6 were females, and 3 were males. The evaluations with the educators were conducted in the schools' computer laboratories. Each participant was first introduced to the system, and then followed by a demonstration of three tasks on the shop-owner user interface. The participants were then allowed to perform two tasks on interface. We observed and recorded each participant's performance and took notes. Each participant was also given a post test questionnaire to complete in order to determine their perceptions of the system. Evaluations with each educator took between 10 to 20 minutes to complete.

We selected 2 participants, each from Mpume and Nqabara, and scheduled them to repeat the same tasks on the following day. This test was conducted to determine whether the participants were able to learn the interface and perform the same tasks better, in shorter period of time with a reduced number of errors. We also observed and took field notes for each participant's performance.

Evaluation of the Customer user interface -The customer user interface was also evaluated with undergraduate and post graduate students. 15 students participated in the process and 12 were undergraduate (none computer science students), while 3 were postgraduate computer science students. The students were between the ages of 22 to 27 years.

The tests were conducted in the post graduate computer laboratory. Each student was introduced to the system and then asked to perform two tasks. We observed each participant as they performed the tasks and took note of their performance by recording time to complete each of the task and the problems or errors they encountered. Possible errors include participants selecting the wrong menu item, issuing the wrong command, entering data at the wrong field, incomplete data, navigating to another screen without completing data entry in the previous screen and others. Each participant was given a post test questionnaire to complete. Evaluations took 10 to 20 minutes to complete.

4.4.16.1 GUI Single User Evaluation Data Collection and Analysis

The data collected during single user studies in the community was combined with data collected during focus groups. Data was also collected through field notes. The data was carefully categorized into performance time and error rate for each of the participants (community members and students). We entered this into a Microsoft Excel spreadsheet. The post-test Likert-scale questionnaire also provided data that was entered into Microsoft Excel spreadsheets. The data collected during single user evaluations were analysed using descriptive statistics (measure of dispersion) to obtain mean scores, and standard deviation. The results were also used to plot graphs and bar charts. We then interpreted the results.

4.4.17 VUIs Evaluation

Evaluation of the VUIs had also followed the same procedure we applied in evaluating the graphical user interfaces. We applied different methods in performing the evaluation, data collection and analysis, namely; focus groups and single user evaluations in order to create a balanced outcome. The methodologies are presented in the following sections.

4.4.17.1 Focus Groups for VUIs Evaluation

We conducted focus groups in the Dwesa community to evaluate the two flavours of the shop-owner voice user interfaces (dual tone multi-frequency input interface and voice only

input interface) with participants from the community in two separate experiments. The experiments were conducted to assess user performance characteristics (task completion time, errors, ease of use, ease of understanding and other details) on the two interfaces.

Experiment 1:

The first experiment was conducted with school learners, clerical staff and crafters.

The school learners (n = 17) were in the 11^{th} and 12^{th} grades. Their median age was 18years with the minimum being 16 years and the maximum 22 years. All the school learners have mobile phones and were relatively computer literate. The evaluation with school learners was conducted in the school computer lab (Nqabara secondary school).

The clerical staff (n = 9) consisted of 3 males and 6 females. 6 were literate and 3 were semi-literate participants. Their ages were between 27 to 45 years. 6 of the clerical staff were literate in basic computer operations. They all owned mobile phones. The evaluation of clerical staff was conducted in the schools computer laboratories (Ngwane, Mpume and Nqabara secondary schools).

The crafters (n = 12) were from the Ngwane and Mpume art and craft centres. They consist of both illiterate and semi-literate participants. They were between the ages of 42 to 56 years. The crafters have been part of previous studies. Three of the crafters did not own mobile phones but have been using mobile phones owned by relatives. The evaluation with the crafters was conducted in the Mpume and Ngwane art and craft centres respectively. We engaged the assistance of an interpreter during the test. The evaluation process was conducted in groups.

Each group session started with an introduction. A short introduction and training followed. We trained the participants on how to use the interfaces. The participants were then asked to perform two selected tasks on the two interfaces separately starting with the DTMF interface. A headset was provided to enable the participants to interact more effectively and eliminate background noise.

We listened to and observed each participant as they performed the tasks. We also recorded data on notes about the performance of the participants. At the end of each evaluation

session, a short interview was conducted with the participants to find out their interaction experiences and preferences regarding the two interfaces varieties. A post-test (Likert scale) questionnaire was also given to the participants to complete. The evaluation sessions took between 1 to 2 hours to complete.

Experiment 2:
The second experiment was conducted to determine tasks success rate among the different user groups as they use the VUIs. Participants were randomly selected from the groups that took part in the first experiment.

Evaluation with the selected school learners (n = 12) in Nqabara secondary school was conducted in the computer labs. Evaluation with clerical staff (n = 12) was also conducted in the computer labs (in Nqabara, Ngwane and Mpume schools).Evaluation with the selected crafters (n = 8) from Ngwane and Mpume art and craft centres was conducted in the two centres respectively. The sessions were held on different days and at times with the different groups.

In each evaluation group, we had a short discussion and training to introduce the participants to the two tasks selected for the test. Each participant was allowed to perform the tasks. We observed the participants and recorded the time of completion of each of the tasks, and those who could not complete them. A short interview was conducted at the end of each group session. The sessions lasted for 1 to 1.5 hour.

4.4.17.2 Focus Groups Data Collection and Analysis

Questionnaires and short interviews were conducted with the participants to collect test data for analysis. Interviews responses were analysed textually while data collected through questionnaires was first entered into Microsoft excel spreadsheet. The data was then analysed using descriptive statistics (measure of dispersion) and paired t-Test statistics. The results were then interpreted to give meaning to the statistical analysis.

4.4.17.3 VUIs Single User Evaluations

We also conducted single user evaluation of the shop-owner voice user interfaces (DTMF and voice input) with educators in the community in two separate experiments. The experiments were the same as the ones conducted using focus groups in the community.

Experiment 1:

Participants for the first experiment consist of 12 educators (5 males and 7 females) from Ngwane and Nqabara secondary schools. Their ages were between 28 and 39 years. The evaluations were conducted in the computer labs.

Two tasks were selected for the exercise. Each participant was given a short introduction and the reason for the evaluation. A demonstration tasks on the interfaces was performed. Each participant was then asked to perform tasks using first the DTMF input and the voice input interfaces. We observed and took notes as each participant performed the two tasks one after the other. We recorded the task completion times and the errors encountered. Each participant was interviewed after the test. A questionnaire was also given to each participant after the test. The evaluation sessions lasted 20 to 30 minutes.

Experiment 2:

In the second experiment, educators were randomly selected from 3 schools in the community to test the two voice interfaces. 10 educators took part in the exercise. The sessions for the second experiment were conducted at different days and times. In each meeting, the participants were given an explanation and a demonstration of the tasks and then allowed to perform the two selected tasks. We recorded the observations on field notes as interacted with the interfaces. Tasks completion time was taken and we took note of those who could not complete the tasks as well as the errors encountered by each participant. Short interviews were held with each participant. Each test session lasted 10 to 30 minutes.

4.4.17.4 Evaluation of the Customer Voice User Interface

The customer voice user interface was also evaluated with undergraduate and postgraduate students to assess user understanding and interactions with the interface. The undergraduate students were non computer science students (n = 12) who were in their second and third year of study. All the participants were computer literate and good users of the Internet and web

and mobile chat rooms. The undergraduates were also familiar with and have used telephony speech applications (e.g. land lines). Five computer science students also participated in the evaluation. 3 were in third year and 2 were postgraduate (Honours) students. The age range of all the students was between 21 to 24 years. The evaluation was conducted in the computer laboratory. Prior arrangements were made with each of the students and the experiment was performed by each student separately and at different times.

In each session, we introduced the reason for the meeting, the participant made his/her introduction and then the student was given a short introduction to the system. We then asked the student to perform the task of placing an order for an item in a shop. We observed each of the participants as they performed the task and we also wrote down notes for each participant's performance time and the errors encountered. A post test questionnaire was also given to each participant at the end of the test to complete. Each test session took 10 to 15 minutes to complete.

4.4.18 User Interfaces Comparison

A test was conducted to compare the task success rate among the different user groups in the community. The task involved the participants performing a given task on the GUI, the DTMF input interface and the Voice input interface (the shop-owner user interfaces). The participants were randomly selected among the user groups and included those who have taken part in previous evaluations.

The participants included 13 school learners, 6 crafters, 9 clerical staff and 7 educators. The sessions with the school learners, crafters and clerical staff were held through focus groups, while the sessions with educators were conducted through single user evaluations. The test with school learners, clerical staff and educators was conducted in the computer lab of the school. The task selected involved the users updating a product number and price in an online shop. The evaluation with crafters was conducted at the art and craft centre (Ngwane).
In each session, participants were introduced to the task and the different interfaces with a short demonstration. They were then asked to perform the selected task in each interface. We observed the participants and wrote down notes for each performance. The group sessions lasted for 1 hour 45 minutes to 2 hours. Each participant was given a questionnaire to complete. The questions were to enable the participants to give their opinion on interface

preferences based on the interfaces used to carry out the test. All the questions were positively rated on a point scale of 5-strongly agree to 1-strongly disagree.

4.4.18.1 Data Collection and Analysis

We used different methods to collect data during the evaluation of the voice interfaces with participants from Dwesa community and students. We listened to and observed the participants as they dialogued with the interfaces and wrote down notes of their performances. The time duration for dialogs between the participants and the system were taken from the system time displayed on the sip phone interface during interactions. We also took notes during post test interviews with participants. A post test questionnaire was also used to collect data from the participants in the community and the students.

Data collected from the community through single user evaluations were combined with data from focus groups and then analyzed. The qualitative data (observations and interviews) collected through field notes was read carefully and textually analyzed to draw out themes for interpretation. The quantitative data collected through field notes were first grouped into task completion times and error rates. We then entered the data into Microsoft Excel spreadsheets and analyzed the data using descriptive statics (measure of dispersion statistical instrument). We also performed t-Test statistics on the data to determine statistical differences between the performance time and error rates for the DTMF input and the voice input interfaces. Graphs and bar charts were generated from the results and then interpreted. Data from post test questionnaires were also entered into a Microsoft Excel spreadsheet and analyzed using descriptive statistics (measure of dispersion and paired t-Test). The interpretations of the results were made. The results provided the basis for drawing up the study conclusions.

4.4.19 Observational Method

The observational method was used to collect data mostly during evaluation of the prototypes (e.g. focus groups evaluation process, single user evaluations). We observed the participants as the carried out tasks on the interfaces. Qualitative and quantitative data was collected during evaluations.

4.4.19.1 Data Collection and Analysis

Field notes were written to keep record of user performance. The notes written were carefully read, summarised and used to upgrade the interfaces. The quantitative data was first entered into Microsoft Excel data sheets. The data was analysed using descriptive statistical methods. The results were used to plot charts and graphs and were then interpreted.

We have described above the various methodologies used and within the research design approach applied during this study. We had to adopt different research methodologies and rigorously apply them due to the study environment and user characteristics in order to meet this study objective.

4.5 Limitations of Study

The study was very successful in that we were able to gain access to the community (Dwesa), which is the focus of this study, whenever we needed to. However, having access to a large number of participants to cut across all the identified occupations in the community was difficult during data collection. The low level of education and technology literacy by a good number of the respondents limited their understanding and conceptualisation of so many issues in connection with the study. All the field studies were conducted within a period of two years. Each study performed in the community (e.g. user study, evaluation) took a period of one to two weeks to complete.

Communicating with community members in Dwesa, using the English language, limited their understanding and the extent of their interactions with the respondents during focus groups and interviews since we do not understand the Isixhosa language. It was also difficult sometimes for us to explain or translate computer jargon into appropriate local content for easy understanding. In some cases, even the help of computer science postgraduate students who were also Isixhosa was not enough, since they too could not translate appropriately.

The questionnaires were all structured in such a way that respondents did not need to give much explanation. This was informed by the general literacy level and as such it narrowed respondents' contributions. Focus group discussions, through a mediator, also had its own limitations as the interpreter may not give as much details as the respondents or may not

interpret the questions very well in accordance with the type of context or meaning we intended.

During prototype evaluation, the think-aloud method was not used due to the inability of the participants to communicate effectively and also the ability to talk aloud when performing a task was not possible for the participants. Contextual inquiry is another method that could have been used but it was not possible to record activities as they are performed. Focus groups proved to be very effective during the study and we were able to engage the respondents in meaningful discussions that facilitated the outcome of the study. The division of the study or data collection activities into five phases (the user-centred approach) and engaging different user groups made the entire process transparent and very easy to successfully keep track of. We did not rely on one user group for data gathering so that we could always review different opinions from different experience levels to find a balance in the information obtained.

4.6 Conclusion

The culture and capabilities of the users influence how they participate with the techniques used during the design and testing processes. For instance, the prominent use of the focus groups for data collection and evaluation processes helped the participants to participate better. Being in a group with other participants was a motivation for everyone.

For effective participation of users in remote areas, adaptation of the data collection methods to suit the capabilities and socio-cultural methods of communication common to the participants' environment is necessary to achieve the expected results (Lalji and Good, 2008; Smith et al., 2004). This is vital in rural communities because these processes of data collection or evaluation as well as the technologies being considered are still new to the people.

We have presented the research methods used in the course of this study. The sampling techniques, data recording and analysis carried out on the data have also been presented. We have reviewed the various methodologies used, indicating their limitations during the study and also provided ways in which we were able to mitigate the limitations by engaging different user groups. Different qualitative data was collected ranging from textual to

graphical data and, as such, to analyse this data required different and simple processes. Quantitative data was also easy to analyse using descriptive statistics. Table 4.1 presents a summary of the research methodologies used, purposes, demography of the participants, duration and general comments based on observations during the study.

Table 0.1 Summary of Research Data Collection Methods

Methods	Data Collection Tools	Purpose	Input/ Output	Participants /Demography	Duration	Help	Comments
On-site visits	Field notes	Training, Learn social interactions, environment study, etc.	Textual data.	School learners, Educators, Clerical staff, Crafters, and other community members.	Study period	Community facilitator	This process motivated the community
Survey	Questionnaire	User/environment data collection	Quantitative data - Community User profile, technology landscape, etc.	School learners, Educators, clerical staff, farmers and other community members (120 responses)	1 week	Community facilitator	A follow up was needed to help low-literacy respondents
	Value survey module questionnaire	User interface adaptation data	Quantitative data - Culture dimension data.	Educators, Clerical staff (42 respondents)	1 week	None	Questionnaire adaptation to suit the local environment
	Questionnaire	User interface adaptation data	Textual and graphical data - Culture markers	Students (15 responses)	2 weeks	None	Computer/cultural experts were needed to validate the data
Audits	Field Notes	Audit of similar applications for tasks and user interface data	Textual data - Tasks and user activities data, user interface,	None	2 months	None	Similar applications are useful were the data collected from the users is not enough.

			etc.				
	Field notes, digital camera	Audit of environment for cultural artefacts and interface metaphors	Textual and graphical data - Cultural artefacts images, names, meaning and uses, etc.	Crafters, and other community members (n = 6)	2 months	Community facilitator	The environment is a good source of data for interface localization
Focus group	Field notes, Digital	User and environment analysis	Social interactions data, business constraints, tasks data, etc.	Crafters (12), Educators(11), Clerical staff(10)	50 minutes to 1 hour a session	Community facilitator	Focus groups are very helpful for interacting with low-literacy users in rural areas during system design
	Field notes, Digital camera	Scenarios design evaluation	Textual and graphical data - Crafted artefacts, interface elements, etc	Crafters (22)	3 to 3hours 30 minutes (1 week)	Community facilitator	
	Field notes, digital camera	Prototype testing	Textual and graphical data - Crafted products, Interface sketches, User preferences, etc.	School learners (15), Educators (8), crafters(13)	1 hour to 1 hour 30 minutes a session. (1 week)	Community facilitator	
	Field notes, digital camera	Interface localization data	Textual and graphical data - Artefacts,	School learners (19), Educators (5), Clerical	50 minutes to 2 hours a session (1	Community facilitator	

			Culture markers, etc.	staff(12), crafters(14)	week)		
	Field notes, questionnaire	GUI evaluation	Qualitative and quantitative data - Evaluation data	*Experiment 1* -School learners (14), Clerical staff (10), crafters (9).	2 to 3 hours a session (1 week)	Community facilitator	
				Experiment 2- School learners (13), Clerical staff (7), crafters (8).	1 to 2 hours 30 minutes (1 week)		
	Field notes, questionnaire	VUI evaluation	Qualitative and quantitative data - Evaluation data	*Experiment 1* -School learners (17), Clerical staff (9), crafters (12).	1 hour to 1 hour 30 minutes a session (1 week).	Community facilitator	
				Experiment 2 -School learners (12), Clerical staff (12), crafters (8).	45 minutes to 1 hour 30 minutes a session (1 week)	Community facilitator	
	Field notes, questionnaire	GUI and VUIs comparison test	Qualitative and quantitative data - Evaluation data	School learners (13), Clerical staff (9), crafters (6), Educators (7).	45 minutes to 2 hours a session (1 week).	Community facilitator	
Interview	Field notes	User data, interface adaptation	Culture markers,	Educators (10), Students (8).	45 minutes to 1 hour (1 week).	None	Interviews were used in situations where the respondents are literate and can communicate effectively
Observation	Field notes	Evaluations	Qualitative data - Evaluation data	Community members.	Evaluation periods	Community facilitator	

Single user evaluations	Field notes, questionnaire	GUI evaluation	Qualitative and quantitative data - Evaluation data	Educators (9), Students (15)	10 to 20 minutes a session	None	Single user evaluations provide data to create a balance in the results obtained during evaluations.
	Field notes, questionnaire	VUIs evaluations	Qualitative and quantitative data - Evaluation data	*Experiment 1* – Educators (12).	20 to 30 minutes a session (1 week)	None	
				Experiment 2 – Educators (10)	20 to 30 minutes a session (1 week).	None	
				Students (15)	10 to 15 minutes a session	None	

CHAPTER FIVE: DATA ANALYSIS AND RESULTS

5.1 Introduction

The study was conducted with the aim of designing mobile user interfaces and interaction techniques that are easy to use and accessible to low-literacy rural users. The study used an iterative user-centred approach with five development phases described in the research design (chapter four). The study phases include user and environment study, tasks and scenarios design, prototyping, cultural adaptation of user interface and design evaluation. Different research methods were applied in each of the study phases to collect both qualitative and quantitative data. The participants consisted of members of the local community (Dwesa). The data that was collected had been analysed using textual analysis and descriptive statistical analysis. The data results include data that was used to design the mobile user interfaces (GUI and VUI) and application and the data from interfaces evaluation sessions that point to the perception and experience of the participants as the interacted with the user interfaces. In this chapter, we present the study findings, the application design being this study intervention and results from user interactions with the interfaces. The overview of the study findings is presented next.

5.2 Overview of Research Findings

In this research, we have viewed the process of data collection and interpretation from a neutral point and not allowing our values, beliefs, interest, personal expectations and knowledge about the research and participants to influence our judgment. We have kept open-attitude in order to understand and explain the data. In most cases in the research design, we have applied more than one data collection method in order not to rely on one method of data collection and avoid being limited on the research viewpoint. Same data was also collected at different times and different user groups in the community to determine if there are changes or similarities in the outcome. This helped in identifying patterns and increase confidence in the outcome. In the case of the artefacts data used to adapt the user interface to culture sensitive interface, the data passed through a validation process with experts who are knowledgeable in the culture of the community and highly computer literate.

The study found that in the Dwesa community, the level of awareness and use of ICTs is very low due to low level of literacy, cost and language barrier. The local business environment is

very poor due to absence of basic requirements like good roads. Interactions with ICTs remain a difficult experience for low-literacy community members as a result of the language of interaction and interfaces that seem difficult for the users to understand. These community users prefer interfaces that present information in a structure that meet their capabilities and depict their cultural preferences and experiences. And so, this study applied different research methods and cultural theories in order to attempt to address these needs. The data collected was also used in the interface design process to create an artefact that the Dwesa community users see as their own and have positive intention to use it.

The design of user interfaces for low-literacy users in rural communities is no doubt a difficult task. This study outcome illustrates an attempt to develop usable user interfaces for users in low-literacy environment through the process of interface adaptation to the socio-cultural experience of the target users. These users are not familiar with computer jargons and are mostly computer illiterates, and in most cases they are unable to understand what is being discussed or cannot state what they want during requirement gathering. However, they have natural and adequate experiences as a result of their interactions within their socio-cultural environment on daily basis. We have made attempt to elicit these information/data from the people and the environment in this study to design culture sensitive user interfaces with interaction elements that are easy to understand and familiar to their socio-cultural experiences. These data include artefacts (representing cultural metaphors/icons on the interface) that are common within the socio-cultural environment. The results of the study point to the fact that even in low-literacy environment their social and cultural knowledge is important when designing user interfaces. This creates a sense of belonging and serves as a motivation for them to use the interface. With the study findings, user interfaces have been designed and evaluated with potential users in the community. The outcome of the evaluations show that the participants perceived that localization of the interface (GUI) to their cultural knowledge made it easy to understand and influences their intention to use the system. Also, the voice user interface designed (DTMF-input and voice-input flavours) for this study was evaluated with community participants. The participants perceived the interface as being simple and easy to use. A higher number of participants preferred the DTMF-input flavour to the voice-input flavour of the voice user interface. Also based on the user studies (evaluation) results, the interfaces meet the preferences and capabilities of Dwesa community users.

The findings of this study are presented in three major parts with subsections. The first part, namely: the user and ICTs environment present the research findings before this study intervention. The findings in the first part are presented based on the local community participants' perspectives in order to understand their concerns and difficulties regarding the technology landscape (e.g. mobile technology usage) and the local business environment prior to this study. The second namely: user interfaces and application design present the design outcome, while the third part presents findings from user interactions with the designed interfaces. The results demonstrate this research attempt to address the study objective.

5.3 User and ICT Environment in Dwesa Community

We conducted user study in Dwesa community to collect data about the users and their environment. In the study, we applied both quantitative and qualitative research methods to gather data. These include site visits for interacting and training community members on computer skill acquisition, in addition to which a survey, observations and interviews were also used.

5.3.1 Users and Technology Landscape

In order to determine the demography and the technology landscape in Dwesa, we conducted a survey. The data gathered via the survey provided information about the user profile, and the level of experience and use of mobile phone technologies in the community. The study found that the technology landscape that includes the level of technology literacy, awareness and use of both Internet and mobile technologies is very low. These factors play a direct influence on users' perceptions and use of any mobile application designed for the community. People who are familiar with the Internet and multimedia messages through their mobile handsets will have a better experience with mobile Internet technology. They will also appreciate the introduction of mobile commerce/applications to the community due to the awareness and experience already derived from the use of these mobile technologies. The findings here show a user group that are technologically inexperience.

The demographic data gathered showed that the people of Dwesa are engaged in different occupations for sustainability and economic livelihood. The study identified occupations such as subsistence farming, crafting, teaching, clerical staff, local clerks, school learners, as well

as those without any form of trade or employment. In the results, 19.7% (23 respondents) were farmers and consisted of semi-literates and illiterates. 15.83% (19 respondents) were crafters and are made of respondents who did not have education higher than grade 12 level. 21.67% (26) respondents were teachers (educators) in schools within the community. 26.67% (32 respondents) were school learners and 16.67% (20 respondents) made up of local clerks, clerical staff, cleaners and the unemployed in the community). Figure 5.1 is a chart which represents the occupation distribution of the respondents. Also, 27.7% (23 respondents) had education above grade 12. Among those who were still in school, 62.5% (20 respondents) were in grade 12, and 37.5% (12 respondents) were under grade 12.

The findings also points to the general low level of literacy in the community as noticed by Pade et al., (2009). This has a negative impact on technology awareness and use. It will also influence the general capability and experience of the users in terms of their understanding and use of information technologies. The study also brings to the fore issues of design consideration such as simplicity in design and the type of user interface and the interactions that will meet the capabilities of the users and be suitable for use in this community.

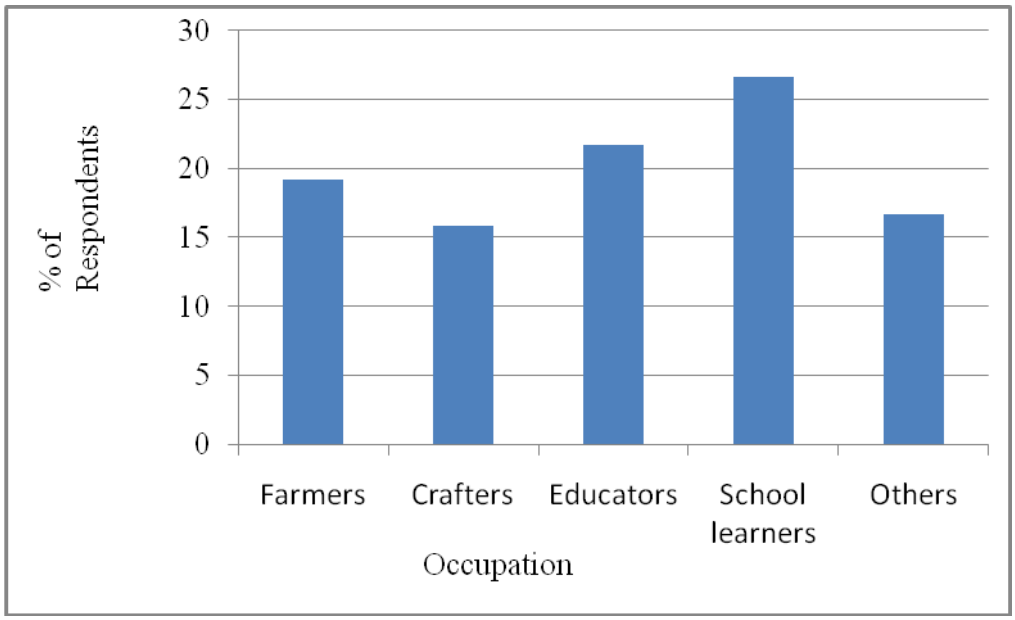

Figure 0.1 Occupation Distribution of Respondents

5.3.2 Literacy and Cost of ICT Usage

Availability and use of new technology increases technology literacy and capabilities of the users. It will also influence users' perception and adoption of new technologies when

introduced. In a rural area, media accessibility is very important for the development and adoption of ICTs. Mobile devices are affordable and accessible when compared to desktop computers in rural areas such as the Dwesa community (Pade et al., 2009; Edim and Muyingi, 2010b). Due to the significance of mobile phones to this study, we also looked at the level of ownership and use of mobile phones among the different demographic groups. The adult populations are engaged in teaching, farming, crafting and trading in the community. The adults' engagement in farming and crafting will benefit positively from ICT services if the services are accessible and aimed at economic improvements. School learners are among the greater population of people in the community. This group of users will also use the interfaces for their own purposes or to assist the elderly. ICT services will benefit the community as a whole if implemented in the areas of need. The study found that the level of phone ownership and use has increased, significantly, to a higher percentage than previous findings by Pade et al. (2009).

The study shows that among the respondents, 10.9% of those who owned mobile phones are in the age bracket of 14 – 19 years and 45.7% are those who do not have mobile phones in this group. 8.7% of mobile phone owners are in the age bracket of 20 to 25 years and 2.9% of them are without mobile phones in this group. In the 41-45 year age category, 19.6% form part of those with mobile phones and only 5.7% within this age group do not have mobile phones. Among the older adults above 50 years, 26.1% are among the population with mobile phones, while 25.7% of them are without mobile phones. In the age bracket of 36-40 years, none of the respondents owned a mobile phone. Subsistence farming and crafting are two traditional occupations in the community. The populations that are engaged in these occupations are adults, the majority of which are 40 years and above. These groups of phone users will also use the application and interfaces if properly designed to meet their standard. The mobile commerce application may help to cut down the cost of transporting artefacts products to markets in the cities for sale. Figure 5.2 gives a graphical representation of the percentage of respondents who owned mobile phones and those who did not, among the different age groups. The graph also illustrates the dominant population groups in the community which are made up of the older adults (over 50 years) and young people of school age (between 14 – 19 years). There are fewer numbers of people in the population groups from the ages of 26 – 40 years in the community due to migration to urban areas in search of jobs and better economic prospects (Pade et al., 2009). The information above has identified

the various categories of possible users of the user interfaces and application in Dwesa community. We can also deduce from the information above that the interfaces that are designed for these categories of users should be provided clear information and be devoid of any implied meaning, hidden information on any item on it in order to give them with the simplicity that is required.

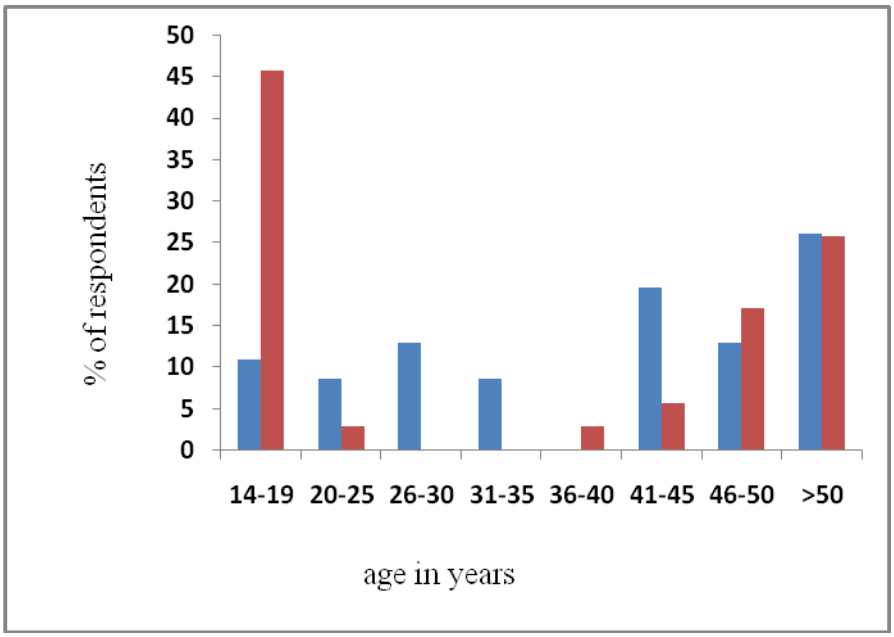

Figure 0.2 Ownership and Usage of Mobile Phones

The awareness and use of the available mobile phones technologies among the people of Dwesa is very much dependent on the level of literacy and affordability. The negative impact of these factors is that if few people use these technologies, very few of them will be better placed to appreciate mobile services meant for the community and little meaningful contribution will come in during system development. This study found that the technology literacy level in the community, in terms of Internet and mobile applications and services is very low. The survey results show literacy and cost affect the use of common mobile services such as Short Message Service (SMS), Multimedia Service (MMS), and mobile web browsing in the community.

Also, among the different user groups in the community those who use services such as MMS and mobile Web browsing are among the literate ones who are gainfully employed within the community. In Dwesa rural areas because of low literacy level and poverty, low brands mobile phones are common and users are restricted to making and receiving calls at most times (W3C, 2009; Pade et al., 2009). Figure 5.3 shows a graphical representation of the level of use of mobile phone services amongst the respondents. From the data collected, 60.61% of the respondents send and receive SMS with their phones; 21.21% do browse the Web , 24.24% send and receive MMS. Some respondents indicated that they only receive SMS (6.06%) and MMS (6.06%) but they do not send out SMS or MMS with their device. 39.39% of the respondents with mobile phones do not use any of the services mentioned.
The general response from the study indicate that cost and literacy problems limit the use of these services. It also shows the technology experience level of the community users.

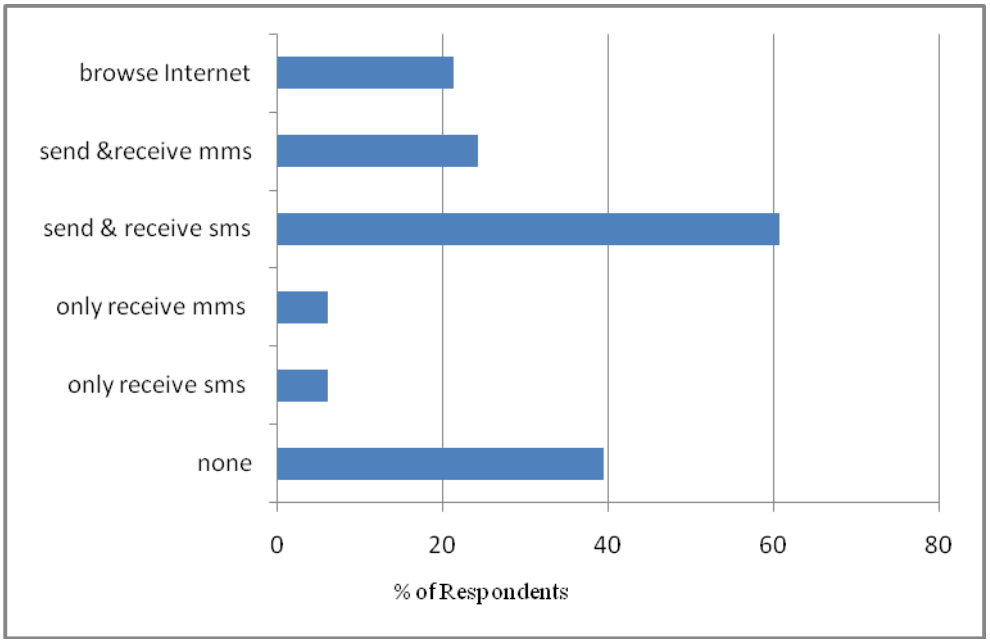

Figure 0.3 Use of Mobile Technologies in Dwesa

Different mobile applications and quality of devices provide different interaction types/modes to the users. Mobile phones in rural areas are mostly used for voice interactions through the mouth piece and speakers. Apart from these common types of interaction modes, other types of interaction modes demandbetter level of literacy and capabilities, as well as affordability on the part of the owner of such a device. The survey study revealed that apart from making and receiving voice calls, the majority of the respondents (80.16%) use phones that they can

only interact with using just the keypad and device screen. Other respondents whose phones are with other facilities for interactions include those with camera phones (12.5%) for mobile phone camera interactions, phones with softkey pad (12.5%) and touch screen (13.21%) for finger touch interactions, and mobile phones that are touch pen enabled (15.5%).

The study indicate that keypad and screen interactions with graphical user interfaces are more commonly used among the respondents. Voice interactions through voice calls is a general issue. Touch and pen-based interactions are limited to a few individuals. Mobile phones with less sophisticated facilities are the dominant ones. Community users are more conversant with the simple form of interactions with their mobile phones. This points to the fact that applications and interface designs that are meant for these users will require simple forms of interactions that include keypad and voice if they are to meet the requirements of a larger number of users in the community. Voice interactions will be able to support users across a large range of mobile phones and users with low literacy problems. Hence, keypad interactions and voice interactions will be able to cater for all the categories of users and be able to meet their low level of interaction experience.

The awareness and use of common information technologies in the Dwesa community is very important to this study. We considered the technology literacy of the respondents which include computer literacy, Internet, e-commerce and m-commerce awareness and use. The experience of the target users in the community with these ICTs will have a direct influence on how much the people in the community will be able to participate during the design. It will also influence their perception and willingness to adopt the mobile commerce application and user interfaces provided. The information also enables us to know the approach to use when engaging with the community members during the system design process. The study survey contained Likert-scale (5- strongly aggree to 1 – strongly disagree) questions that are positively rated.

The study found that the average computer literacy among the respodents is low (Mean = 2.66, SD = 1.19). Knowledge and use of the Internet is also lower on the average (Mean = 2.63, SD = 1.24). Very few respondents have knowledge of or have ever used any e-commerce and mobile commerce applications in the community. For e-commerce, the Mean = 2.43(SD = 1.21) and for mobile commerce the Mean = 2.38 (SD = 1.23). The findings reveals that the awareness and use of these technologies is generally poor across all user

groups in the community. The findings willl have a significant impact on the target users' involvement in the design process. This also represent the level of experience of the users in the Dwesa community in terms of these two technologies. When engaging with the users in the community, it requires a good and easy means of communicating with a language that is simple and devoid of the jargon associated with these technologies. The study also indicate how much experience the community has with these ICTs. The results of the variation on all the technologies shows that there is not much difference among the respondents with regard to the level of experience or literacy the community has of these technologies. Figure 5.4 presents the results of ICTs awareness and use in Dwesa.

The study indicate that, in order to promote ICT literacy and use in Dwesa community, more effort is required for skills training programmes. People in Dwesa community will require significant levels of training to be able to use the ICTs designed for them (Patel et al., 2009). Based on the low level of technology literacy, the users may find it difficult to make meaningful contributions during application development. These groups of users have little experience and capabilities and will, therefore, require interfaces and interactions that are designed for novice users. Customization of the user interfaces and interaction elements will provide the simplicity and create the level of understanding suitable for these groups of users. Customization will also enable the interfaces to comform to the users' cultural experiences and preferences and also help novice users to easily learn the interfaces (Edim and Muyingi, 2010a; Shen et al., 2006). We had conducted different field studies to elicit data and customize the user interfaces and to meet this study objective.

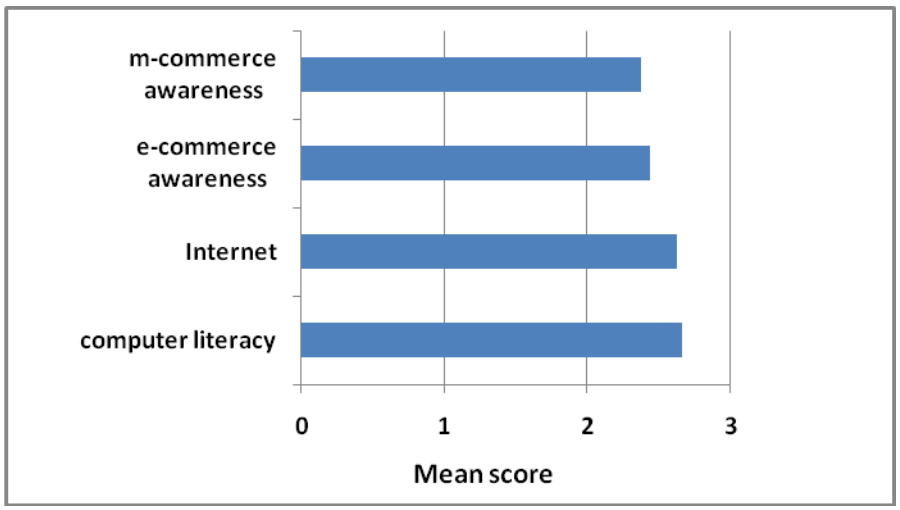

Figure 0.4 ICTs Awareness and Use

5.3.3 Language as a Barrier to technology usage

A study was conducted to examine community participants' experience with phone menus and to also know their perception and mental model of phone menu. We asked participants to make sketches of familiar tasks and menu. Participants made different diagrams of tasks menus (e.g. the menu to create and send a text message, open the phone book and call a friend's number). Figure 5.5 shows two of the sketches that reveal how the participants perceived the menus for these tasks on their phones. Few participants illustrated an abstract hierarchical menu system for these tasks. They were also able to perform these tasks with their phones. Based on the sketches made by the local participants, it showed that they were familiar with the hierarchical menu system. This is an indication that a few people are already familiar with this type of menu structure and will be able to use this type of menu system when used in designing an interface meant for them.

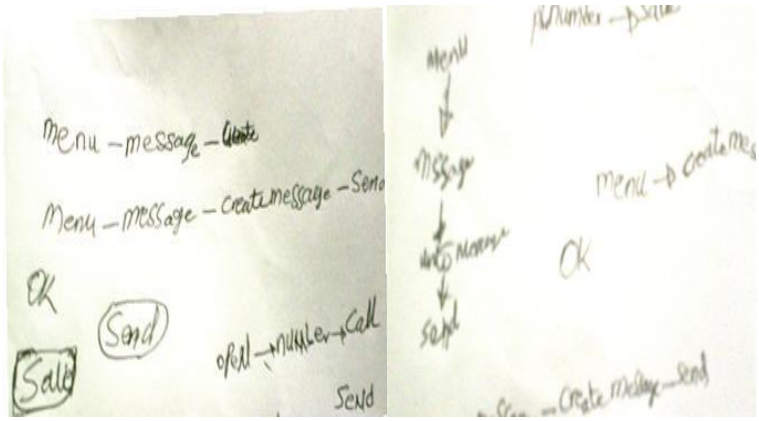

Figure 0.5 Diagrams from Participants on Phone Menu

Participants (90%) said they do not understand all the functions or menu items in their mobile phones. They all admitted that the difficulty was as a result of language barrier (use of the English language) and inability to understand the commands. They made different comments with regard to their limitations in mobile applications (e.g. "… they are difficult that is why I do not understand and I cannot use it…"), ("… If they are in IsiXhosa I will understand them better…"). This is an indication of how much a localized interface will help the users to use new technology better and how localization can help to meet the user preferences and capabilities.

5.3.4 The Local Business Environment

On-site visits and interactions with the community members, we observed and t and had inerviews with community members to study the business environment. The study found that the Dwesa business environment is faced with so many problems (see section 3.3).

The study reveals that poverty, lack of patronage within the local community as well as high cost of transportation due to the un-tarred nature of the road hinder the growth of micro-economic activities in the area. High transportation costs for movement from Dwesa to the nearest town (Willowvile, 50 km away) also prevents local producers, like the crafters, from selling their products outside the community. There are no visible markets within the community. Business activities are very low, while poverty and lack of patronage from the local community affects the morale of the micro-entrepreneurs in the community (Edim and Muyingi, 2010a). The community is concerned about the level of government development programmes. There are very few employment opportunities or jobs in the community schools and the only healthcare centre in Mpume. The high level of unemployment makes the youths (mostly semi-literates and illiterates) prone to crime and alcohol abuse. Less than 5% of the population are fully employed (Pade et al., 2009). The absence of any visible market makes the process of doing business very difficult, and as such the micro-entrepreneurs (e.g. crafters, livestock farmers) are poorly patronized and are not very encouraged. A small number of petty traders (kiosks owners) buy goods from Willowvile for retailing in the community and these are then sold at a very high price to local consumers.

The study findings show that among those interviewed, 61% are not computer literate ICTs can be used to leverage the local economy by providing services that will enable micro-entrepreneurs to market their products outside their community and encourage production (Edim and Muyingi, 2010c). From our observations, the quiet nature of the Dwesa environment is good enough for voice interactions with mobile applications. Also participants say information dissemination in the community is mostly through common social methods and by word mouth. Due to the high level of technology illiteracy as revealed in the previous studies conducted, interfaces for ICT applications and services should be made very easy to understand with much local content as possible. This will encourage users and help them to have a positive perception of the services provided.

The study of the local business environment also revealed the traditional method of buying and selling of goods in the community. The traditional method of buying and selling of goods in the community involves bargaining. According to the interviewees, when a product or item is for sale, the item is displayed publicly on a table or a tray without any price tag on it. The seller gives the buyer a price that initializes the bargaining process. The buyer also responds with an initial price offer. While the buyer negotiates for a price he/she wants to buy, the seller also negotiates on the price he/she wants to sell the item. When a middle point is reached where the seller agrees to sell and the buyer is willing to pay for the item; then it is offered for sale. And if there is no middle point, the seller then announces the last price he/she is willing to accept for the item. We decided to find out how we can incorporate these two-party negotiation processes into the mobile commerce application. The traditional process is different from the auction method, where it is only the buyers that bids and the highest bidder wins the auction or buy the item; also auctions are open multi-party process. It will be interesting if the buyers are given opportunity to interact with the sellers through bargaining before paying for a particular item or good. It will also motivate the buyers to visit the shop at another date and continue to patronize the seller. The shortfall of this method is the network transaction cost for both the customer and the buyer. We will also draw up the required steps in the bargaining process and add this process in the design of the application and interfaces.

The local business environment is poor and it requires urgent attention from government and other organizations. Applications and user interfaces for ICT services design for Dwesa community is a step in the right direction. With the little experience on mobile interaction types and applications as found in the study, complex interaction techniques will be difficult to embrace. Keypad and voice interactions are still the major means of interacting with mobile devices in the community. Internet access and usage are only common with the highly educated people with paid employment in the community. Also, ICT infrastructures are still being introduced; several resources are not yet within the community for the introduction of other forms of mobile interaction techniques.

5.3.5 Cultural Preferences

We conducted studies with community participants through focus groups discussions and surveys to determine cultural preferences of Dwesa people. The study found that local

community users prefer the user interface to be adapted to the local culture; they feel that it will improve understanding and make interactions and tasks performance easier. The participants have also indicated that interaction elements (icons, metaphors) that depict actions and artefacts within their cultural environment will make the user interface easy to learn and understand. This will create a natural sense of interaction and make them accept the interface as their own. This will also enhance user experience and usability when the interface elements are made to take the form of the culture and environment knowledge of the target users (Edim and Muyingi, 2010c). This knowledge is sourced within the cultural environment of the users. The information represents their daily experience as they interact and navigate through the environment. Static diagrams on the user interface in the form of familiar icons/metaphors and other interaction elements will be adequate for interactions.

Table 5.1 gives a summary of participants' preferences. This information was needed for adaptation of the user interface to user cultural preferences. The study found that community users prefer text on interface to be presented in the local language. They will be comfortable with the conventional numbering system. They also want buttons and labels to carry text in local language and images from the local environment and convey meaning. The above information had been included in the interface design. The information also added to what the users feel will create an interface that will meet what they want, improve interface understanding and interactions.

Table 0.1 Users' Preferences for the Interface design

Users' preferences for the shop-owner interface	
Text	They prefer text for interface elements and information to be presented in local language (Isixhosa).
Numbering	The traditional numbering system in the community is of the form: I, II, III ..., participants said they do understand and would prefer the conventional number system (1, 2, 3, ...).
Interaction elements	Participants feel graphics that represent familiar information within the local context and environment will create a better understanding if used to represent interaction elements (e.g. metaphor, icons, navigation, symbols) on the interface.
Menu and layout	Participants want a short hierarchy menu with very shallow depth and preferably a centrally positioned list presentation will help, and will also help them to avoid being confused.
Labels and buttons	The use of local language on labels, buttons and information content was highly suggested by all participants.
Images and graphics	They want graphics and images to portray actions and objects common within the cultural environment. They also feel that it will provide the needed intuition and makes it easy to understand and navigate through the user interface.
Help item	Participants want context help information to assist them during interactions e.g. help information to assist users during navigation or menu actions and commands.

We applied the value survey module (Hofstede et al., 2008) questionnaire (Appendix C) in the community in order to determine the culture dimensions for Dwesa community (Isixhosa culture group). Four of Hofstede et al. (2008) culture dimensions (power distance, masculinity vs. femininity, uncertainty avoidance and individualism vs. collectivism) were considered for the survey. These four culture dimensions are closely linked to an individual's behaviours and perceptions which emanate from the individuals socio-cultural environment (Huang and Deng, 2008). We identified the schools within the community to apply the questionnaire and the staff in these schools that are Isixhosa natives. The study is also aimed at identifying the cultural preferences of the people. Table 5.2 presents the survey results of the survey. The study found that Dwesa culture is a moderate power distance and masculinity society. It also indicates that the society practices collectivism where individuals belong and live as a family. There is a high level of uncertainty avoidance. This means that people are more inclined to believe or accept facts that are unknown or have subjective or intangible interpretations.

Table 0.2 Culture Dimensions Ratings

Culture Dimension (n = 42)	Score	Rating
Power Distance (PD)	66.5	Moderate power distance
Masculinity vs. Femininity (MF)	68	Masculinity
Collectivism vs. Individualism (IC)	-24.5	Strongly collective
Uncertainty Avoidance (UA)	122.50	High uncertainty avoidance

The cultural requirements or preferences and the implications of culture dimensions rating on user interface design can be deduced from the dimensions ratings as proposed by Marcus (2001). Based on the ratings/scores, an interface with artefacts that depicts national pride (monuments, images or colours) will be acceptable to these groups of users. They will also favour the use of gender oriented images and gender sensitive colours markers on the interface (a masculinity society). Symbols and images that represent religion and collective life values or orientation are preferable (collectivism society). These groups of users have shallow mental models of tasks; they would prefer simple designs that are easy to understand without ambiguities which will be able to encourage them to use the interface. These users will prefer a user interface that is simple and without complex structures or hidden information. Metaphors and images should portray their collective values and nature of social life within their cultural environment (e.g. images of their leaders or heroes, religious monuments and artefacts) as indicated on the score of power distance.

The findings also show that these users, or potential users, have a high regard for their local institutions, meaning that institutional metaphors/icons on the user interface will also promote interface understanding and acceptability. Users may tend to avoid or will be easily frustrated by an interface with interaction elements (e.g. navigations, metaphors/icons) that are not familiar and difficult to understand. Complex or long menu hierarchies will easily discourage these groups of users (the high uncertainty avoidance). Traditional colours on the interface would provide the traditional aesthetics that the users want. Input formats and feedback with easy to understand information and outcomes, and without implicit meaning will be preferred. The users will want menu hierarchies with easy navigation options, short or shallow structure to avoid being lost during interactions (short mental models as illustrated by high uncertainty avoidance). These users may not be able to cope with a menu system that

has a tall hierarchy and implicit information. The community users have a mental model that is tasks oriented, and précised. They will require very clear task options with short hierarchies.

The users in this community have very limited experience with mobile applications and interfaces. The interpretation given above with regards to the culture dimension scores points to some of the cultural requirements or preferences that when applied into user interface design will help to take care of some of the cultural expectations of the target group which ordinary can be difficult to get during face to face meetings with the users. The information is necessary to adapt the user interface to reflect their culture preferences and experience. This information is gained by the people as they people interact within their socio-cultural environment and represent their everyday experience. The user interface requirements outlined above and other qualitative data collected during other field studies were used to adapt the shop-owner user interface to meet the culture experience and preferences of the target users. The interface adaptation exercise may have helped in providing ease of use and understanding of the shop-owner user interface which the community users experienced during user interface testing. It will also help community users in enhancing their interaction experience and encourage the use of the technology.

Interviews were also used to gather data about cultural preferences for user interface adaptation. During the process, cultural markers and other information was collected. Table 5.3 presents a summary of colour markers and their meaning. These colours are traditionally used for different purposes or occasions within the Isixhosa cultural environment. They are used for dress/traditional attire, traditional beautification and adding aesthetics to product designs. This means the selection and combination of colours during user interface design is also very important to create the expected feeling and perception among the users in this culture group. Poor selection or the inappropriate combination of colours may repel the users, while a good selection may send an acceptable message that will attract the users' interest. Combinations of these colours (e.g. white, brown, and green) were used to create the needed aesthetics and make the interface attractive to the dwesa users. The colours selection and use on the interface was based on their symbolic and cultural meaning. This process also helped in designing a user interface that the users in Dwesa are willing to accept as their own.

Table 0.3 Cultural Colour Markers and Meanings

Colour marker	Meaning
White	It is a symbol of purity, or peace. It is a celebrated colour and mostly used for traditional attires. Considered as a traditional colour.
Black	A symbol of darkness, evil, or death. Traditionally used for attire that represents the state of mourning.
Brown	A symbol of beauty, symbol of manhood and strength.
Yellow	It is regarded as a national colour.
Green	It is the symbol of the traditional occupation of the people, which is farming.
Blue	It represents calmness, truth and beliefs in the heavenly, peaceful.
Red	It is a symbol of calamity, blood, or danger.

Responses from interviews with community members indicate that everyone in the community is identified according to the family to which he/she belongs. Family values are protected and respected by members of the family. Extended family houses and relations are very common and estates are owned throughout the family. The failure or achievement of an individual is considered a family or collective responsibility. Community and extended family values always supersede that of an individual and as such the people value group interest more than personal interest. Those who are gainfully employed are expected to assist their parents and siblings financially. This is an indication of a collectivist society where a user interface with elements that reflect or give out a message of collective values is preferred.

The men dominate in this community in their social life and activities and also act as agents of social control and family security. Women cannot control family estates and as such the decision making process and economy of the family is controlled by the men. Certain roles are designated as belonging to a particular gender. That is, there is separation in gender roles. In situations where the women are a major source of economic stability in the family, the respondents say their culture demands that the women still respect the man as the head of the house/family. The information portrays a masculinity society where user interface elements that send out a message of gender sensitivity will be preferred.

Traditional and orthodox religions are practiced in the community. These religions shape the social lives and beliefs of those who practice them and also dominate the peoples' way of life. Religious teachings, spiritual interpretations of situations and doctrines serve as sources of guidance to the people. Unemployment and high levels of alcoholism among male and females are a common social menace in the community with high levels of aggression among the youths. Risk taking is not a very easy and common consideration amongst the youths and, as such, taking up a business proposal may be regarded a risky adventure due to the fear of failure. Hard work is regarded as a virtue and is greatly encouraged. Social and religious institutions are agents of change, social cohesion and a medium of information exchange in the community due to the low level of reliance on electronic media. Good relations, moral values and community cohesion are highly emphasized.

The information above indicates a deeply collective, masculinity and high uncertainty avoidance society. The implications on user interface design targeting these groups of users can be deduced from the information gathered; users will prefer simple tasks devoid of implied meaning or hidden information. Interface elements or images on interface that depict religious markers will be accepted. We have designed shop-owner user interface with clarity of tasks and no hidden information. We also provided help information to assist users as they navigate through the interface to avoid being lost or confused during interactions.

5.4 User Interfaces and Application design

In this part of the chapter, we will present what we carried out in this study in order to answer the research questions. This section is divided into the following subsections: tasks and scenarios design, prototyping of the user interfaces, cultural adaptation of the user interfaces and the design evaluation. The previous study findings presented in the first part of this chapter served as input and aided the design of the application and the discussions presented in this part.

5.4.1 Tasks and Scenarios Design

The process of identifying the users' tasks was carried out through two separate studies. The first process involved interviews with crafters and other community members in Dwesa to learn the traditional methods of marketing in the community (already presented in the first

part of this chapter). The second process was the auditing of existing and similar applications (Smith and Dunckley, 2004) for tasks and user interface data.

The information about the traditional business process gathered from the community was carefully studied developed into and outline of steps needed to complete transactions through bargaining. A provision is made in the application for items to be presented for bargaining. The bargaining process involves the following steps:

1. Customer chooses an item placed on bargain,
2. Customer enters an amount to pay for the item and waits for seller response,
3. If the seller is happy with the amount offered, accept offer – step 6 or step 4 - Seller responds indicating a price to sell item,
4. Seller responds to customer by indicating a price to sell item,
5. If not ok to customer, repeat step 2 to 3 (with increased price offer) or step 8,
6. Or else, if customer offer is good, item is accepted for sale, step 7,
7. Customer completes order confirmation processes,
8. Stop bargaining.

The purpose of auditing existing and similar applications was to gather data for tasks design and to incorporate them into the traditional marketing processes. E-commerce and mobile Web sites were studied. We performed tasks on them such as placing an order in an e-commerce online shop application. Tasks and interface design data were elicited. Interface design data includes menu structure, layout of interface elements, interaction elements such as icons/metaphors, navigation and information presentation format and others. The customers' ultimate goal is to search or browse for items and place orders, while the seller's goal is to manage the online shop. Two set of tasks were elicited, representing the customer and shop-owner tasks. The following customer tasks were identified:

- A customer creates a user account with the users' personal information for future login and authentication. The user account information enables the application to keep track of the user and be able to connect the user to his/her data in the database during shopping.
- The customer visits a shop to browse through the products and identifies products or items of interest.
- The customer checks for details and a description of a product.
- The customer can search for a product by entering the product name or a key word.

- The customer can select products into a shopping basket or wish list. The customer keeps track of his/her purchase interests, and he/she is able to remove unwanted products from the basket or wish list.
- The customer places an order, selects a payment method, and performs a confirmation and check out procedures.
- The customer visits his/her account to monitor his/her order, check order status, and modify delivery address if necessary.
- Customer can bargain for an item placed on the bargaining list by the seller/shop-owner.
- A help module to assist customers with necessary information.
- Information on shop-owner details and contacts and others.

At the shop-owner/seller end, the following tasks are performed using mobile devices:

- Create new online shop to accommodate a new online shop or a new shop owner.
- Add new product to an online shop.
- Place an item on bargaining terms and bargain with an interested customer.
- Perform updates on existing products or information in an online shop.
- Check for customers' orders and payment method.
- Obtain the customer delivery address.
- Obtain the customer phone contact and place a call to the customer.
- Update the status of an order.
- Send a message to the customer about the order.
- And others.

At the server level, the functions include:

- Manage the database.
- Authenticate users, perform tasks and respond to queries.
- Perform calculations for the customer order.
- Maintain and manage user information and send emails to customers.
- Manage the user interface and interaction elements.
- Perform and support the user tasks internally. And other functions.

Figures 5.6 and 5.7 represent the hierarchical tasks trees for the shop-owner and customers' tasks respectively. The tasks trees were designed based on the outcome of the tasks analysis

performed. The first diagram (Figure 5.6) shows the tasks that the shop-owner (e.g. a crafter in the community) will perform in order to achieve the major goal of managing his/her online shop. While the second diagram (Figure 5.7) shows the customer tasks that need to be performed to achieve the major goal of placing an order in an online shop. The tasks trees present the tasks used in designing the mobile commerce application and user interfaces.

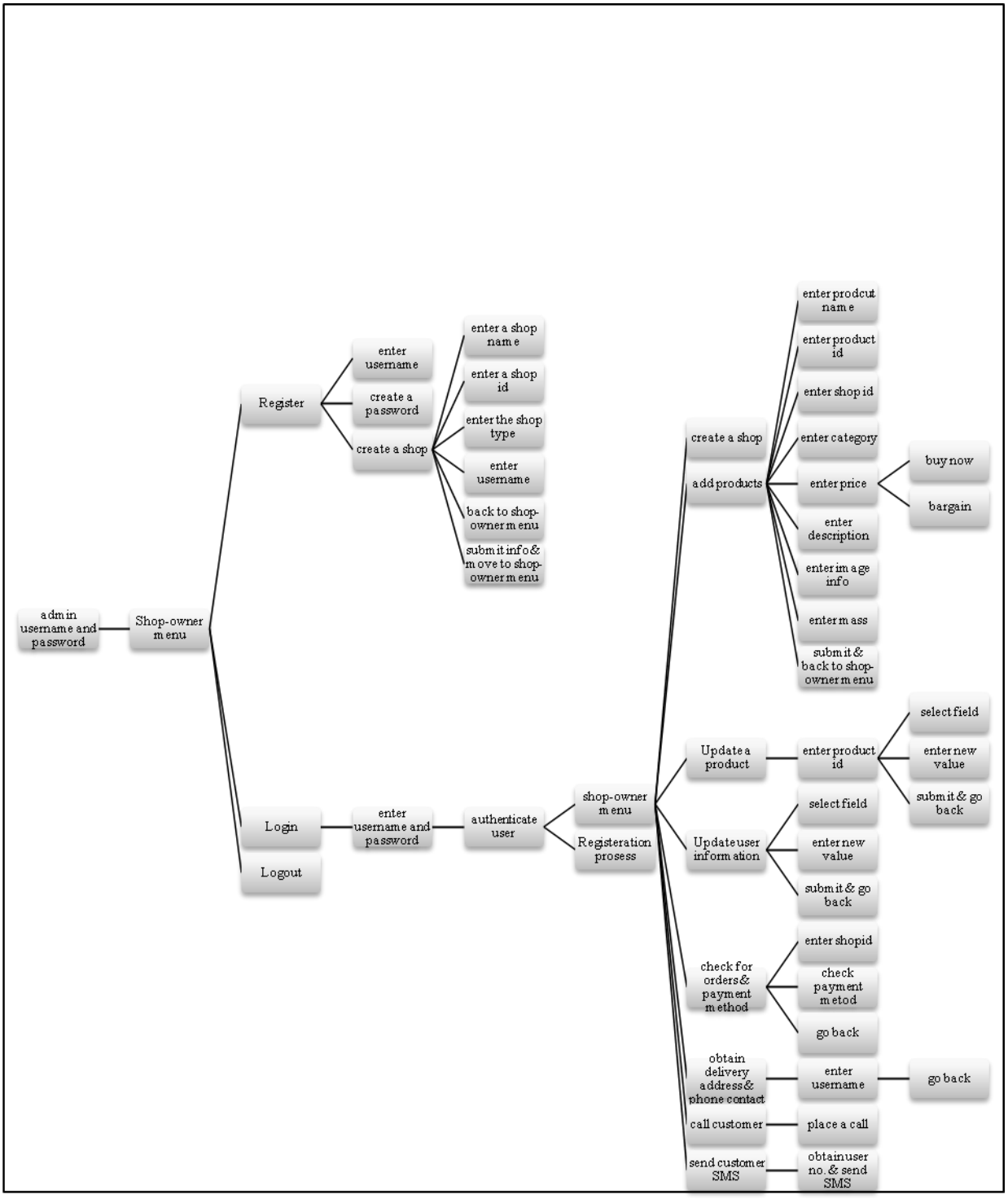

Figure 0.6 Shop-Owner Hierarchical Tasks Tree

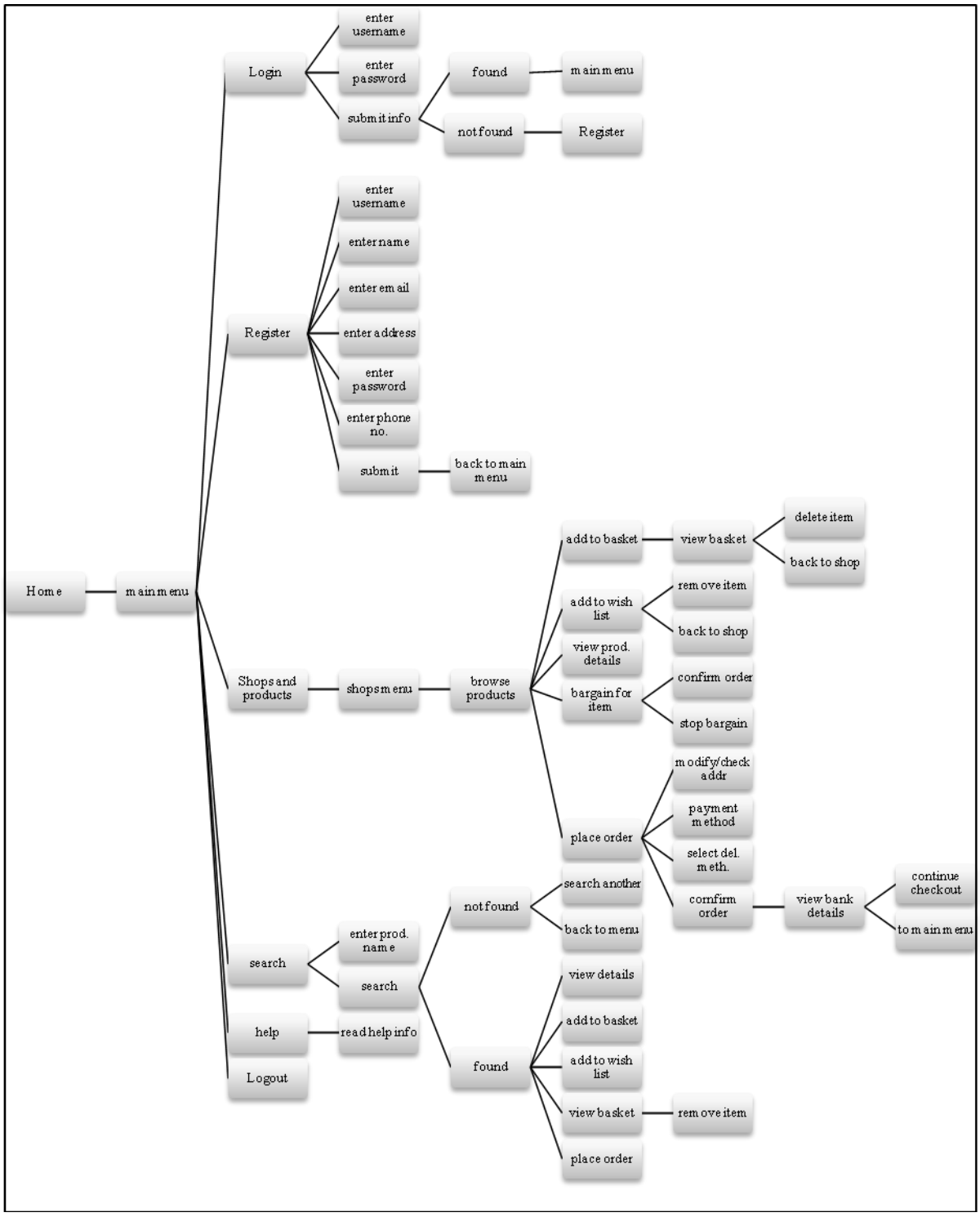

Figure 0.7 Customer Hierarchical Tasks Tree

5.4.2 Scenarios Evaluation Data and Analysis

The information gathered during tasks analysis were used to design scenarios for shop-owners' activities. We designed scenarios due to the simplicity of design and narrative

presentation style they offer during discussions (Huenerfauth, 2006). The scenarios designs are presented in Appendix B. We conducted formative evaluation (scenarios evaluation) with community members to further clarify our design intentions and for data collection. The evaluation was conducted with crafters in the community. The participants listened as we explained the concepts using the scenarios and sketched diagrams. Questions were raised and the participants made their contributions. When we asked the participants about the type of user interface they would like, it was difficult for them to give a specific response which may be due to the low level of technology awareness among the participants. They said they would want to see an illustration in the form of a working program so that they could have an idea. In all the illustrations and discussions we used paper sketches of mobile interfaces (see Appendix B) and our phones to explain the concepts. At this early stage it was common that participants are usually not able to provide much criticism (Isabirye and Flowerday, 2008). Generally, the participants were excited about our design intentions and we also collected data related to artefacts (21 different items from the crafters).

The data collected includes the artefacts' local names, prices, descriptions, camera images, category of product, the personal and contact data of the crafters. The camera images of artefacts are the products' visuals that the customers will see when browsing through the products and online shops. Table 5.4 presents a few of the artefacts data collected during the scenarios presentations and evaluation. The data have been used to design the application database. These items are artefacts produce and sold by crafters from the Dwesa community.

Table 0.4 Crafted Products from Dwesa

Names	Description	Image	Category
Isilude	A local basket used for carrying items		Home products
Intsibini	A beaded necklace with the SA colours		Art and craft
Isipeleti	Brown and black beaded material for decoration		Art and craft
Vulakabini	Blue beaded necklace worn by women		Art and craft
Intsaka	Gold beaded necklace		Art and Craft
Ilapu	Traditional bed sheet		Home product

5.4.3 Prototype Design

5.4.4 GUI Design

The first iteration of the prototype (program) was designed and used as a means of effectively communicating with the target users (participants) in the community to further elicit user and artefact data for the interface and application design. In our previous interactions during scenarios presentation and evaluation participants in the community wanted to see the actual program and they felt that they will be able to get a better picture of the explanation through a

tangible prototype and will be able to understand and make more contributions. With the prototype, we conducted focus groups to elicit data on users' preferences, artefacts and participants' mental model of phone menu. The participants consisted of crafters, school learners and educators. The prototype presents the generic structure described in the prototyping phase presented in chapter four. The GUI outputs/screenshots are presented in appendix E.

The first prototype design (GUI) presented at this point was not localised and the purpose of evaluation was formative. We performed a demonstration of the prototype by performing some tasks and provided explanations during the process. The participants were asked to examine the shop-owner user interface elements with a view to indicating what needed to be changed and to reflect their preferences. Based on the simple test, participants were asked to point out where they feel a change should be made and what they do not like. One of the participants made suggestions that if graphical icons with meanings that are similar to their every day experience within their local environment are used, it could create a better understanding. They mentioned that a static image or icon to represent actions that are familiar will make it easier for them to understand and interact with the interface. The participants were satisfied with the shop-owner interface menu layout (Hierarchical and list), and other interaction elements (button sizes and positioning, labels, input/output formats and others). They reaffirm the need to use text on labels, buttons and other information with isiXhosa local language. The study found that the general opinion was that localization will enable them to use the interface effectively.

5.4.5 VUI Design

The prototype of the VUI is similar in tasks/functions to the GUI. We designed a voice interaction interface so that every user in the community is able to use the application irrespective of their literacy level. The VUI is also connected to the mobile commerce application. With voice and DTMF interactions, the users will be able to have access to the application data/information through the same program functions used with the GUI. The only difference in the two types of interfaces is the use of visuals for interactions on the GUI, while the VUI uses voice and DTMF input dialogs for interactions.

We designed two varieties for the shop-owner voice user interface. The two interface types are voice only input and DTMF only input. This was done to test users' preference and due to poor recognition problems that may arise during interactions.

Figure 5.8 presents the free license Voxeo SIP Phone tool used for testing the voice user interfaces. Two separate experiments were conducted to evaluate the shop-owner voice user interfaces. We observed and took note of each participant's performance, task completion time for each of the tasks and the errors encountered during interactions. A post-test questionnaire was also used to collection user data after the evaluation sessions.

Figure 0.8 The Voxeo SIP Phone Used for Testing the VUI (Voxeo, 2009)

5.4.6 Cultural Adaptation of User Interfaces

Community users wanted the interface to be adapted to their local culture so that they can understand the interactions. The findings already presented in the first part of this chapter and prototype application and interfaces served as input for the adaptation process.

5.4.7 Cultural Adaptation of the Shop-owner User Interface (GUI)

The cultural adaptation of the shop-owner user interface is for the purpose of meeting the user interface preference and interaction experience of potential online shop owners in the Dwesa community. The study leading to adaptation of the shop-owner interface was conducted as an important step taken to improve usability and meet the expectations of the community users. Cultural adaptation of the shop-owner user interface will motivate the community users to accept the application and user interface. It will also enable local users to view the user interface as that is meant for them (create a sense of belonging). Findings made from survey studies and a number of interviews on cultural preferences were used for modifying the shop-owner GUI to reflect the cultural expectations of the community users.

We also conducted audit of the physical environment to elicit artefact data for the adaptation of the shop-owner GUI.

Cultural Environment Data

We conducted a study of the environment to collect artefact data for further adaptation of the shop-owner user interface to the local culture of the target users. The items in Table 4.5 represent a few of the artefacts collected from the community cultural environment. The items were analysed and validated with cultural experts and community members. On the shop-owner user interface, these artefacts are used as static hand-drawn diagrams to represent navigation signs, icons and metaphors on interface. The process was meant to adapt the shop-owner interface into the culture experience of community users. This experience can be conveyed to interface designs in order to provide interface elements that are easy to understand and familiar to the target users. Low-literate users favour the use of static hand drawn graphics on interfaces which have proven to be very easy to understand and have enhanced users' successes during interactions (Medhi et al., 2006).

The experience and knowledge gained within their cultural environment is passed on to the interface and makes the interface artefacts easy to understand and to be used. For low-literate users of technology, the use of their local knowledge for the design of the interface could serve as a motivation for them to use the interface. Table 5.5 presents a few of the artefacts that were used to further iterate the shop-owner user interface to a localized interface. Several bits of artefact data were collected from the community at the beginning. The collected data was analysed with the help of computer science graduates who also share the same culture with the target users through the verification process. The artefact data that best represents the intended actions or message were then selected and used to modify the shop-owner user interface. These artefacts used to represent interaction elements in the shop-owner user interface has help to provide the community users with an interface that was easy for them to learn, understand and use. It also helped to enhanced user perception about the usefulness of the user interface and application. Without this level of localization, the user interface would have been very difficult for low-literacy users in the Dwesa community. This is pointed out by the users as a result of the positive perception they have of the usefulness of localization.

Table 0.5 Cultural Metaphors/Icons

Function	Metaphor	Name/Meaning	Source
Home	 a local hut	Represents a home page metaphor	
Forward or backward	 an arrow	An arrow represents navigation icon	
Login/logout	 A local gate	An entrance/exit gate to a compound.	
	 a door	A door as an entry or exit point	
Shopping basket	 An isilude local domestic basket.	Used for collecting household items and can be used to represent a shopping basket	
Delete	 delete metaphor	A waste disposal container	
	 a local broom	A local instrument (broom) used for sweeping away dirt. It can be used to represent the delete metaphor.	
A shop	 a table with items for sale	A table with items for sale used as a local shop in the community.	

The shop-owner user interface screen shots are presented in Figure 4.8 with interaction elements that are localized for easy learning and understanding by community users/shop-owners. Additional screen shots are presented in Appendix E. Figure 5.9 (a-b) shows crafted

products in an online shop displayed for sale, while 4.8 (c-e) shows interface metaphors/icons that depict artefacts and actions common within the cultural environment.

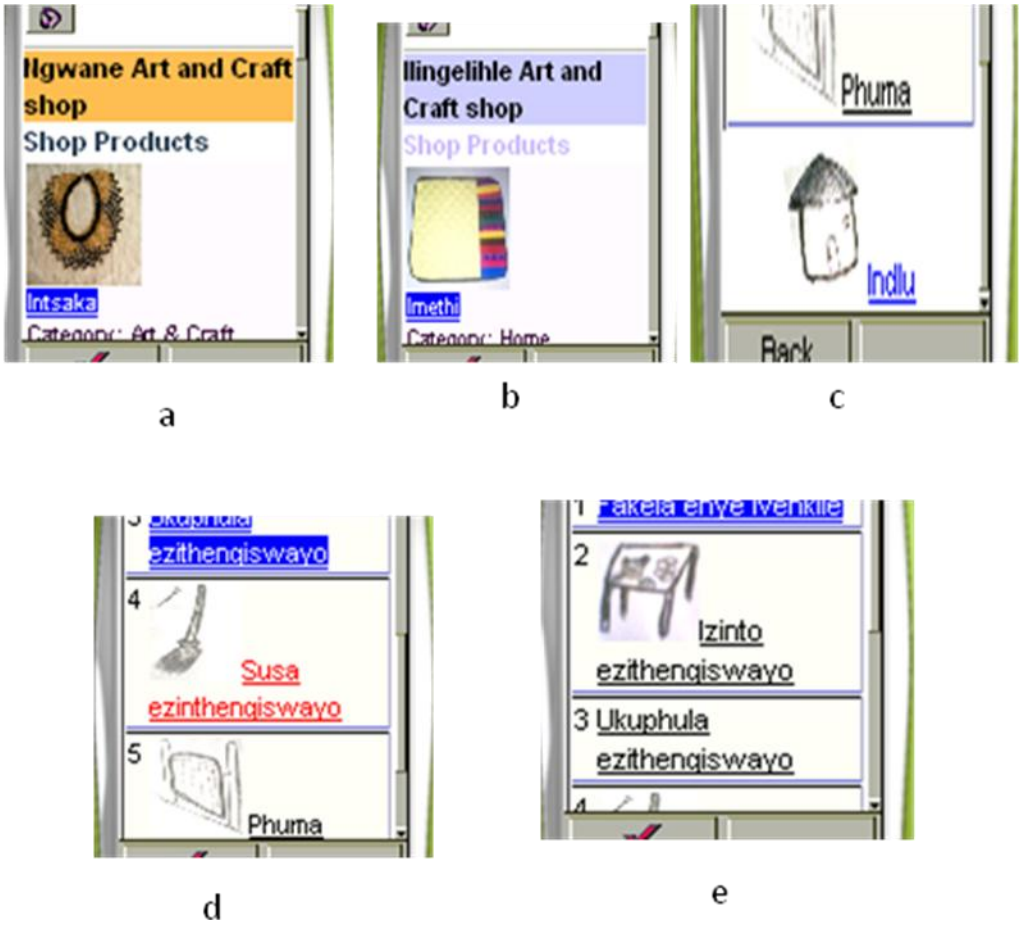

Figure 0.9 Shop-owner user interface screen shots (a – b) Display of products in online shops; (c) A menu item indicating navigation to the home page; (d-c) The shop-owner menu with cultural metaphors indicating the actions

5.4.8 VUI Cultural Adaptation

We conducted interviews with isiXhosa speaking natives to elicit data for transforming the voice shop-owner interface to the language of Dwesa community. We also recorded isiXhosa female professional prompts in the laboratory using a WAV (waveform audio file) sound recorder. The prompts represent mostly clicks in the language that were difficult to implement through text. The voice user interface present two flavours for shop-owner interactions. A DTMF-input only interface and a voice-input only user interface to test user preference. The two flavours of the voice interface are localized providing metaphors,

prompts and feedbacks in the local language. This made the community users to use the interfaces with ease and considered the shop-owner voice interfaces as useful.

5.5 Design Evaluation/User Interactions with Interfaces

The application and user interfaces designed in attempt to address the study questions were put to different tests procedures to find out users' perceptions and experiences after interacting with the user interfaces. This section is divided into two to present the respective findings from GUI and VUIs evaluations respectively.

5.5.1 Users Interactions with GUI

Evaluation of ICT services meant for low-literate users is commonly performed with the target users. This method has produced good results where it has been used (Patel et al., 2009; Sherwani et al., 2007; Medhi et al., 2006). Thes method unfolded design issues that are needed to be addressed before the system is finally put into use. We conducted different evaluation tests and allowed participants from the Dwesa community to interact with interface. A pilot test was first performed with the shop-owner user interface and then two separate evaluation processes were followed in the Dwesa community at different periods. The first of these evaluations was conducted to test users' performance time and error rate as they use the shop-owner interface and the second test was conducted to ascertain the users' perception of the shop-owner user interface and the application. We also conducted an evaluation of the customer user interface with undergraduate students.

5.5.2 Pilot Testing

The pilot test was conducted to enable participants from the community to assess the interaction elements, the layout and presentation of the interface elements on the shop-owner user interface. The evaluation session was for formative purposes. The aim was to find out if it was easy for participants to understand the interaction elements and what action these items (icons/metaphor) represented on the shop-owner interface. The participants were crafters and other community members. They examined the interface elements, the look and feel in terms of colour preferences, the menu, navigation elements, text on buttons and input/output elements and positioning, in addition to the appropriateness of the culture-components used on the interface. Few participants actually understood what was required of them during the exercise. This was their first experience in an evaluation process.

The responses from the participants indicate that it was not too difficult to understand what actions the icons/metaphors represented on the interface and they also said with little explanation it will become easier for them to use the interface. Useful suggestions were also made with regard to colour preferences, even though the suggestions were not uniform. Participants were satisfied with the menu format adopted and could understand the information on labels to input and command buttons which were presented with Isixhosa text. They also identified the ones (text information) that needed modification to give a better understanding to the users. This was as a result of language dialects which we were made to understand that different words could be used for mean the same thing, but the more appropriate one to use is the word that is commonly used within the locality. Another little difference may be as a result of the way words are pronounced in two regions with the same culture (e.g. Transkei where Dwesa community is; and Ciskei where the University of Fort Hare is based in the Eastern Cape Province). Other issues raised by participants were noted and used to update the shop-owner user interface. In the following sections, we present the outcome of the two separate tests conducted with users from the community.

5.5.3 Experiment 1 – Task Performance Time and Errors

The evaluation was conducted with participants from the community. The participants were in groups that represent at least three user groups identified in our previous study. At each session, we introduced the shop-owner interface and carried out demonstrations by performing selected tasks on the application. The aim of this study was to test the ease with which the participants are able to learn and understand the shop-owner interface when they use it and how easy they will find the interactions.

The participants' demography includes 14 school learners with an average age of 17 years who were in the 11^{th} and 12^{th} grades in school. All the school learners owned mobile phones, the majority of which were low brands of phones. Also, among the participants were groups of 10 clerical staff of schools and 9 crafters. The average ages for the clerical staff and crafters were 29 and 51 years respectively.

The two selected tasks include creating an online shop and adding a product to the created online shop. Table 4.6 show the results recorded by the participants for the two selected tasks.

The participants who were able to complete the tasks were asked to perform the tasks three times, consecutively. For each additional trial, participants showed improvement in the time taken and improved precision in completing each of the tasks. Participants were able to learn and understand the shop-owner interface with subsequent trials. We also observed that after the first trial, participants gained confidence and in one of the sessions, the participants were in competition amongst themselves even though they were informed and made to understand that the exercise was not meant to assess them as individuals, but the user interface. In general, there was improvement in time and accuracy among all the participants in each subsequent trial for each of the tasks (second and third trials).

For the first task, a mean time of 83.01 seconds was recorded with a standard deviation (SD) of 19.11 for the first trial. In subsequent trials of this same task (2^{nd} and 3^{rd} trials), participants recorded decreasing mean times and closer time interval for task completion as indicated by the decrease in time variations. The result shows a general improvement among the participants in task completion time. The second task also recorded similar results. In the first trial of the second task, the mean time recorded was 91.18 seconds and SD = 16.01. The 2^{nd} and 3^{rd} trials of the task also indicated an improvement in the general performance with decreasing time of completion and a decrease in time variations. The 2^{nd} and 3^{rd} trials show that participants improved as they used the interface and had come closer to uniformity in performance time and accuracy. The high values in length of time were as a result of data entry in some aspects of the tasks. Participants were generally slow in this regard. The results are indications that participants were able to learn and understand the interface as they continued to use it for interactions. These participants were first time users and also lack basic experience in the technology. The shop-owner user interface presented familiar and easy to understand artefacts in the form of icons, metaphors and other interaction elements that are localized to the Dwesa cultural environment. This helped to enhance user understanding and interaction with the interface and made the participants to see the interface and application as useful.

Table 0.6 Participants' Tasks Performance Time

Task (n = 33)	**Trial**	**Mean** time (in seconds)	**SD**
Create an online shop	1st	83.01	16.11
	2nd	60.27	12.06
	3rd	50.64	8.50
Add a product to the online shop	1st	91.18	16.01
	2nd	78.63	14.11
	3rd	61.43	9.02

We also recorded each error made by each participant as they interacted with the shop-owner interface. Considering the low level of literacy and participants' experience with technology, the mean error rate of the participants was significantly low. Table 5.6 presents the mean error rate of the participants. In the first tasks, participants recorded a mean error = 2.20 (SD = 1.12) and in the second task a mean error = 2.32 (SD = 1.07). The results show that all the participants recorded minimal errors during task performance. The low variation also indicated a common level of understanding of the shop-owner interface by all the participants. There was consistency in the level of improvement and accuracy among the participants as they used the shop-owner user interface. The improvement was as a result of the easy to learn nature of the interface as a result of the adaptation of the interface to the local culture.

Table 0.7 Participants' Tasks Performance Errors

Task (n = 33)	Mean error rate	SD
Create your online shop	2.10	1.02
Add a product to your online shop	2.12	1.07

5.5.4 Tasks Success Rate

The task completion rate for the two tasks among the participants is shown in Figure 5.10. There was a high task completion rate among the different groups of participants. The results show that 75.86% of the participants were able to complete the two selected tasks during the test. The other participants did not complete all the tasks. They either completed one of the tasks or they performed a given task half way and stopped due to errors or after knowing that they have used a lot of time trying to complete the task. The high task success rate indicates

that a good number of the participants were able to understand and interact with the shop-owner user interface and with minimal or no problems encountered during the interactions.

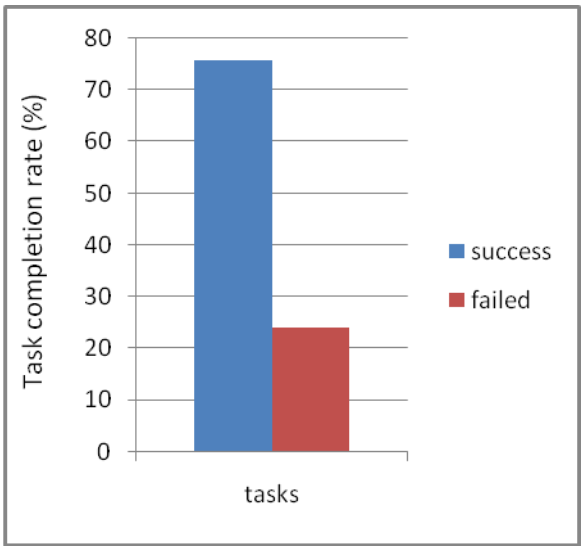

Figure 0.10 Tasks Completion Rate

5.5.5 Shop-Owner User Interface Learnability

We also conducted a test to assess the shop-owner user interface learnability among the users. Participants (n = 20) were randomly selected to perform the two tasks at different times and within two days. The tasks were the same as those they have perform previously. Figures 5.11 and 5.12 present the task completion time curves. The graphs indicate improvements in learning (learning curves). The two figures indicate a downward trend in the time spent with each subsequent trial as the participants performed the tasks. On the first task, participants recorded an average time of 56.19 seconds (SD = 10.37) for first trial, 51.29 second (SD = 7.32) for the second trial and 45.36 (SD = 7.10) seconds to complete the task for the third trial. The second task recorded an average time of 55.23 seconds (SD = 7.95) for the first trial, 54.10 seconds (SD = 6.98) for the second trial and 53.85 seconds (SD = 6.73) for the third trial.

Participants showed significant improvements as they used the interface and became familiar with it. They were able to learn the shop-owner interface as they performed tasks on it. Task performance was better for each participant and errors were significantly reduced in the third trial. The outcome indicates a higher precision in task performance due to an increase understanding and use. There was improvement in task completion times when compared to

the previous test results. It is an indication that it is easy for the participants to learn and use the shop-owner interface. This success recorded by the users was possible as a result of the simplicity in terms of the structure of the interface design (e.g. menu, information, etc.) and the interaction elements. The cultural adaptation based on the cultural theories applied during field study and interface design made the interface to conform to the cultural expectations and capabilities of the community users and hence provided an interface that was easy to learn.

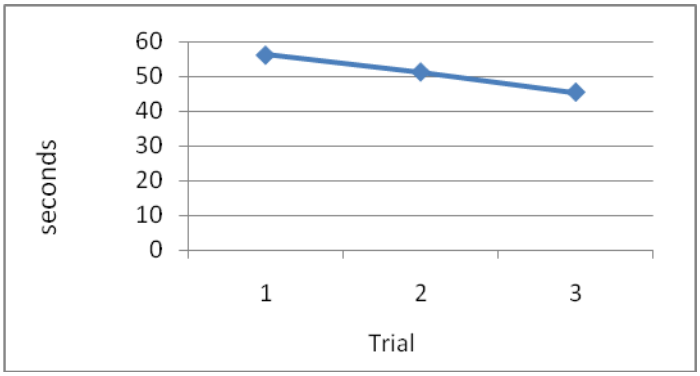

Figure 0.11 The Graph Showing the Learning Curve for the First Task

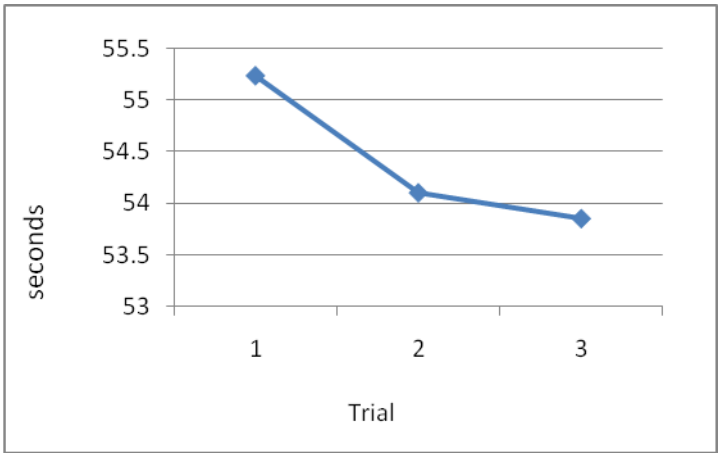

Figure 0.12 The Graph Showing the Learning Curve for the Second Task

Figure 5.13 shows the errors encountered by participants for tasks1 and tasks2 combined. The error rate was reduced significantly in the second and third trials. The number of participants who did not encounter any problems in the second and third trials for the two tasks increased respectively. Figure 5.12 shows the percentage of participants who successfully completed the two tasks with or without encountering an error. During the first trials of the two tasks, 40.77% of the participants peroformed and completed the two tasks without an error, while the second trials recorded an increase in the number of participants who did not encounter any error to 53.85%, and the third task trials recorded 71.92%. The results show an

improvement when compared with the previous tests conducted. There was a higher level of task performance success without errors. The results indicate a high task performance accuracy and interface learnability among the participants. Moreover, from the observations made, participants felt relaxed during interactions. The high success rate shows that the shop-owner user interface was easy to learn and use.

We discovered minor issues such as providing better local terms on menu items and few commands during the test sessions and subsequently made the necessary adjustments on the shop-owner user interface.

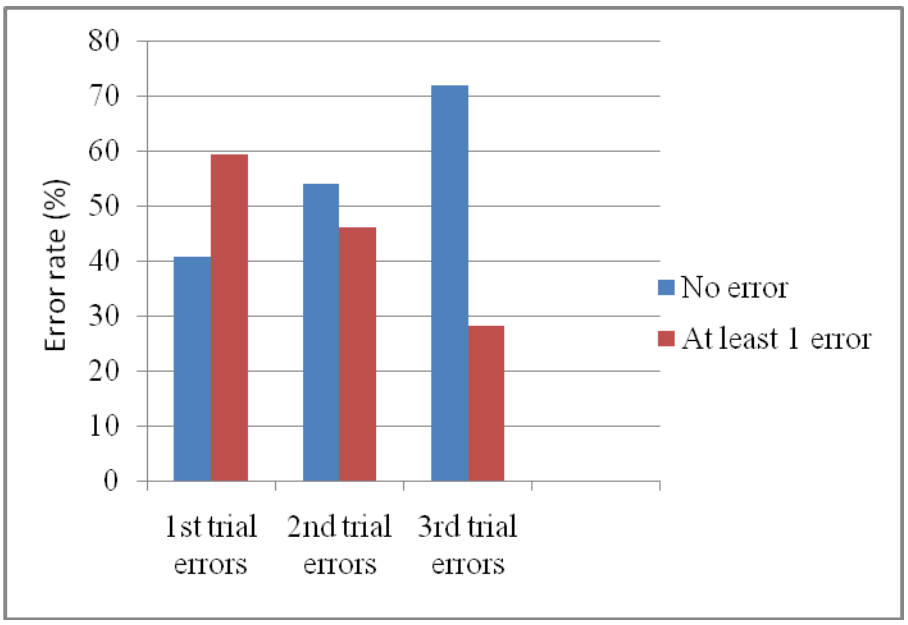

Figure 0.13 Error Rate in each Trials of the Two Tasks

The usability studies performed with participants in Dwesa community and the results presented above, shows that the user interface (GUI) meets the users' capabilities and experience. The tasks completion rate and interface learn ability as demonstrated during the test shows that users in Dwesa community will be able to use the user interface to access information. Also, the participants have demonstrated that the interface meets their preference and were able to use the application without much difficulty.

5.5.6 Experiment 2 - Users' Perceptions

The second test was conducted separately as a continuation of the evaluation process. Different groups of participants were engaged in the test. The aim was to establish

participants' perceptions of the shop-owner user interface and application and tasks success rate among the participants. The test was conducted with groups of participants who represent the user groups identified in the community. The demography of the participants includes 15 school learners in the grade 11 and 12 school classes with an average age of 16 years. 7 clerical staff of schools (average age = 30), and 6 crafters (average age = 51) also participated in the evaluation. The clerical staff consist of people with grade 12 educational qualifications (n = 3) and those with additional qualifications above grade 12 (n = 4). 9 educators also performed the test through single user evaluation process.

Figure 4.14 presents the task success rate for the two tasks based on the different groups of participants. The results show a significant task completion success rate among the different groups for the two tasks they performed using the shop-owner user interface. There was a high tasks completion rate among the participants across the different user groups. The percentage of successful tasks completion among school learners in the 11^{th} grade for tasks1 is 57.14% and 71.43% for tasks2. School learners in the 12^{th} grade also recorded completion rate of 62.5% for tasks1 and 87.50% for tasks2. The crafters had a completion rate of 50% for task1 and 66.67% for tasks2. Clerical staff had better task success rates among all the participants. They recorded 75% completion for tasks1 and 87.50% for tasks2. Participants were able to interact with the interface to carry out the two selected tasks. It was easy for the participants to use the shop-owner user interface. The results show that a properly customized interface which meets the capabilities of the users will improve task performance and the ease with which the users can use the application.

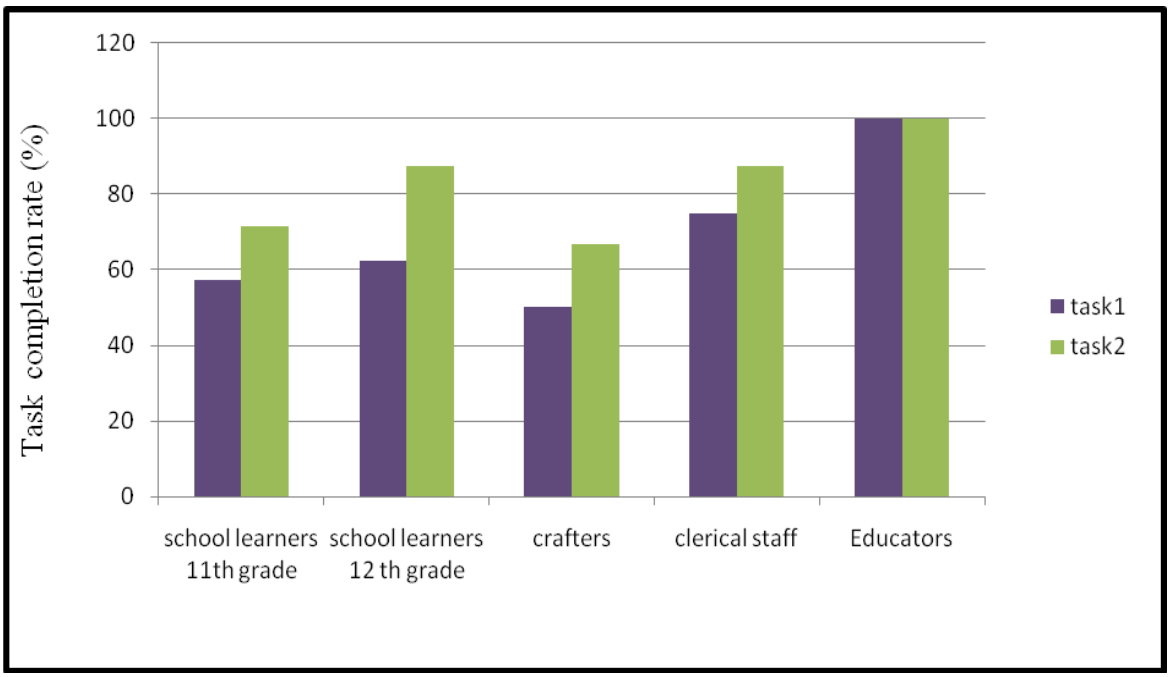

Figure 0.14 Tasks Success Rate among the Different Groups of Participants

Table 5.8 presents the descriptive statistical analysis of the data collected from 23 selected participants who completed the questionnaire after the test (see Appendix D for the complete post-test questionnaire). The details of the ratings given by each participant for each of the question are also presented in Appendix D.

The data collected from the participants indicate that they have a positive perception about the shop-owner user interface and the application. The technology acceptance model (TAM) constructs were positively rated by the participants. They have a positive perception of usefulness of localization (mean score = 3.89, SD = 0.69). They view localization as a contribution to the tasks performance success recorded. The participants feel that the shop-owner user interface meets their preferences and cultural experience due to localization. The small degree of variation shows that participants perceived localization of interface as a useful means for making the interface easy to learn and understand. Perceived usefulness of the interface and application was also positively rated. The mean score and variation (Mean = 4.34, SD = 0.61) for perceived usefulness of the interface shows that the participants perceived the application as very useful to the community. There was a uniform opinion among the participants on the usefulness of the application as indicated by the low variation score. The local users feel that the application is useful to the community. Similarly, the participants perceived the interface as being easy to use. All the participants were consistent

in the rating of the interface as being very easy to use. The intention to use construct was also rated positively by the participants, which is a strong indication that they generally have the intention to use the system. The variation (SD = 0.46) indicates that the participants did not differ much among themselves in terms of their intention to use the system.

Usefulness of localization, perceived usefulness of interface, and perceived ease of use are positively correlated with perceived intention to use the system. It is an indication of how much the three constructs have influenced the participants' positive intention to use the system. The results (as indicated by the p-values in Table 4.8) show that localization, usefulness of application and the ease of use experienced by the participants, during interactions, influence their intention to use the system. Overall, the shop-owner user interface was considered as conforming to the cultural expectations, capabilities and experiences of the community users. The positive perceptions which the participants rated the shop-owner interface was made possible by the extensive adaptation of the user interface to the culture of the Dwesa people through the use of the cultural theories, and familiar interaction elements on the interface to reflect the cultural environment of the people.

Table 0.8 Participants' Perceptions of the System

Mean Scores of Participants' Perception of the System (Likert-Scale questions: 5 = strongly agree; 1 = strongly disagree) (n = 23)				
Participant #	**Usefulness of localization**	**Perceived usefulness**	**Perceived ease of use**	**Perceived Intention to use**
1	5.00	4.33	3.71	4.00
2	5.00	5.00	3.17	4.67
3	3.33	5.00	3.00	4.67
4	4.67	5.00	3.14	5.00
5	4.33	4.67	4.57	5.00
6	3.00	3.33	3.43	4.33
7	4.67	4.33	3.00	4.67
8	3.00	5.00	4.00	4.00
9	3.00	5.00	4.57	4.33
10	3.00	5.00	4.71	4.33
11	3.67	5.00	4.71	4.33
12	4.33	4.00	3.87	4.67
13	4.56	4.00	3.71	4.67
14	4.00	4.00	3.43	4.67
15	3.00	4.67	3.71	4.00
16	4.00	4.67	4.14	4.33
17	5.00	4.00	3.71	4.33
18	4.00	3.33	4.29	4.67
19	3.50	3.50	3.29	3.00
20	3.67	4.00	3.14	3.67
21	3.50	3.33	4.00	4.67
22	3.33	3.67	3.83	3.67
23	4.00	5.00	3.71	4.33
Mean	**3.89**	**4.34**	**3.78**	**4.35**
SD	**0.69**	**0.61**	**0.53**	**0.46**
Correlation with intention to use	**0.40 (p-value = 0.062)**	**0.24 (p-value = 0.271)**	**0.10 (p-value = 0.672)**	

All the participants feel that the mobile interface and application is important and useful to the community and are determined to use the system when fully implemented. Based on oral interviews with the participants, they were excited and also made positive comments about the system (e.g. "It will promote our community", "it is good for business in our community" "I will like to use it", "It is very good for our community and business"). All the participants were novices to mobile commerce applications. 90% said they were not aware of m-commerce technology. Their participation was very effective and they also recorded very few

errors during the test. They said it was easy to understand and interact with the shop-owner interface due to localization. It was easy for them to know the meaning of the metaphors/icons and the actions they represented on the interface since they were familiar within their local environment. Again, cultural adaption has contributed to the positive results presented here.

The evaluation study conducted on the shop-owner GUI revealed that the shop-owner interface meets the capabilities and cultural preferences of these groups of users. With the shop-owner user interface, local shop-owners or potential users from the community will gain access to information from online shops from the Web server. The attitude of the participants concerning their perceived intention to use the system, points to the fact that localization makes a user interface acceptable to the intended users. Localization of interfaces enabled the participants to experience a natural sense of interactions and ease of use as they use the interface (Shen et al., 2006, Edim and Muyingi, 2010a). Low-literate participants were able to interact with the application through keypad inputs and screen display. It indicates that graphical user interfaces that are properly designed to conform to the cultural experiences and expectations of the users will enable low-literate users to have access to ICT services. This shop-owner user interface has been localized according to the cultural knowledge and experience of the users and has helped to create a positive perception in the minds of the low-literacy users in Dwesa community.

We have designed the shop-owner interface by eliciting the cultural knowledge and preferences of the local community users. The user study shows that the culture of the target users can contribute the design of an interface that meets their capabilities and preferences. The cultural environment where the people interact on daily basis can provide the data or information which when sourced adequately will enhance the interface design. The data represent what the users are familiar with and form their basic experience. The interaction elements on the user interface depict what is familiar within the cultural environment of the community and has helped the participants to understand and interact with the application with minimum difficulties. The positive perception towards the use of the user interface (shop-owner GUI) as indicated by participants' rating of the shop-owner user interface points to the fact that community users were satisfied with the interface. This study found that the user interface and the interaction elements on the interface conform to the cultural

experiences and preferences of the participants based on the positive perceptions. These are motivating factors to the users' intention to use the system.

5.5.7 Customer User Interface Evaluation (GUI)

The customer user interface for the mobile commerce application was evaluated with undergraduate non computer science students. The demography of participants includes 7 females and 8 males with an average age of 24 years. At each session, the participants were asked to perform the tasks of placing an order for a product from one of the online shops. The activities for the task include login, visiting a shop, selecting an item into a shopping basket, placing and confirming the order. A post test questionnaire was used to collect evaluation data from the participants.

Task completion times and errors (entering wrong data, selecting the wrong option, not confirming the order placed and others) were recorded for each of the participants. Table 5.9 presents the results. The results show that participants recorded a mean time = 63.40 seconds and SD = 8.80 for task completion time. The results indicate that there was not much difference in the completion time among the participants. They were able to understand the interactions and they used the system with ease. They also encountered minimal errors during the interactions (Mean errors = 1.20, SD = 0.98). The low amount of errors committed by first time users indicates that the customer user interface was very easy to understand and use. The task success rate was high and the participants performed the tasks with ease and with a high level of precision.

Table 0.9 Customer GUI Evaluation Results

Task : Place an order (n = 15)	**Mean**	**SD**
Task completion time	63.40 seconds	8.80
Error rate	1.20	0.98

Table 5.10 presents the result of post test data collected from each of the participants after completing the task. The results indicate that participants were satisfied with the look and feel of the customer interface (Q1 mean score = 3.67, SD = 1.25). All the questions were positively rated with a mean score between 3.67 and 4.27. The results indicate a general satisfaction among the participants in terms of simplicity of interactions and the ease of use which they experienced with the interface.

The participants were positive (mean score = 4.27, SD = o.57) that the interface is simple and does not require any training prior to use (Q4). The participants felt strongly that the customer interface does not frustrate the user during interactions (Q5 mean score = 4.33, SD = 0.87). Also, the participants are strongly positive that there is adequate information provided on the interface (Q8 mean score = 4.27, SD = 0.85) and this made it very easy to understand the customer interface (Q9 mean score = 4.00, SD = 0.82). The variations in all the questions were very low, indicating similarity of opinion among the participants about the characteristics of the interface. The test results show that the customer user interface is very easy to learn, easy to understand and use without any formal training.

Table 0.10 Customer Interface Evaluation Data and Analysis

Customer interface evaluation data and analysis (Likert-scale questions : 5 strongly agree- 1 strongly disagree) (n = 15)																	
participant #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	**Mean**	**SD**
Q1.The look and feel of the interface is good	4	2	4	5	3	3	4	5	1	2	3	5	5	4	5	**3.67**	**1.25**
Q2.The interface is easy to use	5	4	5	4	2	4	4	5	3	2	5	5	2	3	4	**3.80**	**1.11**
Q3.The interface is very easy to understand	3	4	4	4	4	4	5	5	4	5	3	3	4	5	5	**4.13**	**0.72**
Q4.The interface does not require special skills or training to use	4	5	4	5	4	4	4	5	3	4	5	4	5	4	4	**4.27**	**0.57**
Q5.It is not frustrating when using the interface	5	5	5	5	5	5	4	4	3	4	2	4	5	5	4	**4.33**	**0.87**
Q6.I like the interface	5	3	5	5	5	3	3	3	4	5	4	5	4	4	5	**4.20**	**0.83**
Q7.I will prefer to use the interface	4	4	5	5	2	4	4	5	4	4	5	5	3	4	3	**4.07**	**0.85**
Q8.There is adequate information on the interface	5	4	4	4	3	4	5	5	5	5	4	2	4	5	5	**4.27**	**0.85**
Q9.The interface is not difficult to understand	4	5	4	4	2	3	3	4	4	4	5	5	4	5	4	**4.00**	**0.82**

5.5.8 Users Interactions with Voice User Interfaces

The evaluation was conducted to determine the type of interaction technique that the users in the community will prefer, and their task performance and completion rate. The test was conducted with the localized shop-owner voice user interfaces (voice and DTMF) with participants in the community. Two experiments were conducted – tasks performance and error rate test and tasks completion rate. Two different tasks were selected for the test and participants were asked to perform the tasks separately on the two interfaces.

5.5.9 Experiment 1 – Tasks Performance Time and Errors

The first test was conducted with school learners (n = 17 made up of 9 females and 7 males), crafters (n = 12), clerical staff (n = 9 consisting of 3 males and 6 females), and educators (n = 12). The school learners were in grade 11 and 12 classes with an average age of 17 years. The crafters consist of semi-literates and illiterates. The educators are functional literate members of the community.

More than 50% of the participants were able to complete the tasks when they interacted with the system using the two interface types (DTMF and voice input). The first task involves checking for any order placed by a customer in any of the online shops (task 1). The subtasks include login, selecting the check order menu item, specifying the shop name and shop identity number and responding to the voice output prompts. The second task involves updating the prices of a product in an online shop (task 2). The subtasks include selecting the update menu item, selecting the price field and inputting the new price. The first task was more difficult because it required that participants input more data values by DTMF or voice.

Figure 5.15 presents the percentage of task completion for the two tasks using DTMF and voice input interfaces. The overall task completion rate was better for DTMF input than voice input for both tasks (first task – 69% vs. 55.17% and second task – 79.31% vs. 65.51%). We also observed that it was easier and faster for participants to use the numeric keys as inputs than to slowly pronounce numbers one after the other as inputs. The task completion rate for both interface varieties show that with voice interface, low-literate users will be able to adapt and use new technology services adequately, irrespective of whether they are novices to the technology or not. Cultural adaptation of the voice user interface varieties based on the

cultural theories and field study outcome applied in the design provided interfaces that the community users could interact with ease.

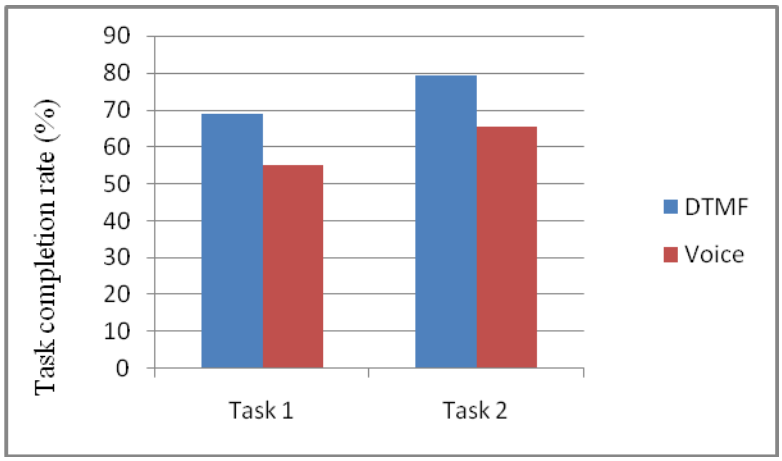

Figure 0.15 The Task Completion Rate for DTMF (blue) and Voice (red) Input

Table 5.11 shows the average time to complete the first task (check for an order placed by a customer in an online shop). Participants using DTMF input interface recorded an average time of 38.07 seconds and a standard deviation of 7.38. With the voice input interface, participants recorded an average time of 49.75 seconds and a standard deviation of 11.44. The results show a faster completion time and smaller variations with DTMF vs. voice input among all the participants. It also indicates a better precision in task performance output for DTMF. The results also indicate that the DTMF input will provide the users faster access to information, better performance and it is easier for the participants to use. Voice inputs also proved to be successfully used from the results. It will be able to provide an effective means for accessing information by the community.

Table 0.11 Performance Result for First Task (time)

Performance result for first task (time) (n = 50)		
Method of interaction	Average time to complete task (seconds)	Standard deviation
DTMF	38.07	7.38
Voice	49.75	11.44

We carried out t-Test statistical analysis (paired t-Test) on the completion times recorded by all the participants during tasks performance (first task). The t-Test results (T-Value = -3.83, P-Value = 0.001, two-tail) show that the difference between the DTMF interactions and the voice interaction was found to be statistically significant ($p <= 0.001$). This implies that the

participants showed a better task completion time on the average with the DTMF input interface.

Table 5.12 presents the average error rate results for the first task. Using the DTMF interactions the participants recorded an average error rate of 1.25 (standard deviation of 0.43), and with voice interactions, the participants' error rate was 2.44 (standard deviation of 0.87). Less errors were committed with the DTMF input. A higher precision was recorded for DTMF interactions.

Table 0.12 Performance Error Rate for First Task

Performance error rate for first task (n = 50)		
Method of interaction	Average error rate	Standard deviation
DTMF	1.25	0.43
Voice	2.44	0.87

Participants encountered more errors when they used voice interactions, but the overall number of errors was low. The t-Test statistical analyses performed on the errors encountered by each participant for the two input interfaces (T-Value = -4.84 P-Value = 0.000) shows that there is a significant statistical difference between the errors encountered using DTMF and voice interactions. This is an indication that with DTMF input, community users will experience better task performance accuracy and ease of use. The errors committed were small for both varieties of interfaces and this shows that community users recorded significant task performance accuracy. It is also an indication that the interfaces meet their capabilities and will be able to use any of the variety successfully.

Table 5.13 presents the average time to complete the second task (update the price of a product in an online shop). Participants recorded an average completion time of 26.25 seconds (standard deviation of 7.41) for the DTMF interactions. For the voice interactions, participants recorded an average time of 32.93 seconds (standard deviation of 7.56). The results show a close outcome in the performance time for both interface varieties. The variation also indicates that the participants completed the task with only a small time difference between them. There was significant improvement in task performance in the second task. The participants became more familiar with the interface voice output prompts and were able to respond faster. They were able to perform the given tasks with ease and a good level of success with the two interface varieties.

Table 0.13 Performance Result for Second Task (time)

Performance result for second task (time) (n = 50)		
Method of interaction	Average time to comple the task (seconds)	Standard deviation
DTMF	26.25	7.41
Voice	32.93	7.56

T-Test statistical analyses (paired t-Test) were performed on the task performance time outcome recorded by all the participants for the interfaces. The results of the analyses (T-Value = -3.40, P-Value = 0.002) show that there is a significant statistical difference between the two interaction methods (DTMF vs. voice). Again test participants found DTMF input easier on the two input interfaces.

Table 5.14 displays the average error rate for the second task. Participants recorded an average error rate of 0.41 (standard deviation of 0.60) when they used DTMF interactions. For the voice interactions, participants recorded an average of 1.82 errors (standard deviation of 1.10). The results also show a general understanding of the interfaces and better performances among the participants. Although the second task was easier than the first task, the outcome shows that few errors were encountered for both interface types.

Table 0.14 Performance Error Rate for Second Task

Performance error rate for second task (n = 50)		
Method of interaction	Average error rate	Standard deviation
DTMF	0.41	0.60
Voice	1.82	1.10

A t-Test statistical analysis was carried out on the number of errors encountered by all the participants as they performed the second tasks with both interfaces. The results of the analyses (T-Value = -6.20, P-Value = 0.000) show that there is a significant statistical difference between the error encountered while using DTMF and the error encountered using voice interactions. The level of accuracy was higher when the participants performed the task using the DTMF input interface. This could be as a result of familiarity or previous experience with key tone inputs or poor recognition problems encountered. On the average, the localized interfaces meet the experiences and capabilities of the target users. This was achieved as a result of providing interface elements (menu, metaphors, feedbacks, etc.) that reflect the culture and what is familiar to the people of Dwesa.

Post Evaluation Interviews - We conducted interviews with the participants at the end of each session to find their opinion about what they feel about the voice interfaces. Despite the difference in task completion time between the two interface flavours, the participants said they were satisfied with the interfaces. They were excited about the use of their local language on the interfaces. We asked the participants to identify with which of the interfaces they encountered problems when inputting data into the system? 58.28% of the respondents said voice, while 32.18% said DTMF. 70.23% feel that they were more comfortable using the DTMF interaction than the voice input. Those who preferred the DTMF input said they were conversant with keypad input which is similar to their previous experience with phone keypad inputs.

The respondents said it was faster and easier for them to simply press the keys than saying the numbers one by one. Although, from our observation, among the school learners, when they encountered problems (e.g. if the system said "I did not hear you" and they needed the required word loudly) they felt they were being laughed at by their colleagues. 29.77% felt that they were comfortable and had no problem using the voice input interface. This group consisted mostly of the educators who were functionally literate. Among those who prefer the use of voice, they said the only difficulty they encounter was that the system was repeating the input request even when they have uttered the word requested ("I said one and the system said I did not hear you so I shouted").

In the two voice interface varieties, we enabled barge-in during inputs so that the participants can reduce the time spent listening to the entire menu list before picking an option. That is, if they are already familiar with the menu or can pre-empt what is required. This was done to also reduce frustration and time wasting. We also observed that due to pronunciation problems, a few participants felt frustrated when they spoke into the system and it repeatedly responded "I did not hear you" and as such they could not complete their task or spent a longer time repeating what they had earlier said.

The study found that poor pronunciation was also responsible for the difficulty encountered (e.g. a participant saying "uwani" meaning one, "utuu" meaning two, or noise from the background). This situation made participants spend a longer time with voice input and was less successful compared to DTMF input. An instance where the user has to speak words one

after the other also slowed the speed of interactions. As humans, we pronounce numbers continuously with very little gaps between pronunciations which is very different when the users of the voice input function speak numbers into the interface. It is very unnatural way of communication. Participants had to learn to say numbers one by one which we observed was not comfortable to everyone. Privacy was another factor we observed that made participants not to alter words audible enough into the application. A greater percentage of the participants prefer the DTMF dialled input/interactions and the results showed that DTMF dialled input recorded better and faster task completion time than voice inputs. This was also noted in a study conducted by Patel et al. (2009). The performance of any of the interaction modes for a voice user interface depends on the design, user study and the tasks performed during the study (Sherwani et al., 2008). The study also discovered that, despite the difficulty encountered during interactions, the participants were excited in their responses concerning the voice application.

Table 5.15 presents the results of the post test questionnaire (see Appendix C for table containing the complete data and analysis table). The purpose of the questionnaire was to assess the attitudes of the participants with regard to the ease of use and understanding of the voice user interfaces, and participants' perceptions. The results show that participants were satisfied with the interfaces (question 1, mean score = 4.10, standard deviation = 0.84). The low value in the different scores (variation) shows that the participants were consistent in their feelings about the interfaces. They also indicated that it was not difficult to use the interfaces (positive scores for questions 4 and 5).

The participants were also strongly positive that the isiXhosa language used in the system was easy to understand and provided adequate information to aid navigation on the interfaces (question 11 mean = 4.38, SD = 0.76). The voice prompts produced by the voice interfaces were not difficult for the participants to understand (question 7). Participants who prefer the voice input interface (question 8) scored a mean = 2.97, SD = 1.27, while participants who preferred the DTMF input interface scored a mean of 3.38 and SD = 1.32 (question 9). The results indicate that participants positively perceived both the DTMF input interface and the voice only input interface as ease to use and simple for effective interactions. This shows that localized voice interfaces met local users' capabilities and preferences and made community participants to understand and use the interfaces with ease. Their satisfaction with the

interfaces as indicated in the rating also shows that the interfaces are useful within this community. Low-literate community members will be able to have access to information with voice interfaces without much difficulty.

Table 0.15 Shop-Owner VUI Evaluation Data and Analysis

Shop-owner VUI evaluation data and analysis (Likert-scale questions: 5 strongly agree – 1 strongly disagree) (n = 42)		
Question	**Mean score**	**Standard deviation**
1. I am satisfied with the interfaces	**4.10**	**0.84**
2. The interface with voice input is more easy to use	**3.31**	**1.12**
3. The interface with key input (DTMF) is more easy to use	**3.69**	**1.18**
4. The interface using voice input is difficult	**2.03**	**1.00**
5. The interface using key input (DTMF) is difficult to use	**1.97**	**0.93**
6. I did hear and understand whenever the system speaks	**3.93**	**0.87**
7. It was difficult to understand when the system speak	**1.86**	**0.78**
8. I prefer to used voice input when using the system	**2.87**	**1.27**
9. I prefer to use keypad (DTMF) input when using the system	**3.38**	**1.32**
10. The interfaces do not require special skills to use	**4.21**	**0.80**
11. The language (Isixhosa) spoken by the system is good and adequate	**4.38**	**0.76**

5.5.10 Experiment 2 – Tasks Completion Rate

We conducted a separate test on the two varieties of the shop-owner voice interface in the community. The two tasks were also selected for this experiment. The aim of the test is to look at the task success rate among the different user groups. The first task (task1) involved the participants updating the wieght of a product in a shop. The subtasks include entering the shop-owner/admin menu, select the update menu, specify the shop, enter the product identity, select the field to update and enter a new weight then, finally, they had to submit. The second task involves creating a new online shop. The subtasks include selecting the create new shop menu item, enter the type, the identity number and the name of the new shop.

The participants include school learners (n = 12), crafters (n = 8), clerical staff (n= 12) and educators (n = 10). The school learners were in grade 11 and 12 classes. The crafters include semi- and illiterate participants. The educators and few of the clerical staff of schools are functional literates within the community.

Figure 5.16 presents the level of task success among the different user groups in the community for DTMF and voice input shop-owner interfaces. For the same task (task1), school learners and clerical staff showed better performances when using the DTMF input interface. 75% of school learners completed the first task using DTMF and 58.33% completed the task using the voice input interface. Evaluation with illiterate users usually required a little training to enable this user group to use the system. This definitely had a positive contribution to their level of performance. 46.78% of crafters completed the tasks with DTMF input and 48.23% completed the tasks using voice input. The success rate recorded for voice input may be as a result of the training given to crafters before they performed the task. The educators and clerical staff performed very well in the two interfaces. The educators are functional literate users which is reflected by their level of performance. These groups of users did not have many problems as a result of being literate. The results show that all the groups performed well which shows that the localized voice interfaces were easy to understand and use. The voice interfaces (DTMF and voice input) meets their experiences and capabilities.

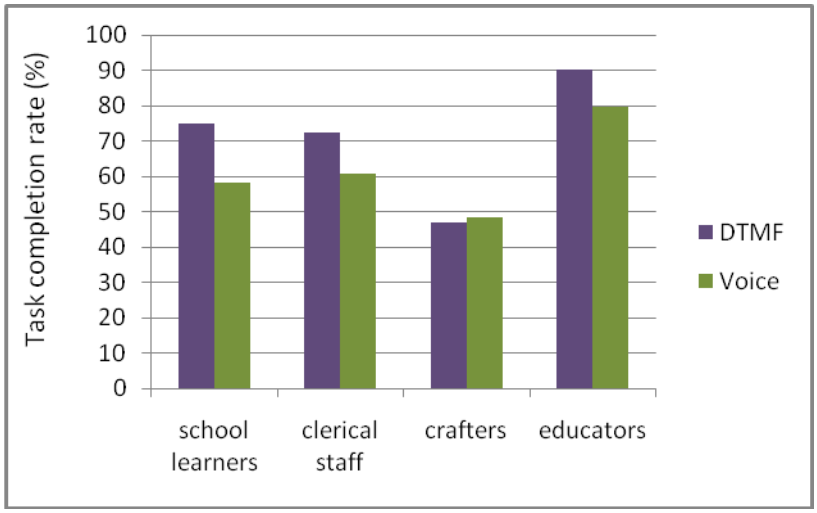

Figure 0.16 Task Completion Rate among Different User Groups (task1)

Figure 5.17 presents the task completion rate among different user groups for the second task (task2). The results show that the task completion rate was higher with the DTMF input

interface than the voice interface for the different user groups. The second task (Task2) was more demanding than task1 with regard to its number of subtasks. We started with an easier task so that the participants will become acquainted with the interfaces and gradually build their confidence.

The overall results show a high task completion rate for both DTMF and voice input interfaces for all user groups. In the second task, participants became more familiar with the operations of the system and responded better. 66.67% completion rate was achieved by school learners using DTMF input, while 53% completion rate was recorded when the same task was performed using the voice input interface. The crafters had a 58.33% success rate for DTMF input and 41.67% for voice input interface. The observations made during the test indicate that problems associated with pronunciation and inaudible inputs affected the performance of the participants on the voice input interface.

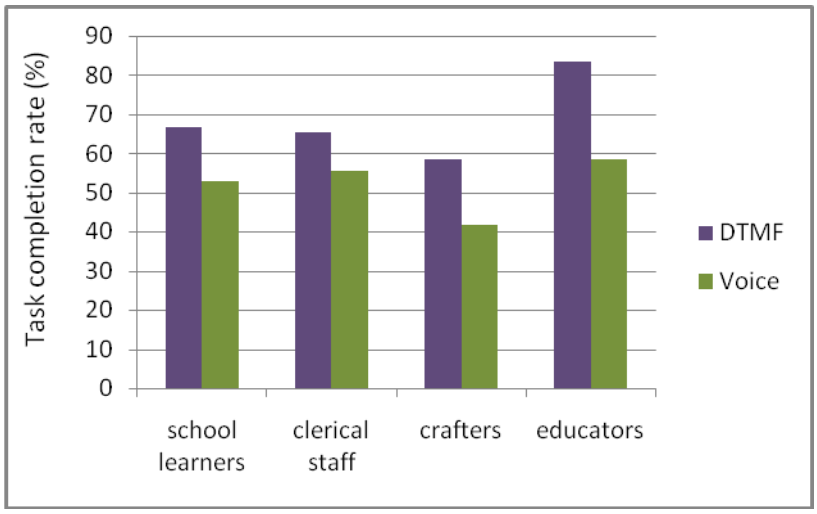

Figure 0.17 Task Completion Rate among the Different User Groups (task2)

This study also found that poor pronunciation of words delayed task completion. For instance, a word like “wani” or “one” can be pronounced by different users as “uwani” or “u one” causing poor recognition error by which the user becomes frustrated. Training was given to participants in order to enable them to use the interfaces better. The training of low-literate users to use an interface can help them to overcome their limitations and produce good results (Sherwani et al., 2009). The choice of an interaction mode for any voice user interface depends on the environment, the type of application and the user groups involved.

Low-literate users of the voice user interface showed high task performance success rates when they used DTMF tone input for interactions versus voice input in different studies (Patel et al., 2009). Speech input can also have high successes, even more than DTMF input; this also depends on the application area and the users. It also depends on how easy it is for users to adequately pronounce the required words for effective and fast recognition (Sherwani et al., 2009). In this study, participants showed higher task successes with the DTMF input interface. The use of a local language in the interfaces motivated the participants during interactions. Localization of the two varieties of voice user interfaces provided easy to understand interactions that enabled the participants to have a high task completion rate among the different user groups even among participants with literacy challenges. More than 50% of the participants completed their tasks successfully. Voice interaction techniques either through DTMF or voice input will make information accessible to semi- and illiterate users for any ICT service provided for them.

Voice user interfaces have the advantage that, if implemented in the local language of the target users, both the semi-literates and illiterates will make use of the service with minimal training.

The user study conducted at the early part of this research pointed out the cultural background and preferences of the Dwesa people and mapped out how this information relate to interface design targeting these users. For instance, these users will easily lose concentration if they interact with a long hierarchy menu or items with implicit meaning.

The voice user interface designed during this study presented interaction elements (e.g. short menu hierarchy, cultural metaphors, feedbacks, etc.) that meet the cultural preferences, experiences and interaction expectation of the community users which are part of the objective of this study. We were deeply concerned on using metaphors and language translations within the cultural context of the Dwesa language during the voice interface design. The culture of the users influence the meaning the users attach to a metaphor. A metaphor helps the user to use familiar experience to create a mental model the information or object for which the metaphor is trying to illustrate. We believe that the cultural metaphors (e.g. welcome to Ngwane art and craft shop, Ok in the local language) provided on the user interface have played a significant role in making the participants acquaint themselves with the voice interface.

The study also found that the participants were able to understand the feedbacks from the interface because they were presented in their local language. Voice feedback in the local language of the target users plays a significant part in enhancing the usability of the interface and the service provided by making it easier and faster to understand. Localization promotes the adoption of new technology.

Culturally, the DTMF input may be more favoured than the voice input modality since voice recognition can be hindered by environmental noise and accent. A few participants were afraid of making mistakes and being laughed at by their colleagues when they respond to the system prompts with voice input. In this regard, DTMF input may be more suitable for delivering voice services to low-literacy users in rural communities. Based on the results obtained during the user evaluation, the localized voice interface (DTMF and voice input) meet the users' capabilities and is suitable for this cultural environment. Cultural adaptation of the voice user interface varieties made the interfaces to conform the cultural expectations, and preferences of the community users. The voice interface will help low-literacy users in the Dwesa community to use the ICT service provided as a result of this study.

Voice interface for low-literacy community brings a lot of challenges such as being able to identify suitable metaphors and translate prompts into the natural language of the users. We suggest that voice interface designers should put plenty of effort in understanding the metaphors within the local language and how to apply them in order to overcome some of the challenges that the users may face during interaction with the interface.

5.5.11 The Customer VUI Evaluation

The customer voice user interface provides female voice output prompts for dialogs with the customer, as previously mentioned in section 3.4.12. The customer is provided with a mixture of voice and DTMF input. The interactions with the application using the voice interface are similar to the GUI interactions, but with little variations in the amount of data input. The GUI gives more room for data input than the VUI. An evaluation of the customer voice user interface was conducted with students. The participants include 12 none computer science undergraduate students, 5 computer science students (3 undergraduates and 2 postgraduates).

Table 5.16 presents the results of the evaluation. The results show that the participants found the customer VUI easy to use (question 1, mean = 3.82 and SD = 0.95). The interface menu

system was rated with a positive score. They considered the menu system as having enough information to enable users to interact with the application. From the score they feel that it is very easy to remember the items on the menu during interactions (question 2 mean = 3.65, SD = 1.11). They also found the process of navigating through the interface very easy to operate and perform tasks successfully (question 7 mean = 3.82, SD = 0.95).

Based on the data analysis, this study found that the participants also demonstrated that the customer voice user interface has provided enough information to the users for effective interaction with the application. They feel that users will not need special skills or training to use the customer voice user interface.

Table 0.16 Customer VUI Evaluation Data and Analysis

Customer VUI evaluation data and analysis (Likert-scale questions: 5 strongly agree – 1 strongly disagree) (n = 17)																			
Participant	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	**Mean**	**SD**
1. I am satisfied with the interface	4	5	4	3	4	4	5	3	2	4	4	3	4	5	2	4	5	**3.82**	**0.95**
2.The interface menu system is very detailed and easy to remember	5	4	4	5	2	2	3	5	4	2	3	5	3	3	5	4	3	**3.65**	**1.11**
3. The interface is easy to use	4	4	5	5	5	4	3	3	3	4	5	5	2	5	5	4	4	**4.12**	**0.93**
4. I did hear and understand whenever the system speaks	3	2	3	4	4	3	4	5	3	5	4	3	4	3	4	4	5	**3.71**	**0.85**
5. It was difficult to understand when the system speak	2	3	3	3	2	3	3	1	2	1	1	2	1	1	2	2	3	**2.18**	**0.81**
6. It is frustrating using the voice interface	3	4	5	5	4	3	4	4	5	3	4	4	3	2	5	5	5	**4.00**	**0.94**
7. It is easy to navigate through the system during task performance	5	3	4	3	3	4	3	4	3	4	5	5	3	3	2	5	4	**3.82**	**0.95**
8. The interface do not require special skills to use	4	3	5	5	5	5	4	4	5	4	3	5	2	2	4	4	5	**4.12**	**0.10**
9. The information provided on the interface is adequate	5	4	3	3	4	4	4	3	5	4	3	5	3	5	3	4	2	**3.77**	**0.88**

The customer voice user interface has been designed using simple interactions and a menu structure with easy navigation. The interface also provides adequate feedback from the system so that users will not be lost at any point during interactions. The mixture of voice and DTMF input ensures that the interface is flexible for inputs and menu selections. Users could

use any mode depending on the length of the data input string required. These users based on their culture and experience required an interface with short menu structure, no hidden information, and clear metaphors and navigation which this voice interface has presented. The user study shows that the localized voice interface (the DTMF-input and the voice input) met the cultural experiences and expectations of the community users. Above all, the voice interface is simple and provides enough information for interaction with the mobile commerce application.

5.5.12 Comparison of the Shop-owner User Interfaces (GUI vs. VUI)

We conducted a test to compare task performance on the interfaces. A questionnaire was given to the participants to complete after the test. Participants were drawn from the different user groups in the community. They include the school learners, the crafters, clerical staff and educators in the community schools. Participants consist of 13 school learners (6 males and 7 females), 6 crafters (all females), 9 clerical staff (2 males and 7 females) and 7 educators (2 males and 5 females). The selected task involves making an update to the price and product number for an item in the application database. The subtasks include the following – select the update item from the shop-owner menu, enter the shop identity number, enter the item number, enter a new price and enter the new number and then submit the data. The graphical user interface requires key board input that makes the tasks take a longer time to complete than the voice and DTMF interfaces. We looked at the percentage of participants who completed the task without encountering errors during task performance for all the shop-owner user interfaces. Figure 5.18 shows the percentage of task completion without error on the different interfaces across the different user groups. The errors encountered were minimal for all the participants in the different user groups. The lowest number of errors was recorded with the DTMF input interface across the user groups. The results also show that the number of errors committed with the GUI was less than the voice input interface. From the observations made, it took a longer time to complete the tasks with the GUI than the other interfaces.

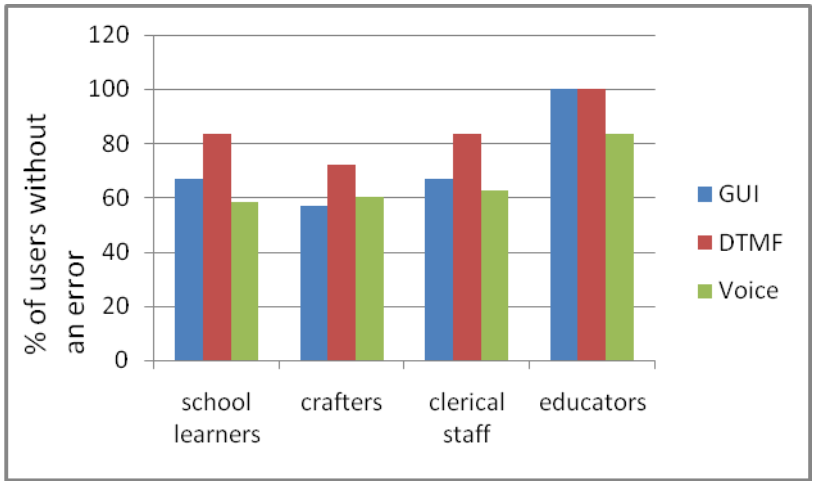

Figure 0.18 Percentage of Users who completed the Task without Encountering an Error

Table 5.17 presents the results from the post-test questionnaire completed by the participants after each test session. The mean scores and standard deviation derived for all the questions are presented in the table. The results show that the DTMF input interface is strongly favoured with an average score of 4.10 and standard deviation of 0.93. The standard deviation indicates that there was uniformity in opinion among the participants across the user groups. Participants did not feel that the interfaces were very difficult to use. The two varieties of the voice user interface were scored positively in terms of user preference for interaction with the application. The participants were consistent about their perceived preference. This is indicated by the standard deviation scores.

Based on the data analysis, we conclude that although the results also indicated that the graphical user interface was easy to understand and use, the participants have a higher preference for the voice interfaces than the graphical user interface. The interfaces meet the interaction capabilities of the participants in Dwesa community.

Table 0.17 Shop-owner User Interfaces Comparison Data and Analysis

Shop-owner User interface comparison data and analysis (Likert-scale questions: 5 strongly agree – 1 strongly disagree) (n = 35)		
Question	**Mean score**	**Standard deviation**
1. The graphical user interface is easier to use than the other interfaces	**3.07**	**1.05**
2. I understand the graphical user interface better than other interfaces.	**2.74**	**1.14**
3.The graphical user interface is more difficult to use than the other interfaces	**3.10**	**1.25**
4. I prefer to use the graphical user interface input when using the application than the other interfaces	**2.42**	**1.04**
5. The voice input interface is easier to use than the other interfaces	**3.03**	**1.06**
6. I understand the voice input interface better than other interfaces.	**2.39**	**0.94**
7. The voice user interface is more difficult to use than the other interfaces	**2.97**	**0.86**
8. I prefer to use the voice input interface when using the application than the other interfaces	**2.77**	**0.66**
9. The DTMF input interface is easier to use than the other interfaces	**3.52**	**1.04**
10. I understand the DTMF input interface better than other interfaces.	**3.84**	**0.85**
11. The DTMF user interface is more difficult to use than the other interfaces system	**2.03**	**0.82**
12. I prefer to use the DTMF input when using the application than the other interfaces	**4.10**	**0.93**

5.6 Summary of Findings

5.6.1 Literacy and Cost of ICT Use

Low literacy in terms of education and technology has a significant impact on information technology usage in the community. Very few people are actually literate enough or can afford to use various mobile phone services due to certain factors. For instance, sending and receiving an SMS is mostly done using the local language. Lack of computer literacy skills among rural people also has an impact on the degree to which the people appreciate technology. They require adequate training to develop the skills necessary to use the services provided. The cost of using technology also restricts the type of mobile device and services that the users can afford to use. Poverty affects technology adoption especially in rural areas.

In order to motivate the community to use ICT services, they should be able to perceive the service as useful and with added value.

In using mobile phone devices, ICT services will only be appreciated if a large population of the target users can use the system. The interaction techniques provided by those devices will motivate the users if they are simple, easily learned and meet users' experience. In this study, we found that few people are aware of different mobile applications. In this case the major factors can be the unavailability of such applications and services that are tailored to the needs of the people and a lack of facilities and reduced literacy levels. Low brands of mobile phones are more common within the community.

Very few people use high-end mobile devices that expose them to different mobile phone interaction techniques. This is also as a result of the inability to afford such devices. Furthermore, people are more acquainted with voice and keypad interactions with their mobile phones. The few people who use other forms of interactions e.g. touch pen or touch screen, are the functional literate ones within the community who have paid employment. Although other types of interactions (like camera interactions) are also used by a few people, factors such as the non-availability of resources, nature of the environment and usefulness of related applications need to be considered before deciding on their implementation.

5.6.2 Language as a Barrier to Technology Usage

Western language used in communicating with technology has been an obstacle that causes low-literate users not to effectively use the services that modern technology offers. Mobile phone users can hardly explore all the services provided by the mobile device they own. This is due to their inability to understand the functions and commands of the user interface which are not written in the natural language of users with literacy challenges which, in turn, limit the extent of their usage. Community users feel that if interfaces are presented with their local language it will better their chances of effectively using the services provided. Texts written in the local language is commonly used even among literate users for communication with friends and relatives; they feel it is easier to understand than text written in English language.

5.6.3 Cultural Preferences

Local mobile phone users are familiar with hierarchical menu models of navigation from the phone applications they use. Their perception or mental model of task structures on mobile devices is hierarchical; which is an advantage for the target users.

Community users prefer user interface elements and content that is customized to their local culture. Interface elements such as icons, text and metaphors need cultural adaptation to suit their cultural knowledge and experience.

Culture dimensions of a target group affect the way in which they perceive and use technology. Dwesa is a collectivist society, with high uncertainty avoidance and masculinity behaviour. This type of society will be more comfortable with the user interface design that presents information and interaction elements that are simple and easy to understand and without hidden hierarchies. Long task structures and hidden information can easily frustrate them. Short menu hierarchies, for interactions, and interface elements that reflect national unity or collective behaviours are preferred.

Interface artefacts representing the cultural preferences of the users are easily sourced from the cultural environment. Colour markers, for instance, have different meanings that reflect the moods, emotions or occasions in community life. For instance, black is regarded as the colour used to show a state of mourning or a situation that is evil.

User interface adaptation motivates low-literate users to interact with new technology. It creates easy understanding of the interface and enables users to accept the artefact. Community users performed tasks successfully with the graphical user interface despite being first time users of the technology. Task performances and task success rates were high among the different user groups. The users feel that customization of the interfaces has contributed to task performance rates.

5.6.4 User Interactions with Interfaces

A user interface that meets the cultural preferences and experiences of the target users is easy to learn and understand. The community users demonstrated their ability to learn and understand the graphical user interface as they used the interface continuously.

Among users with low levels of literacy, user interfaces that are not customized will be hard to use. The voice interface adapted to the natural language of the local users motivated them to use the system. In this study, low-literate users encountered problems of poor recognition as a result of poor pronunciation and inaudible inputs when they used voice input to interact with the application. There were significant statistical differences for task completion times and the error rate between the DTMF input and voice input interface. The DTMF input interface had higher task performance accuracy across the different user groups than the voice input interface. The community users were more positive about the voice user interface than the graphical user interface. And among the interfaces, DTMF input interface recorded better task performance accuracy than other interfaces.

5.6.5 Participatory Challenges (Researcher and Target Group)

The study has also revealed that the culture of a user group affects the design method and use of an interface. In this study, focus groups and the word of mouth method of communication conformed to the socio-cultural methods of everyday interactions among community members. These methods were successfully used in the study. Community members interact better when they are in groups. Apart from the functional literate members of the community (educators) who we met at different occasions in the course of this study, people that belong to other user groups (crafters, clerical staff) did not make meaningful responses when we interacted with them on an individual basis. However, the think-aloud user evaluation method was tried with participants in the community. The method was abandoned because the participants could not communicate effectively during evaluation: talking and performing tasks at the same time seems difficult for the participants. Literacy and language barriers were the obstacles that were observed during these attempts. The method is still not applicable and adequate training of the participants is required for the successful use of this method in the community (Edim and Muyingi, 2010a). The community users are fluent in speaking their local language, and maybe direct communication with the researchers using the local language during system design will yield better results. The use of a facilitator still has its limitations during interactions with the community members.

5.7 Conclusion

The usability evaluations show a successful design of user interfaces and interactions for low-literate users in the Dwesa community. The results show that it is possible to deliver

information effectively to underserved regions using mobile applications. The results also raised the issue of considering the type of interaction possibilities when designing for any user group especially in low-literate environments. In the study, we have considered, to a great extent, the issue of adaptation of the interfaces to suit the local environment and culture. Rural users of ICT services or technology have very limited experience and therefore lack many of the capabilities required to use the services provided. To overcome these challenges, in designing the user interfaces is study, we have considered the user environment in order to provide interfaces and interactions that meet their experiences and preferences. This we have done by taking into consideration several cultural theories/models and the cultural environment of Dwesa people and adapted the interfaces to meet their capabilities and preferences. This will enable them to enjoy easy access to the service and develop their experience and confidence in the technology. The community users have demonstrated their ability to use the shop-owner user interfaces as indicated in the evaluation results.

Adaptation of user interfaces to the users' culture enhances usability, increases users' experience and creates a sense of naturalness during interactions (Shen et al., 2006, Huang and Deng, 2008). In the different interface designs for Dwesa users (the GUI and the VUI), the community participants were able to learn and use the interfaces successfully in performing the given tasks during evaluations due to interfaces adaptation to the local culture. The task completion rate was high and the average score on the perception of and intention to use the interfaces was positive. The comparative results for all the interfaces show that community members have a higher acceptance for the DTMF input interface. This may be because users did not experience input recognition problems and interactions were faster. Positive comments were also received from the participants about their satisfaction with the interfaces and application usefulness to the community.

The study results indicate that the interaction techniques provided to the users through the GUI and the VUI are easy to understand and use, and also meet the capabilities and cultural experience of the target users. Using the cultural experience and knowledge of the users, gained from interaction with their environment, can enhance interface understanding and make the technology acceptable to the target community. Semi-literate and illiterate users in the community will gain have access to the mobile commerce service without hindrance. The application will provide economic benefits to the micro-entrepreneurs in the community.

CHAPTER SIX: CONCLUSION AND FUTURE RESEARCH

6.1 Introduction

The demand in developing countries for the use of information and communication technologies to assist the poor and underserved communities has highlighted the need to conduct this study. The affordability and increasing widespread use of mobile phones in these communities as a means of communication and access to information offered an opportunity to explore how mobile user interface and interactions will enable low-literate users to have access to ICT services and interact with applications targeting entrepreneurship development within these communities. The evaluation of the graphical and voice user interfaces and data analysis detailed in Chapter five revealed that language and culture has a noticeable influence on users' perceptions, preference and experience for user interfaces to technology (e.g. mobile technology). The perceived usefulness of ICT service and ease of use of the user interfaces influences the intention of the target users for using the system and will eventually inspire the people to adopt the application.

6.2 Research Approach

We conducted extensive literature review to have knowledge of current research work related to this study and to identify methodologies and draw up the research approach for this study. Based on this, a research design was adopted for the study. The approach is a user-centred design approach with five study phases to enable us to reach this study objective. With this approach, we applied ethnographic research methods to interact with Dwesa community participants during the study. Qualitative and quantitative data were elicited and analyzed and then used as inputs to the study. These methods were selected to suit the socio-cultural environment of the target users and enhance user participation.

6.3 Research Contributions

The literature visited shows that culture is a significant factor that has an influence on users' perceptions and the use of technology. Users are easily motivated to accept and use technology when the medium of interaction conforms to their cultural experiences. That is, user interface adaptation enhances users' ability to learn the interface, creates confidence and experience a natural sense of interaction. Different interaction techniques and user interfaces have been developed primarily for highly literate societies in the Western culture. However, to our knowledge none of scholarly works have demonstrated how actual culturally related

UI design can affect usability in a low-literate African context. From the reviews presented in this work, culture related interface design theories have been applied in the study to demonstrate how they can also influence interface design and user perceptions about the interface in a low-literacy rural community.

At the beginning, this study identified different user interfaces and interaction techniques for mobile and desktop applications. As ICT and user interfaces design in rural areas are a big challenge, this limits the development of ICTs in rural communities. This study's findings indicate that for low-literacy users to show keenness to accept ICT services into their life, the user interfaces for these services should conform to their capabilities and cultural experiences within their natural environment. These groups of users may be technology illiterates, but they have natural experience which can be elicited from the people and their natural environment and used to aid interface design. The findings suggest that low-literacy users in rural areas require user interfaces that provide interaction elements (e.g. metaphors/icons) that are familiar to them and their environment and reflect the interaction experience of the people gained from their daily interactions in their natural environment.

The localized graphic user interface developed from this study findings have demonstrated the use of information obtained from the socio-cultural environment knowledge and experience of low-literacy rural users in order to meet the cultural preferences and natural experiences of the community users. That is, artefacts that represent interaction elements (metaphors/icons, colour markers, text) on the interface were sourced from the local environment. These artefacts are elements that are familiar to the community people. This helped to create an interface that the community users perceived as easy to understand and use. We do not claim to have elicited all the data about user preferences and cultural knowledge. We also noticed that community members who could not read or write even at a minimal level still found it difficult to interact with the system. A localized voice user interface was designed to demonstrate how this group of users can also be included in this study. Results from user interactions with the interface suggest that an acceptable level was reached in meeting the user preferences and cultural experiences.

The localized voice user interfaces also developed from the findings of this study demonstrated that low-literacy users could interact with the interfaces. The users did experience difficulties when interacting with the interfaces, which were due to pronunciation

and recognition problems. These problems need to be further looked at with the hope of resolving them. The study findings suggested that low-literacy users could use the voice interfaces with ease when performing tasks. The community users found the DTMF-input interface easier to interact with. A higher percentage of low-literacy users in Dwesa prefer to use the DTMF-input instead of the voice-input interface. This may be due to pronunciation and recognition problems mentioned earlier. The findings from the study suggest that low-literacy users have a positive perception about the voice user interface and interactions. The voice user interface was not difficult for the users to interact with. This indicates that the interface may have been within the limit of their capabilities and interaction experiences.

At the beginning, this study found that the business environment in Dwesa is very poor due to literacy, poverty and lack of developmental infrastructures. For instance, micro-entrepreneurs engaged in crafting often find it difficult to sell their products within and outside their community. And very few people are computer literate in the community. These findings motivated us to choose to develop a mobile commerce application to create an avenue for advertising these products to potential buyers outside Dwesa community. The mobile commerce application has only covered micro-entrepreneurs engaged in art and craft. The application can be extended to cover other local economic activities in the Dwesa community.

This study provides evidence that cultural adaptation of user interfaces and interactions can support effective use of ICT services in rural communities. This is because interface adaptation process may help designers be able to capture or identify the culture components, cultural behaviours, motivations, preferences and expectations pertaining to the cultural environment. These data when identified and used to design the user interfaces and interactions, the users' experiences and perceptions are enhanced.

Finally, from this research, a number of peer-reviewed conference papers and journal articles have been exposed to the research community and published in scholarly and industry journals (Edim and Muyingi, 2010a, 2010b, 2010c, 2010d).

6.4 Conclusions

The mobile phone revolution, across different geographical regions and cultures, has made media and information accessibility possible for low-literate rural communities in developing

countries. It is one technology, aside from the radio receiver, that has penetrated different communities at a higher level and provided information technology experience to poor and marginalized communities. The mobile phone provides a medium for harnessing the potential of ICTs to contribute to the social and economic development of rural underserved communities. User interfaces that enable the users to interact with the ICT services that are provided should be made simple and usable by low-literate people in rural communities.

In this study, after a critical review of existing mobile user interface and interaction techniques, the user and environment's contextual and cultural factors in low-literate community, we have designed user interfaces that conform to the cultural expectations and experiences of the target users. The user interfaces are easy to use, easy to understand, and meet the preferences of the users. Semi-literate and illiterate users in the Dwesa community will gain access to the mobile application through the user interfaces and will be able to use interaction techniques that meet their experiences. The results from this study indicate that:

Local users found the user interfaces easy to use, easy to learn and were able to perform and complete tasks with the interfaces with appreciable time intervals.

The Localized shop-owner user interfaces enhanced users' ability to learn and understand the interfaces and to perform tasks with minimum failures. While continuous use of the interfaces showed that the users were able to improve on their performances. These findings could be as a result of interface customization. This is an indication that cultural issues that influence the behaviours, motivations and attitudes of a target cultural group should be taken into consideration during interface design (Huang and Deng, 2008).

The community users prefer the use of a voice user interface to that of graphical user interface for interaction with the mobile commerce application. The study found that, despite the recognition problems encountered, community users still feel that the voice user interface is better due to the ease with which they interacted with it. This is evidenced by the high task completion rate when they used the voice interface compared to when the used the graphic interface. The community users were excited as they listened to the system as it gives instructions in their local language.

The community users also perceived the user interfaces as useful and are positive about their intention to use the system. Analysis of perceived intention to use the system indicates that the target users are willing to accept the technology. For rural users, with low literacy levels, user interface usability and user experience is enhanced through the adaptation process that takes into consideration the cultural knowledge of target users for designing the interface. It enabled the community users to experience an appreciable level of ease when they interacted with the user interfaces.

Community users were able to perform tasks using the interaction techniques presented in this study. The users were able to performance tasks on the interfaces with few errors and decreasing task completion times. These groups of users are still novices to the technology, but through the user interfaces, they were able to learn and interact with the application.

We can assume that, all other things being equal, low-literate users in rural underserved communities elsewhere would be able to gain access to information technology services with user interfaces and interaction techniques that meet the capabilities and experience of the user groups in the communities where they are implemented.

Mobile commerce can be used to harness the potential of ICTs for the benefit of micro-entrepreneurship initiatives and development in rural communities. Community members have a positive perception of the mobile commerce application as useful and also feel that the application will create a positive impact on small businesses in the community. The user interfaces and the ubiquitous nature of the mobile application fit very well into Dwesa environment in terms of the various challenges faced by the community. Desktop applications such as Sicelo (2007), in low-literate environments that do not conform to the cultural preferences and experience of the users, remain under-utilized. The target users require extensive training and computer skills in order to increase usage. The popular telecenter projects in rural communities failed (Heeks, 2008) due to computer illiteracy and the inability of the service providers to effectively train the communities to acquire the necessary skills to use the systems. Mobile phones and applications are accessible to low-literate users and will be widely accepted as a medium of interaction and access to information in rural communities.

Culture influences users' perception and use of technology. Users are willing to accept applications and user interfaces that are useful to them and conform to their cultural experience (Yeo, 1996). User-centred methods used during the design process should be implemented with consideration of everyday way of life of the people and environment. This study has shown that, with culture sensitive user interfaces, users' acceptance of technology can be facilitated. It will also encourage the use of ICT services for socio-economic development in rural communities.

6.5 Suggestions for Further Research

6.5.1 More Cultural Artefacts/Interface Elements

The cultural artefacts or culture components used to design the graphical user interface in this study are not exhaustive, further research is required in the community to identify more culture-components (artefacts) or interaction elements for more robust interface designs targeting this cultural group.

6.5.2 Geographical Context Adaptation

Researchers can explore cultural environments with a certain degree of similarity to Dwesa community to identify several culture-components that will aid interface design library tools for cross-culture adaptation. In addition to which, comparative studies could be carried out to test their effectiveness across different cultures.

6.5.3 Other Micro-Businesses in the Community

In this study, we have used the products from art and craft micro-entrepreneurs to design the mobile commerce application. Further research is required to cover the activities of other micro-entrepreneurs (e.g. farmers) in the community. Also, designs for other application areas will be required in the community to create a higher socio-economic impact upon a larger number of community members (e.g. in education and entertainment). That is, providing other mobile applications to encourage community members to engage in other forms of trade.

6.5.4 Design and Testing of Suitable Interaction Technique

Different applications require different user interfaces and interaction techniques. Available resources in the user environment will enhance the design and testing of such interfaces in the

environment. In the future, more mobile phones with higher capabilities may be found among rural users. Other facilities, like near field communication devices and gesture recognition applications and servers, can be installed in rural communities to assist the people. Further research will be required to design and test other user interfaces and interaction techniques for low-literate users as a means of simplifying and enhancing user interaction experiences and taking ICTs closer to the people.

6.5.5 Adaptation to User Devices

We have designed the GUI with the assumption that the WALL tool used will generate device-specific versions. We suggest that more testing should be conducted to test the effectiveness of and how well the GUI adapts to different user devices in the community.

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APPENDIX A

USER AND ENVIRONMENT STUDY QUESTIONNAIRE

This is part of our research to design a mobile commerce application. This questionnaire is intended to help us know the users and the technology landscape in Dwesa. Please kindly assist us and give your contribution by responding to the questions below. THANK YOU.

Please give us some useful information about yourself by marking an "X" in the boxes below.

Occupation:	Farmer		Craftsman		Teacher		Student		Others……..

Gender	Male		Female	

Age	14-19		26-30		36-40		46-50	
	20-25		31-35		41-45		51 & above	

Educational level	Grade 12	Less than grade 12	Above grade 12	Degree	None

1. Do you have a mobile phone? If no skip to next page.

Yes	No

2. How long have you been using a mobile phone (tick if applicable)

Less than one year	1 year	2 years	3 years	4 Years and above

3. Which of these facilities can be found in your phone? (Tick as many as applicable to you)

Keypad	Screen	Touch screen	Touch pen	Soft keypad	Camera	
						Others……

4. In addition to making and receiving calls what else do you use your phone for? (Tick as many as applicable to you)

Send SMS		Receive SMS	
Send MMS		Receive MMS	
Browse the Internet/Web			

In the table below please tick the option that relates to how you feel about each of the statements below.

The options are: SA- Strongly Agree, A- Agree, N- Neutral, D- Disagree, and SD- Strongly Disagree

Statements	SA 5	A 4	N 3	D 2	SD 1
5. I am computer literate					
6. I am aware of the Internet					
7. I can use the Internet very well					
8. I am aware of e-Commerce					
9. I have used an e-Commerce Website before					
10. I am aware of the benefits of e-Commerce					
11. I am aware of Mobile commerce					
12. I have used a mobile commerce Website before					
13. I am aware of the benefits of Mobile commerce					
14. I will like to use a mobile Website with my phone					

Attitudes. 15. I like the idea of bringing mobile commerce to our community					
16. It is wise to use mobile commerce for our local business					
17. My attitude towards using mobile commerce is positive					
Intention 18. I think I will like to use mobile commerce for local business					
19. I intend to use mobile commerce to market our local products/produce if given the chance in our community					
20. I will like to see a mobile commerce Website that is specific to our community					

21. Select any of the methods you will like to use for browsing with your phone if given the opportunity

: (please tick as many as you feel applicable to you)

Keypad text entry	Mouse and graphics	Touch screen	Touch pen	Phone camera	Voice commands

APPENDIX B:

SCENARIOS FOR SHOP-OWNER ACTIVITIES AND SCREEN DESIGNS

Umtando specializes in making beaded necklace and handbags. She is worried that people do not buy much from her work. For the past two weeks she has not sold any of her products. She will like to take her products to the nearby town to sell but the cost of transportation to and fro is too much for her to afford. She knows that is she does not sell there is no way she will make new ones. She thought of was to do for a long time. She complained about her poor sales to her friend and the friend informed her of the SLL facility which she has been told that can help people to sell their products of any kind to customers outside their community without travelling and continuously whenever she makes a new product. She then asked her friend how and she responded that through her phone and the Internet and that she will need to register in the website and then creates her own shop online. She then visited the facility the next day to get the full information and teaching on how to go about it. There she was adequately informed and taught how to do it. Umtando has no previous experience on how to use the Internet.

Step 1: Umtando types the link and she is presented with the first page with a menu. She presses the arrow key on the keypad and highlights the registration option. She presses the ok button and waits for a while. The registration page is displayed with fields that she need provide the necessary information for the registration process. She then types in her user name then presses the down arrow key to move to the next field. In the next field, she enters her user name and moves down to the next field. She continues the process until she has entered the last field and then she presses the submit button to send the information and her online shop is created.

Step 2: After creating the online shop, she will need to put her products into the shop so that customers can see them on display and decide whether to buy or not. To do this, she moves to the menu and select the add product item on the menu. The screen appears with fields for her to put in the necessary information. Umtando enters the product name in the first field then presses the down movement key to move to the next field. She enters the product number/id and moves to the next field. She entered all the information for the first product, then for the second and for the third and so on until she has entered for all the products.

Step 3: She will need to check regularly if someone has visited her shop to buy any of her items. To do this, she logs into the system and select the menu that says, check orders. After selecting and pressing the ok button, the check order screen is displayed. On the display, she

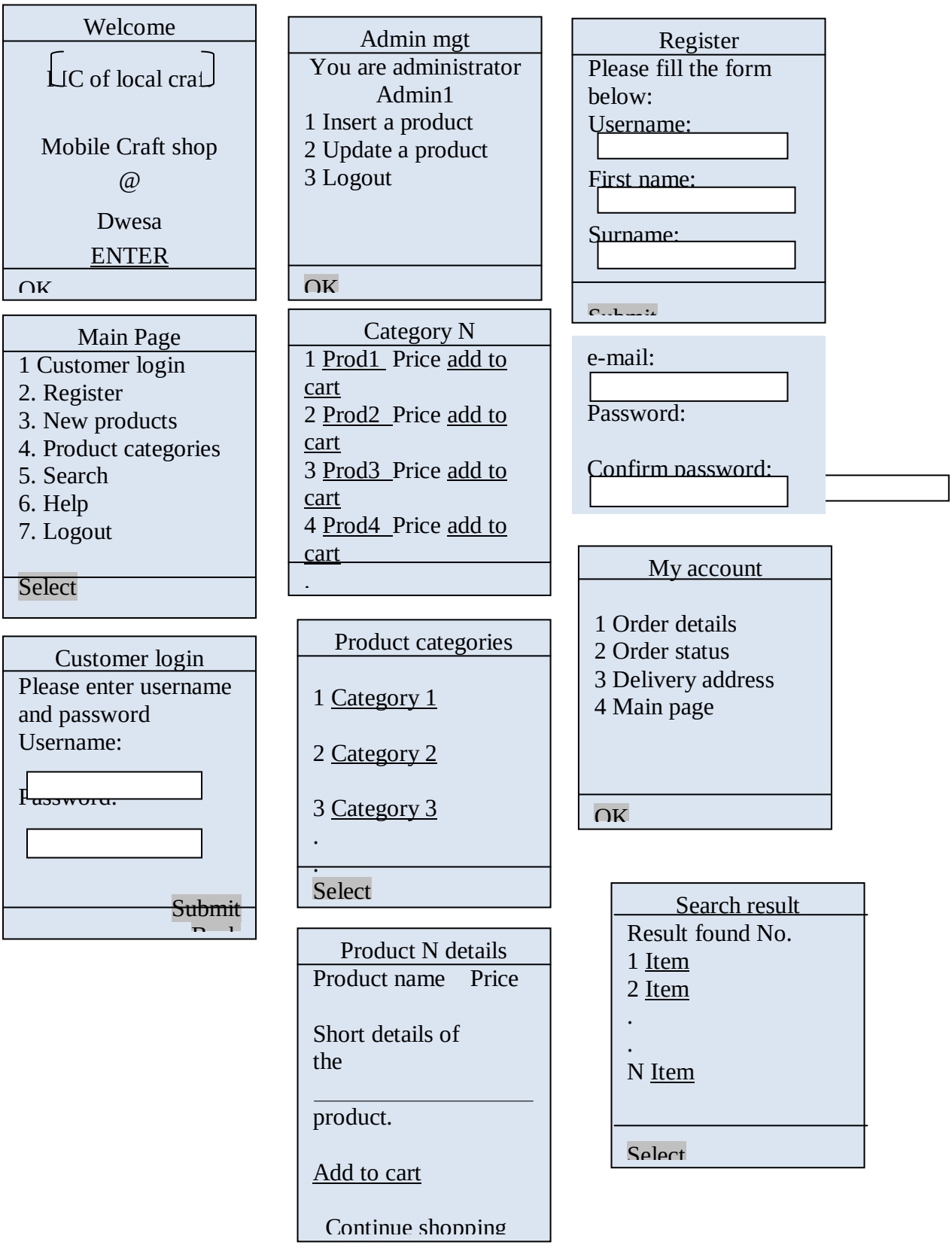
enters her shop number and name. The information that is needed is then displayed indicating the name of the buyer, the item that has been ordered, order number and the address of the customer. She will then decide to contact the customer through and SMS or a call. She will then plan to send the item to the buyer as soon as she confirms from her bank that the money for the item has been paid correctly. After confirmation of payment, she packages the item with the buyer's name and address and then decides whether to travel to Willowvile herself or give it to a trusted person from the village that is travelling to Willowvile to post it and bring back the tracking number for her. She is happy that she has completed the sale of her item to somebody outside the community.

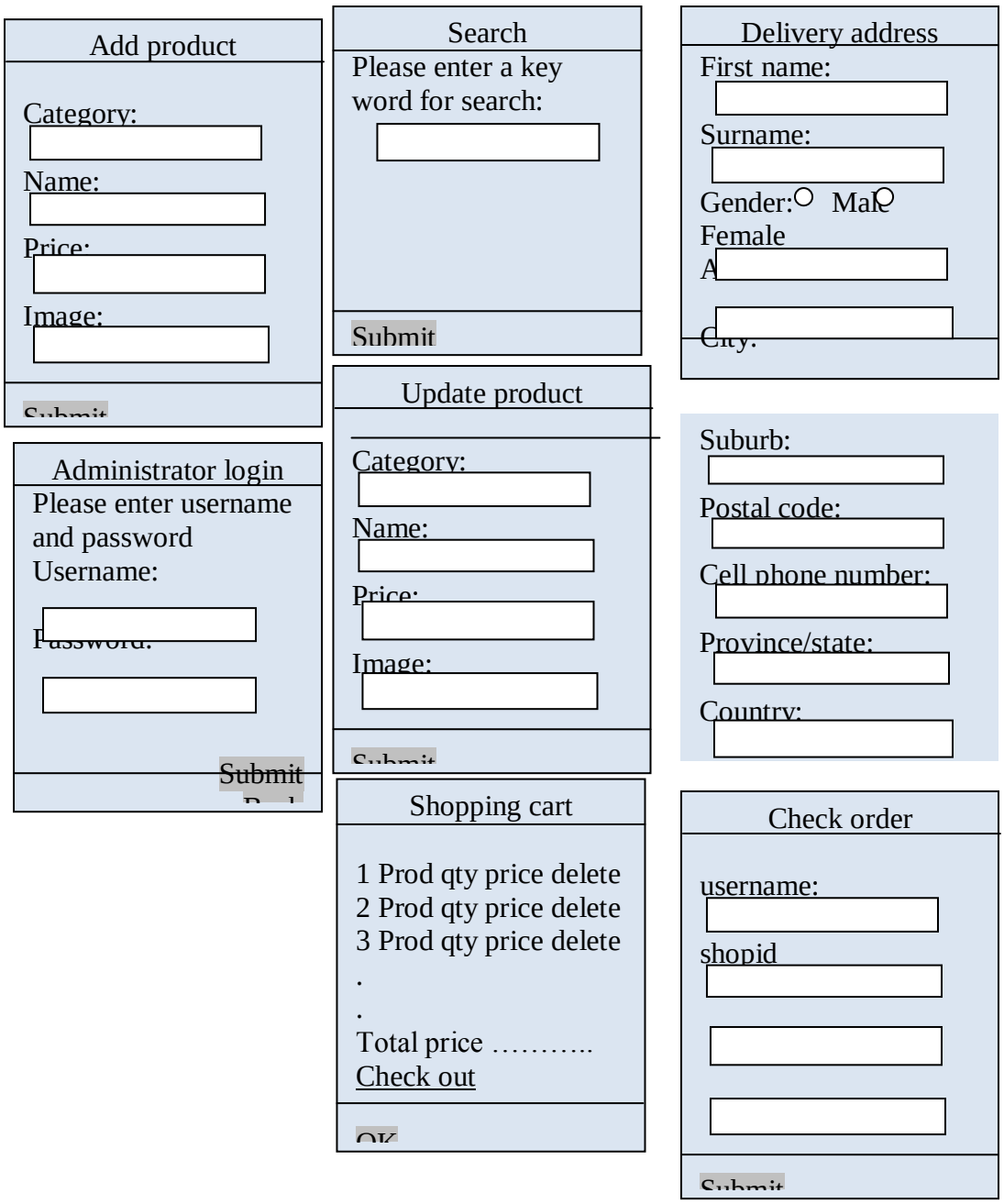
Step 4: A product that that has been sold out and she currently does not have it in stock is still displayed in her shop. She will need to remove it for now so that no customer will place an order for it. She will not want to disappoint any of her customers and so it should be remove for now and added when she has made it. She logs into the system menu and then selects the delete item from my shop option. As she presses the OK button, the screen displays the interface that will enable her to do this. In the display, she will need to enter her shop number, her username, the product id and the product name. This she does one after the other through the input fields on the screen and presses the OK button. The next screen display informs her that the product or item has been removed. She then highlights go back to main menu on the display and presses the OK button. The main menu appears then she signs out.

Step 5: There are some products that the prices are not fix. She has to check regularly to see if a customer has offered a price so that she will respond. She opens her shop as usual and selects bargains option. She is sees a price being offered. She then enters her own offer and presses the send button.

Step 6: There is a product that she has noticed has been on the shop for a long time. She will need to review certain information to make it more attractive. On the other hand, she needs to review information about a product on her online shop. She then selects the update menu item on the main menu and presses OK button. She will need to enter the product number and the shop number first. She does this and the system confirms the existence of such product. She then selects the field she will want to review, enters the new information, say price and then presses send. The update is completed information appears next and also ask her if she will want to update another. She then highlights go back to main menu and presses the OK button. She then selects logout.

Screens design




Add product
Category:
Name:
Price:
Image:
Submit
Search
Please enter a key word for search:
Submit
Delivery address
First name:
Surname:
Gender: Male
Female
A
City:
Administrator login
Please enter username and password
Username:
Password:
Submit
Update product
Category:
Name:
Price:
Image:
Submit
Suburb:
Postal code:
Cell phone number:
Province/state:
Country:
Shopping cart
1 Prod qty price delete
2 Prod qty price delete
3 Prod qty price delete
.
.
Total price ……..
Check out
OK
Check order
username:
shopid
Submit

APPENDIX C

THE ADAPTED VALUE SURVEY MODULE (VSM-2008) QUESTINNAIRE FOR DWESA

Please your response to these questions will help us in our research and will be used for research purpose alone. Kindly help us by answering the questions below.

Please imagine a good job, do not consider your present job. How important is it to you if you are to choose a good job? (Please mark "X" in any one answer)

1. Do you attach any importance to having enough time for personal or home life [ ] 1 highest importance [2] very important [3] modest importance [4] little importance [5] no importance

2. How important is it to have a boss (principal) you can respect [1] highest importance [ ] very important [3] moderate importance [4] little importance [5] no importance

3. Like being recognized for good performance [1] highest importance [2] very important [3] of moderate importance [4] of little importance [5] no importance

4. How do you consider security of employment [1] highest importance [2] very important [ ] [3] moderate importance [ ] [4] little importance [ ] [5] no importance

5. Is it important to have nice people to work with employment [1] highest importance [2] very important [3] moderate importance [4] little importance [5] no importance

6. Is it important to do work that is motivating [1] highest importance [2] very important [3] moderate importance [4] little importance [5] no importance

7. Is it important for your principal to seek your opinion in decisions involving your work
[1] highest importance [2] very important [3] moderate importance [4] little importance [5] no importance

8. Is it important to you to live in an attractive area [1] highest importance [2] very important [3] of moderate importance [4] of little importance [5] no importance

9. Is it important for you for your family and friends to respect your job? [1] highest importance
[2] very important [3] moderate importance [4] little importance [5] no importance

10. Is it important to have promotion chances? [1] highest importance [2] very important
[3] moderate importance [4] little importance [5] no importance

Indicate how the following statements are important to your private life: (please mark "X" in any of the answer)

11. Do you make time free for fun [1] highest importance [2] very important [3] moderate importance [4] little importance [5] no importance

12. moderation: to have few needs [1] highest importance [2] very important [3] moderate importance [4] little importance [5] no importance

13. showing kindness to people [1] highest importance [2] very important [3] moderate importance [4] little importance [5] no importance

14. modesty: being humble, not arrogant [1] highest importance [2] very important [3] moderate importance [4] little importance [5] no importance

15. If you don't have enough money to buy an expensive, what do you do?
[1] save first before buying all the time [2] usually save first [3] sometimes borrow , sometimes save, [4] always borrow then pay off later [5] always buy now, pay off later

16 How regular do you feel anxious or tense?

1 always 2 usually 3 sometimes 4 not often 5 Never

17. Are you happy? 1 always 2 usually 3 sometimes 4 not often 5 Never

18. Do you behave the same both at work and at home?

1 quite the same 2 mostly the same 3 don't know 4 mostly different 5 quite different

19. Do you get prevented from doing what you want to by people or situations beyond your control?

1 yes, always 2 yes, usually 3 sometimes 4 no, not often 5 no, never

20 . How is your present health condition?

1 very good 2 good 3 fair 4 poor 5 very poor

21. Is religion important to you?

1 highest importance 2 very important 3 moderate importance 4 little importance
5 no importance

22. Are you proud to be a citizen of your country?

1 not proud 2 not very proud 3 somewhat proud 4 fairly proud 5 very proud

23. How often, are those who are subordinates scared to oppose the principal?

1 never 2 not often 3 sometimes 4 usually 5 always

What is the extent of your agreement or disagreement with the following statements? (please mark "X" in any of the answer)

24. You can be a good manager even if you don't have exact answer to questions asked by you juniors in your work place.

1 strongly agree 2 agree 3 undecided 4 disagree 5 strongly disagree

25. The only way to have good results is through determination.

1 strongly agree 2 agree 3 undecided 4 disagree 5 strongly disagree

26. A school where there are two bosses (principals) should be avoided no matter what.

[1] strongly agree [2] agree [3] undecided [4] disagree [5] strongly disagree

27. A school's rules should not be broken, even if the employee thinks it is for the interest of the school.

[1] strongly agree [2] agree [3] undecided [4] disagree [5] strongly disagree

28. We need to respect our past heroes.

[1] strongly agree [2] agree [3] undecided [4] disagree [5] strongly disagree

Give us information about yourself.

29. Are you: [1] male [2] female

30. What is your age? [1] Under 20 [2] 20 – 24 [3] 25-29 [4] 30-34 [5] 35-39

[6] 40-49 [7] 50-59 [8] 60 or over

31. How long did you spent in getting formal school education (or its equivalent), did you complete the study (right from primary school)?

[1] 10 years or less [2] 11 years [3] 12 years [4] 13 years [5] 14 years

[6] 15 years [7] 16 years [8] 17 years [9] 18 years or over

32. What is you kind of job in this school?

[1] Not paid job [2] Uneducated or semi-skilled manual worker

[3] Trained office worker [4] Vocationally trained technician, nurse, clerical or equivalent

[5] A professionally trained teacher or educator or equivalent (but not a manager of people)

[6] An educator and manager of one or more people (but not managers) [7] An educator and

manager of one or more people (who are managers)

33. State your nationality? ----------

34. Sate your country of birth (if different)? ----------

APPENDIX D

POST-TEST QUESTIONNAIRE

This is part of our research to design a mobile commerce application. This questionnaire is intended to help us understand your feelings about the mobile application and the user interface. Please kindly give your response to the questions below. THANK YOU.

Please give us some useful information about yourself by ticking in the table below.

Occupation:	Farmer		Craftsmanship		Teacher		Student		Others…..

Gender	Male		Female	

Age	14-19		26-30		36-40		46-50	
	20-25		31-35		41-45		51 & above	

1. Do you have a mobile phone?

Yes	No

2. How long have you been using a mobile phone (tick if applicable)

Less than one year	1 year	2 years	3 years	4 Years and above

3. Have you ever browse the Internet with your phone?

Yes	No

In the table below please tick the option that relates to how you feel about each of the statements below.

The options are: **SA**- Strongly Agree (5 points), **A**- Agree (4 points), **N**- Neutral (3 points), **D**- Disagree (2 points), and **SD**- Strongly Disagree (1 point).

Statements	**SA** 5	**A** 4	**N** 3	**D** 2	**SD** 1
4. I am satisfied with how the interface look and feel					
5. This system will help market our products outside the community					
6. This system will promote business in our community					
7. The system will help to increase people's income in the community					
8. The interface is easy to use					
9. The interface is easy to understand					
10. The interface is not difficult to use					
11. The interface is not difficult to understand					
12. The interface does not require special skills or training to use					
13. It is not frustrating to use the interface					
14. If the system is available, I intend to use it					
15. I do like the interface					
16. I will prefer to use the interface					
17. The use of IsiXhosa culture on the interface made it easy to understand.					
18. The use of IsiXhosa culture on the interface made it easy to use.					
19. There is adequate information provided on the interface					
20. My attitude towards using mobile commerce is positive					
21. I think I will like to use mobile commerce application with my phone					

22. Please give us any other observation or opinion about the program/application: ……

23. What are the positive points about the system?:

…….

24. What should be improve on the interface?: ……..

POST-TEST RESULT FOR SHOP-OWNER GUI

Appendix D: Participants Scores for each post-test question (5 = strongly agree; 1 = strongly disagree)																									
P#	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**M**	**SD**
Q1	5	5	5	5	5	4	4	5	5	5	5	4	4	4	4	4	4	4	4	4	4	4	4	**4.5**	**0.49**
Q2	5	5	5	5	5	4	4	5	5	5	5	5	4	5	5	5	4	4	4	4	4	4	5	**5**	**0.50**
Q3	5	5	5	5	4	3	4	5	5	5	5	4	4	4	5	5	4	3	3	3	3	2	5	**5**	**0.81**
Q4	3	5	5	5	5	3	5	5	5	5	5	3	4	3	4	4	4	3		5	3	5	5	**4.27**	**0.87**
Q5	5	5	4	4	4	3	3	5	5	5	5	4	3	4	4	4	3	4	4	4	4		3	**4.05**	**0.71**
Q6	3	5	3	4	5	4	3	5	5	5	5	4	3	4	3	4	3	4	4	3	4	4	4	**3.5**	**0.76**
Q7	5	1	2	3	4	4	2	4	4	5	5	2	3	2	4	4	4	4	4	3	4	3	4	**4.5**	**1.08**
Q8	3	1	2	1	4	4	2	4	4	5	5	4	3	2	3	4	2	4	1	5	4	3	5	**4**	**1.30**
Q9	2	1	4	2	5	3	4	2	5	4	5	4	5	4	4	4	5	5	3	3	3	4	4	**3**	**1.13**
Q10	4	1	4	2	5	3	4	4	4	5	4	4	5	4	4	5	5	5	4	2	5	5	3	**3.5**	**1.09**
Q11	5	5	5	5	5	4	4	4	5	5	5	4	4	1	4	4	3	4	1	3	4	3	5	**5**	**1.16**
Q12	3	5	4	5	5	4	5	4	4	4	4	5	5		4	5	5	5	5	4	5	5	4	**4.5**	**0.58**
Q13		5	5	5	5	5	5	4	4	4	4	5	5	1		4	5	5	3	4	5	3	4	**4.29**	**0.98**
Q14	5	5	3	5	5	2	3	2	2	2	2	4	4	5	5	5	4	4		1	1	1	2	**3.27**	**1.48**
Q15	5	5	3	5	5	3	3	2	2	2	2	4	4	4	5	5	4	4	4	2	2	1	2	**3.5**	**1.28**
Q16		5	4	4	3		4	4	5	5	5	5	4	3	2	2	4	4	3	3	4	3	5	**3.86**	**0.94**

Post test questionnaire for the shop-owner voice user interface evaluation

This is part of our research to design a mobile commerce application. This questionnaire is intended to help us understand your feelings about the mobile user interface and application. Please kindly give your response to the questions below. THANK YOU

Occupation

Gender

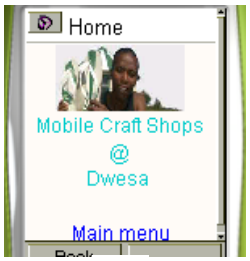
Age

Do you have a mobile phone?

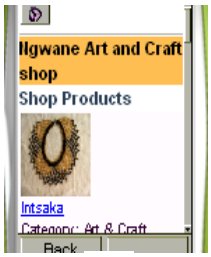
1. I am satisfied with the interfaces
2. The interface with voice input is more easy to use
3. The interface with key input (DTMF) is more easy to use
4. The interface using voice input is difficult
5. The interface using key input (DTMF) is difficult to use
6. I did hear and understand when the system speaks
7. It was difficult to understand when the system speak
8. I prefer to used voice input when using the system
9. I prefer to use keypad (DTMF) input when using the system
10. The interfaces do not require special skills to use
11. The language (Isixhosa) spoken by the system is good and adequate

Appendix D. Shop-owner VUI evaluation data and analysis (Likert-scale questions: 5 strongly agree – 1 strongly disagree)											
P#	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**	**Q9**	**Q10**	**Q11**
1	3	2	4	2	2	4	1	4	5	4	5
2	4	3	5	1	1	5	1	3	4	4	5
3	5	2	3	2	1	4	3	2	3	4	3
4	3	3	5	2	2	3	2	2	3	5	3
5	4	5	2	3	3	2	2	4	3	3	3
6	5	3	5	1	1	4	1	3	3	4	4
7	5	5	4	3	1	5	1	3	1	5	5
8	5	2	4	4	2	5	1	3	2	5	5
9	4	2	4	3	1	4	2	3	4	3	5
10	2	2	3	2	1	5	3	1	5	4	4
11	3	3	2	1	2	4	2	2	3	5	4
12	4	4	3	1	3	4	1	2	3	5	3
13	5	4	2	1	3	4	1	1	5	5	5
14	5	2	1	2	3	5	2	5	5	5	5
15	5	2	5	1	2	4	2	5	3	4	4
16	4	3	3	2	1	3	2	3	4	2	5
17	4	5	4	2	1	3	2	5	3	4	4
18	3	5	3	2	2	3	2	5	3	3	5
19	5	2	5	1	3	4	1	2	2	4	5
20	4	3	2	1	5	3	1	3	5	4	5
21	4	4	3	1	1	4	3	1	5	4	5
22	4	4	4	3	1	3	4	1	3	5	5
23	4	3	3	4	2	3	2	2	2	4	4
24	5	3	5	3	3	5	2	3	1	4	5
25	3	4	5	4	2	5	2	2	5	5	4
26	4	5	5	3	2	3	2	1	1	5	5
27	3	2	5	2	2	5	3	1	2	5	4
28	5	5	5	1	2	5	2	2	5	5	3
29	5	4	3	1	2	3	1	2	5	3	5
Mean	**4.10**	**3.31**	**3.69**	**2.03**	**1.97**	**3.93**	**1.86**	**2.62**	**3.38**	**4.21**	**4.38**
SD	**0.84**	**1.12**	**1.18**	**1.00**	**0.93**	**0.87**	**0.78**	**1.27**	**1.32**	**0.80**	**0.76**

APPENDIX E : ADDITIONAL SCREEN SHOTS FROM THE APPLICATION



a



b

c

d

e

f

g

h

i

Figure (a-i) Screen shots (GUI) from the mobile commerce application