

ASSESSING THE SUITABILITY OF USER CENTRIC DESIGN METHODS WHEN  
APPLIED IN A DEVELOPING WORLD CONTEXT

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## **Abstract**

The application of information and communication technologies to development (ICT4Dev) is widely believed to have the potential to improve livelihoods in developing regions. Within the field of HCI, it is recognised that user-centred design (UCD) methodologies need to be applied if ICT4Dev activities are to yield locally appropriate technologies. However, there is no overarching methodology or framework for the application of UCD within 4Dev design initiatives. This thesis sets out to explore which UCD methods best enable designers to work successfully outside their own contexts, what challenges arise and how UCD methodologies can be developed to support ICT4Dev designers. Two field studies were conducted, applying two UCD methodologies: An empathic and a technology probing approach. In each case the author designed an artefact, evaluated it in situ and reflected on the suitability of the design methods, tools and techniques employed. The design environments were the rural Eastern Cape province and the township of Khayelitsha near Cape Town, both in South Africa. An empathic approach was found to have two major shortcomings: It was unable to overcome significant communication challenges and, partly as a result, it failed to identify major design problems until very late in the process. The major benefit of technology probing was its open-ended nature, which fostered user engagement and participation and yielded valuable design inspiration for future modifications of the probe. However, the emergent scenarios of use in the case of a technology probe were heavily influenced by the nature of the technology itself. We thus conclude that technology probing, while it has a valuable place in the ICT4Dev design toolbox, should be deployed in tandem with other techniques to ensure that important livelihoods problems are not overlooked.



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# 1 Introduction

For some people, information and communication technologies (ICTs) are ubiquitous components of everyday life and an integral link to the global information society. For others, ICTs remain largely inaccessible. Many of these individuals are situated in developing regions where resources such as education and daily income are limited, and access to ICTs even more so. The access gap [43] or digital divide is seen by many as a major limiting factor for socio-economic development in these regions. Bridging this access gap is imperative if organisations and individuals within these countries are to be empowered to participate within the global information society. Brewer et al. [15] state in addition that effective access to ICTs can play a role in alleviating poverty and improving the livelihoods of the world's poorest people. There is a widespread belief that ICTs can play a role in international development activities, the ICT4Dev movement being one manifestation of this belief.

ICT4Dev refers to initiatives that aim to improve the livelihoods of the world's poorest people or reduce their vulnerability [10]. The United Kingdom's Department for International Development (DFID) broadly defines a livelihood as '*the capabilities, assets (both material and social resources) and activities required for a means of living*' [40]. A positive livelihood outcome is therefore any outcome that leads to an increase in financial, physical, social, human or natural capital. This could include more income, increased wellbeing, reduced vulnerability, improved food security or a more sustainable use of local natural resources. The underlying assumption of ICT4Dev initiatives is that local communities, once provided with access to relevant and meaningful information, will be empowered to take action or at least be able to negotiate with external agencies to improve their livelihoods.

The first attempts by governments, research institutions and non-governmental organisations (NGOs) to bridge the access gap involved deploying ICT solutions that had worked well in developed-world settings [56, 84]. Although several of these initiatives began well, subsequent research revealed that many of them proved unsustainable under developing-world conditions. A classic case study highlighting this problem is the Lincos project [56, 9] (see Chapter 2 for a detailed discussion of this project).

ICT4Dev researchers now believe that researchers and designers must develop an appreciation for local factors if they wish to deploy ICT solutions that serve the real needs of people in their context [16,25,31,43,108]. The international ICT development NGO

Bridges.org [16] recommends that ICT4Dev researchers design and evaluate ICT solutions with knowledge of local social, cultural, economic and political environments before settling on and implementing ICT4Dev strategies.

The question then arises: What are the most useful design and evaluation methods? A small group of researchers working within the developing world believes human-computer interaction (HCI) methods, tools and techniques can play an important role in designing ICTs to meet local needs [31,43, 94]. Dray, Siegel and Kotzé summarise three areas of concern:

1. The fit between human, technology and context.
2. Facilitating suitable interactions between human and technology.
3. Managing the process of technology introduction.

They believe user centred design (UCD), a widely accepted HCI method within the developed world, can help ICT4Dev researchers and designers produce interactive ICT solutions that are appropriate for local use and able to empower local users.

## 1.1 User Centred design: A Brief History

Don Norman introduced the notion of UCD to the HCI community in 1983 in his seminal paper *Design principles for human-computer interfaces* [119]. Norman encouraged software development teams to focus on end users, suggesting that designers should observe how people use computer systems and study the mental models users form during their interactions with the system. Norman believed the HCI community needed a set of guidelines that were both accessible enough for development teams to use when building interactive systems, and general enough to cope with a widening variety of technology applications.

Norman's UCD guidelines have evolved over the years into a set of international standards for how human factors should be approached within interactive system development. Formally, the international standard ISO13407 [76], Human-Centred Design Processes for Interactive Systems, defines UCD in terms of an iterative four-phase process:

1. Understand and specify the **context** of use
2. Specify the user and organisational **requirements**
3. Produce **design** solutions
4. **Evaluate** the design against the previously specified requirements.

The process captures the essence of UCD: The design focus is established on the target users from the very beginning, and the designed solution is continually checked against user requirements to ensure that it is satisfactory [10,76]. Within the field of HCI, UCD has emerged as the prescribed design approach for developing interactive technologies, advocated by the authors of popular HCI handbooks [32, 130] as well as leading technology companies such as IBM [71], among many others.

Despite the rise in popularity of HCI and UCD over the past 25 years, there are few documented studies that focus specifically on the HCI aspects of an ICT4Dev design process, let alone the UCD methods, tools and techniques used.

## **1.2 ICT for International Development (ICT4Dev): A Brief History**

The literature around Information Technologies for International Development (ITID) and Information Communication Technologies for International Development (ICTD) has covered several research topics over the past 15 years. Heeks, [63-66] a leading researcher in the field of ICTD, suggests that those who wish to understand the progression of such research should first understand the origins of ICTs within developing countries. In most cases, ICTs were first introduced in the public sector during the 1980s. The 1990s saw increasing private sector adoption by multinational and other firms, but access for the broader population remained scarce. India is a paradigm example: The most basic of ICTs, the fixed-line telephone, grew from 3.11 per 100 inhabitants to 4.44 per 100 in the period 2000-2005 [75] – still an extremely low number. Low ICT penetration [75], high costs, lack of skills and training and low literacy rates [157] effectively prevented the wider Indian population from accessing ICTs.

Based on the belief that ICTs were key to economic development, several researchers highlighted the provision of ICT access and training as an area of concern [16]. At the same time there was marked scepticism regarding the benefits of large-scale ICT investments and whether these would have the desired development impact [65]. Heeks reminds us that there were many who believed that providing basic services such as health care, clean water, housing and employment would have far greater impact on livelihoods than installing IT infrastructure [65,158].

ICT4Dev nevertheless increasingly caught the attention of the international community, partly as a result of the rapid growth of the Internet in the late 1990s, and partly in line with a

marked shift of the global political spotlight to focus on international development [158]. As the Internet emerged as the ICT platform for the growing global economy, it seemed obvious to many that developing countries needed to be connected to this global platform if they wanted to be a part of that economy. Others focused on the immense potential of the Internet and ICTs for helping to achieve the Millennium Development Goals (MDG) such as improved health care, education and gender empowerment and equality [101,126].

As a result, MDG-related themes emerged prominently within ICT and international development literature. Researchers investigated ICT topics ranging from the development of English language skills [104], through the use of ICTs within schools [143] to novel public educational initiatives [83]. Healthcare researchers investigated links between ICTs and public health promotion [102] while others investigated the potential of ICTs to empower women [101]. The economic side of ICTs sparked significant research interest. Avgerou [3] tackled this question head on, commenting on how macro-level policy and economics affected ICT usage. Chowdhury, Ehikhamenor and Donner investigated the economic impact of ICT investments by small and medium enterprises (SMEs) and the financial sector [26, 44, 39]. Others focused on the financial sustainability of telecentres and Internet kiosks [84, 50].

The realities of ICT deployment began to emerge during the late 1990s [56, 65]. The research community began to document case studies of unsuccessful ICT deployments, and those that did not achieve their intended development goals. Chepaitis [25] and Molony [105] reported on the social dimensions of ICT usage, finding that the success of ICT deployments rested on issues such as trust. Morales-Gómez and Melesse [108] found that ICTs were not ‘silver bullets’ that automatically led to development and that addressing the technical issues alone could not guarantee success. ‘Soft’ issues relating to the socio-cultural, legal, political and economic context were found to be as important as technical issues.

Others focused on the policy and regulatory foundations for successful ICT-led development. The effectiveness of ICT strategies and programs hinged on government support, but the policy environment was not always conducive to ICT growth [27]. The effect of government policy was particularly evident within the work of Neto, Best and Gillett [113], Galperin [52], Pentland, Fetcher and Hasson [127] and Lewis [88] who investigated wireless networking and Internet access. Government policies were often found to be at odds with ground level ICT delivery strategies and thus a source of tension.

The technical aspects of ICT service delivery and connectivity for rural and poorly serviced areas has also surfaced as an issue – but research in this area has tended to focus primarily on the development and application of low cost, resilient, wireless networks [23,127].

The mismatch between off-the-shelf ICT solutions and local contexts -- what Heeks [66] calls the ‘design-actuality’ gap – emerges as a critical theme in the ICT4Dev literature. As discussed above, HCI researchers believe that HCI disciplines, UCD in particular, can play a role in bridging this gap. However, HCI does not feature prominently in the ICT4Dev literature and the issues associated with human-technology interactions are discussed very little. The few examples that have been published include Plauche et al.’s [129] work on speech driver interfaces for illiterate users, Pawar, Pal and Toyama’s [125] coupling of multiple mice to a single computer, Ramamritham et al.’s [135] Aqua agricultural portal and Medhi et al.’s [101] text-free user interface.

Reports on ICT design strategies and methods are even scarcer. Puri et al. [132] discuss the contextuality of participation in information system design, Panchard [128] provides a basic description of the use of participatory design and Brand and Schwittay [14] remind designers to develop an appreciation for local practices, socio-cultural context and political conditions, as these were found to affect the uptake and use of an ICT solution.

### **1.3 HCI for International Development: A Brief History**

While HCI is mostly absent from the ICT4Dev literature, HCI researchers themselves approached the same topic from a different angle in the mid 1990s. The growth of the Internet and global dissemination of personal computer technology meant that users of software and online services were now spread across the world, including developing countries. The HCI community responded to the growing need for cross-cultural design, with active research being led by researchers such as Marcus [93]. He found that existing interaction paradigms and metaphors were not suitable for all users.

The first Universal Access in HCI conference in 2001 focused on designing technology interfaces that were accessible to a wide variety of users, especially those with special needs such as elderly, illiterate and disabled people. The initial conference did not publish any research focussing specifically on developing world users and their accessibility needs, but the shift in focus sparked a renewed interest in cross-cultural design [79,122-124,134]

Researchers from Apple Inc. (Grisdale, Graves and Grünsteidl [58]), adopted a pragmatic, immersive approach to cross-cultural design in the late 1990s, when tasked with designing a graphical user interface for a mobile computing device aimed at rural Indian midwives. The authors emphasised the effect of contextual factors such as language barriers, social hierarchies, cultural customs and organisational structures, and admitted that these affected their design strategy and final solution.

On the other side of the world, HCI researchers living and working in South Africa such as Blake [12, 14], Marsden [94,95] and Tucker [14], began exploring the design of technologies that provided access to digital information systems for the rural and urban poor. Blake et al. [12] reported on the design of Cybertracker, a GPS-enabled mobile tool that enabled semi-literate animal trackers in remote nature reserves to capture complex data and upload it to an information system. Their work highlighted the importance of focusing on the context of use, the target users and their capabilities; while not called UCD, the work captured its essence.

Blake can thus be included among those HCI researchers [31, 43] who believe that UCD is necessary for bridging the design-actuality gap, ensuring contextual fit and locally appropriate solutions. There are, however, few detailed case studies of real-world applications. Parikh's work [122-124] on the design of the CAM financial data collection and management tool remains perhaps the best HCI for development case study. The CAM project tried to automate inefficient paper-intensive information processes by using rich multi-media features of a mobile phone to capture micro-finance data. Although this was not explicitly stated, the designers appeared to adopt a user-centric approach. They used tools and techniques from the field of HCI including rapid ethnography [103] and low- and high-fidelity prototyping techniques [148]. Their findings covered the design challenges encountered within their ICT4Dev work, including gathering design inspiration from in-situ prototype demonstrations as well as task-based assessments that evaluated the usability of the CAM mobile phone application.

Joshi [77] and Kam et al. [78,79] have begun reporting on the suitability of existing HCI methods and how these may need to be adapted or modified for developing-world use. Their work marks a shift within the HCI for development research agenda: Existing work has focused primarily on the success of artefacts produced by applying HCI methods, without reflection on the suitability of the methods used. Monk [107] notes that UCD originated from

studies of HCI in the workplace; its methods, tools and techniques might not be suitable for every design context. Monk's research focus is the developed-world home, as opposed to a work environment; we are interested in a developing-world design context.

## **1.4 Primary thesis**

Our primary thesis is that designers of ICT4Dev solutions can benefit from using UCD techniques. User-centric approaches enable the design of interactive technological systems that are both useful and usable within the target context, empowering users to achieve positive livelihoods outcome for themselves or their communities.

## **1.5 Assumptions**

This body of research therefore explores the application of UCD within a wider ICT4Dev initiative. It is built on the following assumptions:

1. ICT4Dev can help to solve international development problems (see the work of leading ICT4Dev researchers such as Brewer et al. [15], Heeks [63-66], Parikh et al. [122-124], Luk, Ho and Aoki [92] and Kam [78,79]).
2. UCD, already a proven and accepted design methodology within the HCI community (see Cooper, Reimann and Cronin [32], Preece, Rogers and Sharp [130] and IBM [71]), is a promising way to design locally appropriate ICT4Dev solutions.
3. Given the right tools and techniques, designers can successfully work outside their own contexts.

## **1.6 Research questions**

There is currently no overarching HCI4Dev framework or methodology available for designers wishing to work in a developing-world context. Similarly, there is very little literature documenting the suitability of UCD within ICT4Dev initiatives.

This lack of work on the suitability of HCI design methods for developing-world design applications is a glaring gap in existing literature. This thesis therefore seeks to investigate the practical application and effectiveness of existing HCI design methods, tools and techniques – specifically UCD – within a wider ICT4Dev design initiative.

The following research questions guide the research:

1. Which UCD methods best enable designers to work successfully outside their own contexts?
2. What challenges and pitfalls arise?
3. Can we develop and improve the UCD methodology to better support ICT4Dev designers?

The research questions are explored through the pragmatic application of two variants of UCD within two distinct design environments: A rural clinic in South Africa's Eastern Cape province and the shanty town of Khayelitsha, near Cape Town.

The results of each design project are considered to determine both the appropriateness of the resulting technological artefact and, most importantly, the suitability of the chosen UCD approach. An appropriate ICT artefact is defined as one that:

- Is both useful and usable within the target context.
- Supports the achievement of the user's goals.
- Directly or indirectly improves the livelihoods of its users or the community they aim to serve.

We determine the suitability of the chosen UCD approach by the designer's ability to use the associated method, tools and techniques to:

- Learn about the users, their context and needs.
- Translate those requirements into a design concept.
- Communicate the design concept to the users.
- Gather feedback on user interpretations of the designed artefact.

## **1.7 Research overview**

Two different UCD approaches for producing appropriate solutions are tested.

The first, applied to a primary health care clinic in the rural Eastern Cape, is what Leonard and Rayport [86] call an *empathic* UCD strategy. The designer is required to immerse himself in the local context, learn from the local people and then design an artefact that satisfies a local need and is suitable under the given circumstances. More specifically, the designer must:

1. Develop an appreciation for the problems or needs of the local people and their context.
2. Translate the requirements into an appropriate solution design.
3. Evaluate the design against the original requirements.

A distinguishing feature of the strategy is that it follows a traditional UCD approach of presenting a prototype artefact to the users during each design iteration. The prototypes are progressively refined, with their fidelity gradually changing from low to high – users only experience high-fidelity prototypes of the design solution late in the process.

The second UCD approach to be tested, applied in Khayelitsha near Cape Town, is based on a design technique called *technology probing* [70]. This approach exposes users to simple, high fidelity prototypes early on in the design process. Further design possibilities are suggested through active user participation, utility experiences and probing the complex socio-cultural issues surrounding the technology.

These alternative approaches were applied to the design of two cellular phone-based interactive systems, each aiming to provide a locally appropriate interface to rich multi-media information. The first system, MuTI Mobile, aimed to use multi-media messaging to enable new, collaborative medical processes between a rural hospital and a remote clinic in the Eastern Cape. The second system, SnapAndGrab, enabled playful interactions and multi-media sharing within a work environment in Khayelitsha.

It should be noted that this thesis is an attempt to compare the suitability of two different UCD approaches when applied within a wider ICT4Dev initiative; it is not intended to be a study comparing the suitability of a particular solution between deployment sites.

## **1.8 Research delineation**

The primary focus of this body of research is on the design process. To validate a design process, Design Research [121] says we need to produce an artefact – but the artefact itself is not the main goal.

It should also be noted that this research was not carried out in a laboratory context -- in ICT4Dev projects, the real world is the only available laboratory. This unavoidably limited the researcher's ability to control the study environment. As will be seen, unpredictable

factors from far outside the immediate context of study profoundly affected the design process.

The author was further constrained with respect to the choice of deployment site in the rural Eastern Cape, where the design project was part of a collaborative venture between the author and a team of networking researchers from the University of the Western Cape.

## **1.9 Summary of work completed by the author**

### **The MuTI Mobile project**

- Execution of rapid ethnographic field study.
- Analysis of ethnographic data.
- Execution of contextual inquiry.
- Construction of contextual models.
- Assistance in the construction of a long range Wi-Fi (wireless fidelity) network.
- Design of the MuTI Mobile system (mobile client and communication server).
- Implementation of MuTI Mobile (mobile client and communication server).
- Testing of MuTI Mobile.
- Deployment of MuTI Mobile.
- Evaluation of MuTI Mobile.

### **The SnapAndGrab project**

- Design of SnapAndGrab technology probe.
- Implementation of SnapAndGrab technology probe.
- Testing of SnapAndGrab technology probe.
- Design and execution of laboratory study.
- Design, execution and management of Learn to Earn field study.
- Deployment of SnapAndGrab technology probe.
- Evaluation of SnapAndGrab technology probe.

## **1.10 Outline**

### **Chapter 2: Literature Review**

The second chapter describes, in detail, the origins and rationale behind the two chosen UCD

approaches. Previous applications of UCD in 4Dev design initiatives are explored, and any documented shortcomings or modifications are highlighted.

### Chapter 3: Research Design

The third chapter describes the design of the research, and the methods and practical tools used to address the research questions. Specifically, it describes the overarching Design Research [121] framework and the two alternative UCD processes applied within it: Empathic [86] user centred design and a technology probe. As well as describing research methods and design, this chapter also describes the methodologies, tools and techniques used to design and evaluate the resultant artefacts.

### Chapter 4: The Design of MuTI Mobile

The MuTI Mobile project entailed applying a modified version of the empathic UCD approach to MuTI, a failing ICT4Dev system. MuTI's objective was to decrease unnecessary referrals to a rural hospital from remote clinics, by enabling better communication between clinic nurses and hospital doctors. The original developers believed the solution was failing because of its complex user interface: Usability problems were preventing effective use of the technology. The author was drafted onto the team to re-design the MuTI user interface.

The failing system was re-evaluated using an empathic UCD approach, seeking answers to the following specific questions:

1. Was the existing MuTI technology appropriate for remote medical consultation in a rural health care environment?
2. Could the application of an empathic UCD approach result in a more appropriate solution?

The design process revealed several contextual misfits and an alternative design path, which led to the design of MuTI Mobile, an application that ran on a cellular phone rather than a desktop computer. Further evaluative work revealed that the primary reason for the rejection of the MuTI system lay in complex sociocultural issues, rather than merely in contextual fit or usability. The empathic UCD approach only identified this problem in the late stages of the process, after the clinic nurses had experienced a high-fidelity prototype.

We conclude that the MuTI and MuTI Mobile technologies were inappropriate solutions to

the communication problems between the hospital and outlying clinics. In addition, we conclude that the empathic UCD approach failed to identify complex underlying sociocultural problems sufficiently early in the design process.

## Chapter 5: The Design of SnapAndGrab

The technology probe variant of UCD described in this chapter uses a simple and highly accessible technological artefact to probe a community's attitude to and perspective on a technology experience. Instead of specifying how and when the technology should be used, a technology probe presents the community with a basic artefact that is open to interpretation and without a prescribed use. The findings are then used to inspire the design of new interactive systems to support people in similar environments and address emergent needs.

The design process began with an assessment of the socio-economic conditions within poor South African communities, with the aim of identifying general accessibility barriers that prevent community members from interacting with technology systems. The findings shaped the design of a simple interactive technology for sharing multi-media through the use of Bluetooth enabled camera phones. The resultant artefact, called SnapAndGrab, was used as the technology probe.

The SnapAndGrab probe was deployed and evaluated in two very different contexts: A university laboratory and a community centre in the township of Khayelitsha. A combination of task-based assessments, Heeks's Information Chain [63], the RA/RI criteria [16] and a polyphonic assessment [53] were employed to gauge the usability of the technology probe and the community's progression from basic access to application of the technology within their daily lives.

## Chapter 6: Conclusions

Chapter 6 presents a summary of the author's conclusions regarding the suitability of the two alternative technology design methods investigated. The chapter ends with a brief overview of possible future research built on this thesis.

## 2 Literature review

This review explores approaches other researchers have adopted to the design of interactive technologies for developing-world deployment. Its purpose is to summarise these approaches and to enumerate the variety of user-centric methods, tools and techniques used. The following are of particular interest:

1. **Accounts** of UCD approaches to the design of interactive technologies for the developing world.
2. **Assessments of the suitability** of UCD approaches in the developing world.
3. **Suggested modifications** of UCD methods, tools or techniques.

The discussion relies heavily on the concepts of appropriate technology and design for international development (“4Dev”). We thus begin with a detailed discussion and definition of these terms.

### 2.1 Appropriate technology

A naive definition of appropriate technology might be that it is any technology that:

1. Is able to satisfy a particular need; and
2. Is suitable for the circumstances under which it will be used.

Popular HCI design methods such as UCD are built on this view. UCD requires a designer to develop an understanding of the context within which an artefact will be used, translate the contextualised requirements into a candidate design and then to evaluate the design against those requirements.

Designers typically go through repeated iterations of a UCD process until they arrive at a design that is both useful to, and usable by, the intended users. Appropriateness is then judged according to the users’ ability to use the designed artefact to satisfy their needs. An appropriate solution is therefore the product both of an iterative design process and of the designer's ability to learn from the users and incorporate these lessons into the process.

Dix [42] and Salovaara [140] take a slightly different approach, focused on developing an appreciation for the user's subjective interpretation of a technology experience or artefact. Appropriateness is measured by the extent to which the user can report or show vision,

understanding and application of the artefact. An appropriate technology is thus one that the user can envision a use for and then successfully apply. In the design process, Dix and Salovaara both advocate using the evaluative findings to modify the technology so that it better suits the envisioned uses and applications.

Both UCD and Dix [42] and Salovaara's [140] approaches allow the designer to build value or meaning into the technology. The major difference between the two approaches is that UCD first attempts to identify a problem or need, then to develop and iteratively refine a technology until its use solves the problem or satisfies the need. Both Dix and Salovaara's approaches, by contrast, explore application and use possibilities that emerge when users are given the opportunity to experience a technology interaction in the design process. These emergent applications and usage scenarios, Salovaara contends, will reveal the underlying problem or need.

## **2.2 Design for international development**

A design strategy or set of activities can be termed 'for international development' (4Dev) when its ultimate goal, as discussed in Chapter 1 above, is to improve the livelihoods of the world's poorest people.

DFID's Sustainable Livelihoods Framework (SLF) [40] for planning and executing development initiatives stresses the need for design to focus on people and their livelihood needs. The goal is to shape the internal objectives, scope and priorities of a design project around the real situation and needs of those who are intended to benefit.

The framework is centred on six core values:

1. Be people-centric: People and their own livelihood goals should be placed at the centre of all development processes.
2. Take a holistic view: There will be multiple influences and actors at work, creating both constraints and opportunities. Given this complex interplay of forces, individuals may adopt a variety of strategies to achieve their livelihood goals.
3. Understand the dynamism of forces: The SLF encourages researchers to understand and learn from change so that they can support positive patterns and mitigate negative patterns of change.
4. Build on strengths: The SLF recognises local strengths and translates these into

- potential that can be developed by providing support and removing obstacles.
5. Consider micro-and macro-level factors: The SLF attempts to bridge the gap between macro-level policy and institutions and micro-level livelihoods.
  6. Make livelihoods sustainable: A livelihood is described as being sustainable when it is resilient to external shocks and stresses, not dependent on external support, maintains the long-term productivity of natural resources and does not undermine or compromise the livelihoods of others.

### 2.2.1 ICT4Dev

The SLF [40] does not specifically address the issue of technology design; however, it does encourage all designers to evaluate their strategies in terms of their ability to achieve positive livelihood outcomes for target communities. This is a useful backdrop to any discussion of ICT4Dev initiatives.

4Dev advocates such as Brewer et al. [15] argue that information technology systems are able to play an important part in improving livelihoods, to the extent that information and communication technologies (ICTs) [73] should be ‘considered among the greatest enablers for an improved quality of life’. Indeed, ICT4Dev dominates discussions of technology design for development.

Published ICT4Dev research has tended to focus on broader issues of economics, policy and sustainability [27,39,84,88]. There has also been a significant amount of work focussing on the technical aspects of ICT service delivery, in many cases researching appropriate technologies for rural deployment. For example networking research groups [23,127] have led the way in providing connectivity to rural and poorly serviced areas through the use of low cost, resilient, wireless networking hardware and protocols to provide “first mile”<sup>1</sup> telecommunications access to rural communities. Other researchers have provided poor communities with computer hardware and software in an attempt to leverage the benefits of these technologies within the domains of education, healthcare, finance and skills development [78,79,122-124,126,132,134].

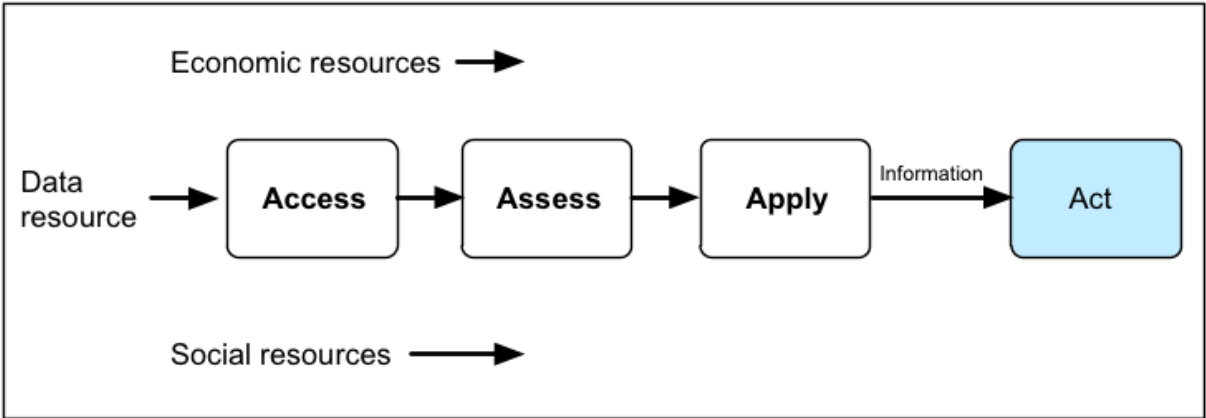
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<sup>1</sup> The phrase “first mile” is used here instead of the more commonly used phrase “last mile”. In the telecommunications industry, “last mile” refers to the link between the exchange and the individual customer. “First mile” is an activist alternative phrase that refocuses attention on the user perspective [89].

Recently, ICT4Dev research involving mobile phones has attracted significant attention [38,122]. The interest stems from the fact that the mobile phone is a powerful computing platform as well as a communications tool; as it becomes ubiquitous in developing regions, it has become a promising target for 4Dev initiatives.

Although the ICT4Dev research community is vibrant and growing, there have been few detailed reports documenting the HCI aspects of ICT4Dev initiatives. HCI is an important aspect of information access: The delivery of data via a telecommunications link will have no impact on livelihoods, according to Heeks [63], if end users are not able to access, assess and apply the information presented to them in their daily lives (see Heeks’s information chain, Figure 2-1). It is increasingly recognised that successful ICT4Dev initiatives must include an HCI component [31,43,94].

**Figure 2-1: The Heeks Information Chain**



**2.3 “Appropriate technology” revisited**

In the light of the preceding discussion, we can extend our definition of “appropriate technology” to include the requirement that it should improve livelihoods for users and their communities. The implication is that designers should identify livelihoods-related problems or needs, then ensure that the design process produces technologies that can be used to achieve these livelihoods goals. Following Salovaara, the designer might adapt a technology prototype based on user interactions in which users apply the initial artefact to a livelihoods-related problem or need. In this case, the designer’s goal would be to evolve the artefact to better suit emergent uses, and thus enhance its livelihoods impact.

No matter which approach a designer chooses, the SLF [40] advocates that it be people-

centric. The field of HCI provides a design methodology that achieves just this: User Centric Design.

## 2.4 User centric design

User centric design (UCD) is a popular HCI design methodology that includes target users in the design process from the very beginning and continually checks design against user requirements to ensure that it is appropriate [10, 76]. Formally, the international standard ISO13407 [76], *Human-Centred Design Processes for Interactive Systems*, defines a UCD approach in terms of four core phases, namely:

1. Understanding and specifying the context of use
2. Specifying user and organisational requirements
3. Producing design solutions
4. Evaluating the design against requirements.

UCD is attractive from a 4Dev perspective: It is not only people-centric, it uses evaluative techniques to help refine the designed solution to ensure an appropriate final product. This is usually achieved by iteratively gathering feedback from users and evaluating the findings against the requirements before continuing with the next design cycle.

The next four sections will consider each of the core UCD phases in turn.

### 2.4.1 Understanding and specifying the context of use

Several design methods within the HCI domain advocate the importance of understanding the user's context and can be considered user-centric. We will discuss two of the most popular, contextual design and ethnography.

#### 2.4.1.1 Contextual design

Contextual design [6] (CD) is one example of a methodology that provides the designer with a set of tools and techniques for gathering contextual data and transforming it into a detailed requirements specification. CD emphasises the importance of developing a detailed understanding of a user's environment and daily life, from their own perspective. This is achieved using techniques such as contextual inquiry (CI), in which the designer plays the role of an observer trying to gain an understanding of the user's context. The designer is then required to reflect on these observations and to generate a set of accurate work models to

represent the user's daily activities. These models serve as design tools for analysing activities and then envisioning how a technological solution might better support or enable new activities.

The underlying assumptions of CD are that:

- The contextual inquiry gathers field data that is sufficiently rich and detailed.
- The designer is able to aptly and sensibly [2] interpret the field data.
- The evaluative methods are able to validate the appropriateness of the solution – that is, its usability, contextual fit and usefulness (perceived value).

CD has some important limitations, however. As Muller, Wildman and White [111] note when they include contextual inquiry in their taxonomy of participatory design practices, it is more about the designer participating in the users' world than users participating actively in design decisions. Second, the scope of its analytical lens is purposefully reduced to include only a handful of key individuals asked to discuss very specific tasks and artefacts. This tight focus means contextual inquiry is unlikely to uncover broader contextual issues [36]. Rather it is used to understand the user's immediate context and to produce highly contextualised models that have direct implications for design [36]. This is unproblematic in cases where designers and users share a common context and it is unlikely that significant factors will be missed. However, as will be discussed below, in ICT4Dev environments this assumption is dangerous.

#### 2.4.1.2 Ethnography

Ethnographic research provides an alternative approach to integrating 'real world' knowledge and understanding into the design process [2, 69]. It is an attempt to develop an understanding of people and their experiences of everyday social and cultural activities and then to synthesise a representation that can be used to inform a design process [2, 33]. Most importantly, an ethnographer, like a contextual designer, tries to understand these experiences from the user's perspective.

Ethnography, like other qualitative research methods, accepts that subjective perspectives on an experience cannot be reduced to a set of measurable variables. They should be viewed rather as localised, holistic 'culture' that can be made sense of only through observation [33].

Designing an appropriate interactive system requires the system designer to develop a detailed understanding of this underlying social setting. A mismatch between the interactive system and the wider social process may result in an undesirable user experience.

Two examples will help to make the dangers of such a mismatch clearer:

1. A 70-year-old woman tries to purchase a train ticket from a vending machine but ends up struggling to complete the transaction due to the complexity of the new user interface and the pressure of a long queue of people behind her. She starts to panic. In her frustration she hits the red 'cancel' button, grabs her ticket and decides to look for someone to assist her.
2. A new video conferencing technology enables two individuals to collaborate more effectively on a web design project -- but at the same time puts the junior party under pressure to be present in his office at all times. He thus spends less time collaborating face-to-face with the graphic design team, resulting in a website that does not meet company expectations.

Ethnography provides a way to gain a detailed understanding of social setting and processes, thus helping the designer to set the design problem [143]. The findings provide a platform from which the designer can seek out opportunities for transforming a problematic social situation into one that is more desirable. From an ICT4Dev perspective, the belief is that such a transformation can be enabled through an appropriately designed technology. Designers benefit from ethnography's wide, holistic lens [147] and its ability to identify multiple opportunities for such a design intervention.

That said, traditional ethnographic methods are often criticised for their inability to accommodate the time pressures typically associated with systems development [2,69,103]. Ethnographic research may take months or even years to gather the required field data, analyse and interpret it. Furthermore, system designers often struggle to assimilate the outputs of an ethnographic study. The results are typically presented in a discursive format, requiring significant interpretation before the various design options become evident.

Reluctance to adopt ethnographic research methods is also partly fuelled by a commonly held misconception that an ethnography is simply a recording of what the researcher observes within a particular social setting [2, 103]. This is not the case: ethnography is more accurately

described as ‘motivated looking’, in which the ethnographer seeks to identify patterns and to describe the relationships between them [2]. This involves making choices about what to study, whom to observe, what activities to record and how to analyse and integrate the data into valuable insights [103].

In the case of ICT4Dev, such choices are shaped by the desire to find opportunities to solve a problem or meet a need through ICTs. To do this, the ethnographer must formulate an appropriate set of research questions, and later a set of analytical lenses through which to uncover and describe the underlying social setting. At the same time, the ethnographer will seek to highlight ways in which behaviours might be transformed, and livelihoods improved, through the provision of ICTS.

Millen’s [103] description of rapid ethnography provides some useful guidelines for incorporating ethnographic research into a design process. His approach focuses on three key ideas:

- Narrow the focus of the field research before entering the field, zooming in on important activities and behaviour.
- Use multiple interactive observation techniques to increase the likelihood of discovering exceptional and/or useful behaviour. Examples of such techniques include the use of key informants and interactive observations.
- Use collaborative and computerised iterative data analysis methods.

#### 2.4.1.3 Accounts from 4Dev literature

In the field of HCI, contextual design and ethnographic methods have historically been applied in developed-world work or consumer settings. However, they are also promising approaches to ICT4Dev initiatives -- several HCI researchers have emphasised the importance of developing a detailed understanding of the local context in this case.

#### **Reports from the field**

Parikh and Lazowska's [123] work on the CAM project in rural India captured some important insights into the challenges of executing design for development processes. The project tried to automate inefficient, paper-intensive information processes by using the rich multimedia features of a mobile phone to capture micro-finance data. Some of their broad findings consisted of a list of design challenges, many of them linked to physical constraints

within the local environment such as:

- Intermittent power;
- Intermittent mobile network connectivity;
- Long travel times;
- Variable population density; and
- Lack of secure storage.

Most importantly, their work highlights the need for designers to identify and address physical factors from outside the immediate context of use that may be taken for granted when designing for a workplace setting in developed regions. They also emphasise the need to develop a deep understanding and appreciation for local people and their abilities. They found that limited education levels, underemployment and lack of disposable income were some of the day-to-day challenges faced by people living in rural areas. These factors had a significant impact on the design of the CAM system, particularly the user interface. For example, low literacy levels were addressed by providing voice feedback and visual and numeric codes on the user interface instead of text.

In a preceding paper, Parikh, Ghosh and Chavan [124] describe the early design phases of a micro-finance management system that led to the design of the CAM system. Here they describe two geographically separate ‘contextual studies’ that served as an input to their design process. Although this not explicitly stated, the approach appears to be user-centric in nature, consisting of a rapid ethnography. Their description highlighted a series of important techniques typically used in a rapid ethnography [103]:

- *Narrowing the focus:* Parikh and his team identified the research area of interest – micro-finance - before conducting the field visits. They also gained a detailed understanding of the micro-finance environment in rural India and the associated structures and processes that made it work.
- *Setting research questions:* The researchers understood the major problems facing the micro-finance industry in India, where all transactions must by law be documented and audited at the end of the fiscal year. For micro-finance institutions this is a time consuming task, made more difficult not only by the sheer number of transactions but also by the time and cost associated with travelling out to groups operating in rural

areas. Parikh questioned whether there might be a way to capture rural transactions and have them transparently transported and effectively integrated into wider accounting systems.

- *The use of key informants:* Parikh partnered with Dilasa and CCD (Covenant Centre for Development), non-governmental organisations (NGOs) operating in Aurangabad in Maharashtra and Tamil Nadu near Madurai. Dilasa and CCD initiated support for local micro-finance groups in response to the challenges associated with accessing loans from banks and government programmes. Their managers and field staff became Parikh's field guides (a type of key informant) and leveraged their existing relationships with the micro-finance groups to arrange a series of meetings for the research team. Working with the guides enabled Parikh's team to use their field time more effectively, focusing on micro-finance transactions rather than using up precious field time trying to work out where and when to look [103].
- *Interactive observations:* Parikh's field visit included in-depth observations of the people, processes and artefacts associated with micro-finance transactions. The team was able to ask questions during meetings to better understand how group members performed their transactions. They noted interesting patterns of activity such as reliance on a set of shared ledger books and the fact that data was often entered into the books by a child who attended school and could therefore read and write.
- *Collaborative data analysis:* Parikh's team met with CCD staff to review their notes and to discuss their observations, assisting them in interpreting what they saw and providing additional insight and knowledge.

Medhi, Sagar and Toyama's [101] work reiterates the importance of developing a thorough understanding of target users, their abilities and their physical context. They describe the design of a graphical user interface intended to serve illiterate and semi-literate novice users. Two specific applications were designed: The first provided an interface for finding a job as a domestic labourer in the city of Bangalore, whilst the second provided an interface to a generic map application for navigating the city.

Their strategy included a detailed ethnography that helped the designers gain a deeper understanding of the users and their daily activities, and enabled them to document specific

design challenges including:

1. How to establish trust and rapport within the community.
2. How to foster a relaxed environment in which participants felt able to discuss relevant design issues openly.

The researchers addressed these challenges by arranging frequent visits and by focussing on group work, which resulted in discussions and observations that formed the basis for their design.

Rachovides and Frohlich [133] comment on the execution of an interaction design project in the rural village of Budikote in Kolar, southern India. Their StoryBank project focussed on enabling community members to capture and share local stories in audio-visual format using a camera enabled mobile phone. Although not specifically stated, it appears that Rachovides and Frohlich [133] utilised a form of contextual inquiry on their first research visit to gain a detailed understanding of the physical and social conditions surrounding the research site, a local IT resource centre.

They became aware of several infrastructure limitations: The centre's power supply was unreliable and there was no GSM network coverage, ruling out the possibility of using MMS (Multimedia Message Service) to share the captured stories. They also noticed that the resource centre was a community hub and hosted a wide range of community activities including self help group meetings, IT classes, production work for the local radio station and even general visits by curious individuals. These findings led them to re-evaluate their initial assumptions and encouraged them to consider alternative networking options such as Wi-Fi or Bluetooth instead of GSM and to use the resource centre as the central hub for displaying and sharing the captured stories.

Rachovides and Frohlich [133] adopted a similar strategy to Parikh, Ghosh and Chavan [124] by seeking out local partners – in this case NGOs Voices and Myrada, who together ran a radio station that operated from the IT resource centre. The centre manager became their key informant and played an important role as a field guide by assembling the participants for focus group sessions.

Grisedale, Graves and Grünsteidl [58] describe a year-long contextual inquiry that analysed a work context and daily process flow within a rural Indian hospital. Their goal was to design a

mobile computing application for Auxiliary Nurse Midwives. The designers were working in an environment that was completely alien to them and posed numerous challenges. Some of these challenges arose from broad contextual issues such as language differences, complex social hierarchies and cultural customs, while others stemmed from organisational complexities within the healthcare sector.

### **Best practice and guidelines**

Brand and Schwittay's [14] work on human-driven design and research summarises the importance of understanding the local context in what they call "the four human dimensions of ICT": Local practices, participatory design processes, socio-cultural contexts and political conditions. They suggest that the success of an ICT4Dev design process, in their case the Lincos [56] project, hinges in part on the designer's attention (or lack of it) to these factors.

The Lincos ("Little intelligent communities") project specified an assembly for a telecentre that provided rural communities with access to ICT equipment, services and training. The centres were implemented in Costa Rica and the Dominican Republic, initially with the aim of extending the model throughout Latin America. However, the project never developed any further [56].

Brand and Schwittay's [14] research consisted of a longitudinal ethnography and analysis of the Lincos telecentres four years after they were first deployed. They found that almost all the public telecentres had been either abandoned or transformed into private businesses; in either case, the model of public provision had failed. Their evaluation produced a design approach called Human-driven Design and Research (HDDR) that highlighted the following points:

1. ICT4Dev initiatives must be driven by human needs and aspirations and complemented by an appropriate technology.
2. Assumptions about technology benefits and use should be put aside.
3. Existing technology solutions should be evaluated within the intended context of use to ensure that they are fitting or appropriate.

HDDR emphasises the need for designers to gather detailed knowledge of local physical, social, cultural, and economic conditions through long-term, human-centred research, for example an ethnography.

Bridges.org [16] echoes Brand and Schwittay's [14] call for ICT4Dev designers to develop an appreciation for the realities of local context. The NGO's *Real Access, Real Impact* (RA/RI) criteria present a simple analytical framework that aims to draw designers' attention to pertinent issues including:

1. Physical accessibility.
2. Appropriateness.
3. Human capacity and training needed to use the technology.
4. How the technology integrates into daily life.
5. The availability of locally relevant content and services via the technology.
6. Levels of trust in the technology.
7. Sociocultural factors.
8. The macro-economic environment supporting the technology.
9. Sustainability of the local economic environment required to support the technology
10. Public support and political will.
11. The relevant legal and regulatory framework.
12. Affordability of technology use.

Bridges.org developed this list of criteria after analysing many ICT4Dev initiatives to discover commonalities in the types of factors or forces that led to their success, partial success or failure. Each criterion embodies a particular factor or force that has been found to have a significant impact. The criteria can be used as an analytical lens to draw a designer or ethnographer's attention to pertinent issues, practices or patterns of behaviour.

The criteria encourage designers to widen their analytical lens and to appreciate that use of, or access to, particular technologies is subject to forces operating at a much broader level. This suggests that contextual inquiry, which tends to be highly focused in nature, may not be ideally suited for use in ICT4Dev initiatives. At the very least, such inquiries may have to be complemented by a method of inquiry, such as ethnography, that analyses a context through a wider lens [147].

#### 2.4.1.4 Discussion

ICT4Dev designers have used variants of two popular HCI methods, namely ethnography and contextual design, to develop an understanding of target users and their social context. These

activities were essential steps in establishing the research area of interest, setting the problem and identifying opportunities where an ICT could have a positive livelihoods impact. Several familiar tools and techniques have been used for this purpose:

- *Local partners and key informants:* ICT4Dev research agencies such as Bridges.org [17] and the Information Technology Applications Centre (ITAC) [50] stress the importance of fostering partnerships with local stakeholders. Bridges.org recommends partnering with a local champion, a person or group that sees the potential in ICT solutions and understands the vision and objective of the research. A local champion plays a key role in communicating and liaising with the community, actively promoting the initiative and acting as an advisor on local politics, social and cultural dynamics.

HCI researchers [58,122-124,133] have adopted a similar approach, partnering with local NGOs or organisations to identify key informants. Their notion of an ethnographic field guide, a type of key informant [103], is synonymous with Bridges.org's local champion. Field guides and local champions differ, however, in terms of their involvement over the course of the design process. A field guide is used primarily during the contextual analysis phases whilst a local champion participates throughout the design process. As an example, consider Rachovides and Frohlich's [133] IT resource centre manager, who performed additional roles such as arranging prototype evaluations and managing the deployment of the StoryBank system.

In all these cases, local partners and key informants played an important role in identifying the research area of interest and framing the problem to be addressed by an ICT design process.

- *Interactive observations and collaborative data analysis* – Parikh, Ghosh and Chavan [124] used these two techniques to good effect during field visits to rural Indian villages. They worked closely with field guides who introduced them to key members of the local self help groups within which micro-finance transactions were conducted (their research area of interest). Parikh and his team were able to interact with group members, asking questions about how they conducted transactions to develop their understanding of the process. The findings were then collaboratively consolidated with the help of knowledgeable field guides who were part of the Dilasa NGO that

supported micro-finance groups in the area.

- *Guidelines* – Brand and Schwittay’s HDDR, Bridges.org’s RA/RI and DFID’s SLF each provide a useful set of guidelines that help focus a designer’s attention on easily overlooked issues that may affect the success of a 4Dev initiative. The guidelines share some commonalities: All are people centric, accept that a broad range of dynamic, complex forces may be at work, acknowledge that micro- and macro-level factors must be considered and encourage designers to develop a detailed understanding and appreciation for the local context.

The clear message from 4Dev literature is that gaining a first hand, in-depth understanding of the local context is the first step towards designing an appropriate ICT4Dev system. Methods such as ethnography and contextual inquiry offer immersion into the users’ world and ultimately a reality check that helps to break down any false assumptions on the part of the researchers. A good example of such a ‘reality check’ can be found in Rachovides and Frohlich’s [133] paper, which describes how their initial assumptions about GSM and MMS availability were challenged soon after arrival in the field.

Leonard and Rayport’s [86] article in the Harvard Business Review dubbed this type of immersive, observational approach ‘*Empathic design*’, a term that we will use throughout this thesis.

### **The scope of UCD**

Kam et al.’s [78] call for UCD to expand its scope, and for designers to consider comparative studies across multiple sites, is a point of interest. Following this suggestion would help to address the dynamic and complex factors discussed above – but would also require more field time. As mentioned above, longitudinal ethnographies have previously been used to develop exactly this in-depth understanding of complex social settings, but have been criticised as time-consuming and unable to meet the demands of industrial software processes [103]. The HCI community has responded with a variety of highly focused ‘quick and dirty’ [2,69] approaches to gathering information about a social setting, for example rapid ethnography [103] and rapid contextual design [67]. Usability experts such as Nielsen [116] have developed similar discounted variants of traditional user-centred techniques to enable software companies to reap the benefits of usability engineering despite cost and time

pressures.

There is a tension here. In the ICT4Deve context, HCI researchers have made it clear that additional field time is required to produce appropriate ICT solutions, be it for building local partnerships, understanding the social setting or for building local capacity through training. Parikh, Ghosh and Chavan [124] reported on the need for design teams to spend additional time in the field to build trust and rapport with the local community and to dispel their 'novel' status. Industry, however, is calling for rapid approaches, discounted techniques and quick answers.

Beyer and Holtzblatt [11], for example, encourage contextual designers to develop a 'cultural model' as a way to factor the effects of the user's culture into the design process. They argue that although culture is invisible, it affects a user's social setting, how they approach their work and ultimately their actions. The cultural model therefore depicts influencers (people, organisations and groups) as well as the cultural pressure or weight they exert on the user's actions. However, generating such a model requires aggregating and consolidating many observations and conversations over a period of time: it is a time-consuming exercise. Beyer and Holtzblatt thus do not include this process in their rapid contextual design method.

Bridges.org [16] believes ICT4Dev researchers must develop a solid understanding of social and cultural forces, and therefore suggest taking the time to construct cultural models. Well-structured organisations in the developed world may be resilient to technological designs that do not fit the context perfectly, but evidence from ICT4Dev literature suggests that social, cultural and political forces can derail the uptake of an inappropriately designed solution.

## **Summary**

The HCI community has long accepted that in order to build appropriate computer systems designers must focus on the needs, abilities and context of the target user throughout the design process. In the words of Bill Buxton [19:143] "I simply take it for granted that the user is both considered and involved throughout the process."

UCD, a popular method amongst HCI designers, provides a set of proven methods for achieving this, namely ethnography and contextual inquiry. These methods attempt to develop a sense of empathy for users and their context through observation and inquiry. The purpose is to gain a detailed understanding of a particular work or social activity, the user's experience

of it and how it fits into their wider social situation. The designer uses these insights to frame [8] the problem space and to identify opportunities for a technological solution, both of which will be encapsulated in the requirements specification.

The success of UCD therefore hinges on the designer being able to gather the necessary contextual information, interpret it correctly<sup>2</sup> and generate a requirements specification that addresses a locally relevant problem. From an ICT4Dev perspective this process would need to result in a requirements specification that addresses a livelihoods problem within the community.

ICT4Dev researchers have pointed out, however, that in developing-world contexts UCD methods also have to appreciate wider social, cultural and political factors in order to produce an appropriate requirements specification. This process, in their opinion, demands additional field-time, which is at odds with the demands of the industrial software industry. What is good, efficient design practice in first-world work settings may fail in other environments.

#### 2.4.2 Specifying user and organisational requirements

Having understood the context of use, the next step in a UCD process is to analyse, consolidate and codify the contextual data and then use the findings to generate a requirements specification. The purpose of the transformation is to ensure that user needs are central in shaping the requirements to be satisfied by the designed solution. The design artefacts that make up the requirements specification (documents, diagrams or multi-media etc) may also be used for supporting important design communications between the various projects stakeholders and the designers. It is important to note that even though the users are primary stakeholders, the nature or format of the artefact may not be suitable for communicating with them – it is not a solution prototype.

The first two phases of a UCD process are therefore concerned with the setting [143] or framing [8] of the problem, in other words defining the problem that needs to be solved and communicating it (as currently understood) to the stakeholders and designers. The details of the problem space serve, amongst other things, to provide designers with a set of observed opportunities for a technology intervention, inspiration and a list of known constraints.

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<sup>2</sup> A correct interpretation, in this case, implies that the designer's interpretation of the contextual information leads to the design of an 'appropriate' artefact.

Formally, a software requirement is described as high level, abstract statement of service that the system should provide [149]. From a user centric perspective a requirement can be described as a service needed by the user to solve a problem, in our case a livelihoods problem. System requirements can typically be split into two groups: Explicit and implicit. Explicit requirements relate to the future work or social processes that the system aims to support or enable, which in turn are traceable back to the livelihoods problem being addressed. Implicit requirements are those that do not emerge directly from the contextual analysis, but are still requirements for an appropriate solution -- usability is a good example. ISO 9241 [10,76] defines usability as the 'extent to which a product can be used by the specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use'. Contextual findings help define these specified goals, users and context of use, but it is left to the designer to define the quality metrics and measurements for effectiveness, efficiency and satisfaction. Cockton [29,30] believes that these have to be at least good enough not to degrade the delivery of value, which will stem from the user's ability to address a livelihoods problem through the designed technology.

The challenge for the designer is, as Rachovides and Frohlich discovered [133], to avoid relying on assumptions. For example, researchers have reported on the low levels of education and high levels of illiteracy evident in rural India [101,124]. A designer for such a context cannot make assumptions about what is considered usable and what isn't: Each quality (effectiveness, efficiency and satisfaction) has to be defined and evaluated within context. As Bridges.org [16] has pointed out, the implication is that pre-packaged solutions that have worked in developed regions may not be appropriate for use in developing regions – or at least not without modification. Once the explicit and implicit requirements have been defined, they are used to produce metrics against which the designed solution will be evaluated.

#### 2.4.2.1 Requirements specification and Contextual Design

Contextual design [11] uses physical, flow, sequence, artefact and cultural models to capture users' existing work and social practices. To achieve this, the models must be centred on users and grounded in the realities of their social setting. The models serve as a tangible design artefact and can be used for design communication between the contextual researchers, stakeholders and designers. The models are presented to the stakeholders and designers and consolidated through discussion and reflection. Parikh, Ghosh and Chavan [124] noted that it

was useful to include their field guide in the consolidation sessions as the guide provided additional insights and validation of the team's interpretation of users and their context.

The consolidated models are then used to identify opportunities for technology to better support or enable a particular work or social process. The models help keep the designers focused on how a technology can help people get work done, or enable a desirable social activity, rather than focussing on all the possible things the technology can do [11]. The redesigned models are portrayed in 'vision' stories that describe how the users will use the technology in the future. A popular technique is to capture the stories in a series of scenarios [20,21,55]. A scenario is a representation of one of the situations the technology will have to support, captured in a narrative about a user's interaction with a technology that describes how the technology should work, how it would be used and how it should fit into the user's context and daily routine.

Scenarios, like contextual models, are intended to be an accessible platform for design communication between stakeholders and the designers. They are, for this reason, packaged in simple textual narratives, graphical storyboards or video mock-ups. The goal is to create a common platform for engagement and immersion for all stakeholders, which is in striking contrast to traditional requirements specifications that are often complex, full of technical terminology and void of user goals or details regarding the context of use.

#### 2.4.2.2 Requirements specification and ethnography

Ethnographic data, similarly, is typically analysed and packaged into detailed, discursive narratives that present the findings of the field study. The findings serve to inform the designers about the social situation under investigation, as it is experienced by the target users. Crang and Cook [33] point out that an ethnographic report is an attempt to represent the field material and the subjects' (target users') views and to expose related patterns and behaviours. The latter is a crucial step in the analysis of ethnographic data: It enables researchers not just to uncover what the subjects say and do, but why this has come to be the case and what the wider causes and effects of their views might be [33].

Whatever the raw data consists of, designers must codify it in an attempt to highlight meaningful patterns and themes. Crang and Cook [33] describe the codifying process as the process of giving similar events, themes or actions similar labels to show a logical relationship. The labelled items then need to be categorised in an attempt to identify

meaningful patterns, connections and themes. These will, in turn, form the basis for the requirements specification, which encapsulates the contextual data regarding the users, their context and the underlying problem or needs to be addressed through the designed artefact.

A good example of the use of an analytical framework or lens applied to contextual data can be found in Reddy and Dourish's [136] use of temporal rhythms to surface meaningful patterns and themes in how information was accessed and transferred between staff members in a hospital setting.

#### 2.4.2.3 Accounts from 4 Dev literature

ICT4Dev literature currently includes very few accounts that document the process of translating contextual findings into a requirements specification. A typical example would see the author/s describe the context, indicating that some sort of fieldwork was conducted, followed by a concrete description of the problem that was addressed and the resultant prototype that was deployed [12,124,125]. The process of developing a requirements specification is not discussed.

A critical analysis of a seminal HCI4Dev account provides some insights regarding this gap. Grisedale, Graves and Grünsteidl's [58] account of the design of a mobile data capture interface for Auxiliary Nurse Midwives (ANMs) in rural India provides a brief but thought-provoking perspective on the translation process. They begin with a contextual overview of rural India and the role played by ANMs within the healthcare sector, before presenting a set of design goals derived from their observations of the ANMs and discussion with the Indian government. The latter was their attempt to frame the problem space and negotiate a design trajectory based on a set of general user and organisational requirements. In essence they wanted to support an inefficient, paper-based process with a digital data capture tool. In a section titled 'Transferring from paper to an electronic format' the authors describe how difficult it was to get to grips with the problem. Their first sentence reads: "This was not as easy as it sounded." [58:474]. They add that it took them over a year to figure out how the captured data fit into the wider healthcare information system. This provides an indication of just how complex the design environment was, and how difficult it was for outsiders to gain a working understanding of the healthcare information system.

For example, the researchers [58] describe a design workshop at which they attempted to engage with Indian healthcare experts. The abstract nature of the design concepts discussed,

combined with language barriers and a general misunderstanding of the design process, made it difficult to generate a comprehensive understanding of user needs or to generate a requirements specification. The health care experts were confused as to why American design experts were acting naïve and asking them so many design-related questions.

Grisdale, Graves and Grünsteidl [58] tackled this complexity by rapidly iterating through UCD cycles, using picture cards and task sequence cartoons to work around language barriers and to gather feedback from various stakeholders. The findings were used to adjust their understanding of the users, their context and their needs to finally generate a set of requirements .

#### 2.4.2.4 Summary

The designer's task is to analyse contextual data and transform it into a requirements specification. CD achieves this by generating a series of work models and scenarios, consolidating and then remodelling them with the help of stakeholder input. Ethnography uses a process of working through the contextual data, codifying it and identifying meaningful patterns and themes before generating a requirements specification.

CD and ethnography have been applied successfully in developed world design initiatives, but once again 4Dev literature highlights several challenge, including language barriers, that make the generation of a requirements specification difficult. 4Dev designers have addressed this problem by starting down a design trajectory, then iteratively adjusting their understanding of the problem space through techniques that develop design communication with primary stakeholders.

#### 2.4.3 Producing design solutions

Once user requirements have been specified, UCD requires the designer to generate a solution based on these requirements — and then to factor evaluative feedback from users back into the process after each design iteration. One popular technique is to use design prototypes of varying degrees of fidelity and interactivity to communicate, explore, refine and evaluate design ideas [148]. Norman [120] sees a technological artefact as a medium through which the designer communicates a conceptual model, based on the requirements specification, to the user [119,120]. A prototype, likewise, can be considered a medium that both encapsulates the designer's conceptual model of a proposed solution and conveys it to the user.

The next step in the communication process is for the designer to determine whether user interpretations of the prototype (their mental models) coincide with the designer's conceptual model. A simple way of evaluating a prototype is to ask users to describe, through words or actions, how they would use it to complete a particular task, achieve a particular goal or solve a problem. The prototype is validated according to users' ability to interact with it to complete the task. A breakdown in design communication happens when there is a mismatch between users' mental models and the designer's conceptual model – either the designer's conceptual model or the prototype is not appropriate and needs to be adjusted.

In some cases, the breakdown may simply be a result of the fidelity of the prototype. Fidelity refers to the degree to which the prototype represents the breadth, depth and finish of the intended solution [148]. Low-fidelity prototypes are important because they are able to convey a design concept to users early in the design process. They typically simulate a simplified version of a proposed design solution that doesn't look 'finished' or present users with all the intended interactive functionality. Such prototypes are valuable because they are quick and cheap to build, yet also able to uncover several usability problems [148].

There are limitations to their usefulness, however: Lim et al. [88] found that the abstract nature of low-fidelity prototypes led to certain visual elements being misunderstood and visual affordances missed. They found that it was sometimes difficult to determine if a usability finding was the result of the design concept being evaluated, or of the prototype itself. Stacey, Eckert and McFadzean [151] point out that sketched prototypes can be ambiguous; that is, they may afford alternative symbolic interpretations. They point out that the design space (designer's concept model) gets mapped to an interpretation space (user's mental model) through the sketch; ambiguity may result in the two spaces not coinciding. Tohidi et al. [154] found that low-fidelity sketched prototypes can be used to expose inherent usability problems ('get the design right') but are, on their own, not as effective at eliciting feedback regarding the underlying design concept ('getting the right design'). They do, however, believe that low-fidelity prototypes used in combination with procedures and activities from Participatory Design [56,81,82,110,111] (discussed in more detail below) can be used to solicit ideas.

This raises an interesting point. The intention of Participatory Design [56,81,82] is to empower the voices of all participants, creating a democratic platform on which all voices can

be aired and equally valued. The success of such an environment relies on effective communication and engagement between all participants. So, low-fidelity prototyping relies on a strong auxiliary communication platform between designer and user, outside of the communication that is happening through the actual prototype. As discussed above, Gridsdale, Graves and Grünsteidl [58] pointed out that a breakdown in their auxiliary communication was detrimental to the design process, especially when abstract design artefacts and concepts were introduced. These required additional explanation from the designer.

De Souza [35] sheds some additional light on this issue. She points out that if a designer is able to communicate the reasoning behind the underlying design concept, the user will find it easier to uncover the intended conceptual model via the prototype. Norman [120] explains that graphical user interfaces (GUIs) are good at informing users of the possibilities that are available at any point in a task sequence, but not necessarily the reasoning behind them. In his example he describes the familiar greyed-out button which tells users that a feature is currently unavailable: it does not suggest why this is the case, nor how to make it available again.

One way of communicating design reasoning is for designers to explain their intentions directly to users. This is essentially what happens during a participatory design session, which aims to facilitate communication and reasoning around a design concept. As we have seen, however, building a solid foundation for design communication in a 4Dev environment can be challenging.

#### 2.4.3.1 Accounts from 4Dev literature

Gridsdale, Graves and Grünsteidl [58] presented paper prototypes to health care experts in an attempt to foster a platform for design communication. They note that their design “concepts were not well received by the very practical and dedicated members of the healthcare community”, describing how shocked some of their Indian collaborators were when they presented medical experts with paper prototypes and asked naïve questions. There was clear evidence that the participants did not all understand the purpose of the design session and how it fitted into the wider design process. The researchers needed design props, in the form of cards with drawings showing the typical daily activities of an ANM, to foster design dialogue in the face of language barriers. Despite these challenges, the authors were able to collaborate with their target users to produce and evaluate sketched prototypes of icons for the mobile

user interface.

Medhi, Sagar and Toyama [101] used a similar approach when developing text-free user interfaces for a job search portal for domestic labourers and a map for navigating the city. They experimented with mock-ups (assumed to be paper prototypes but not explicitly stated by the authors) of the two applications, consisting of printed imagery, graphics and numbers to convey the necessary job and navigational information. The prototypes were presented to users to elicit reactive feedback and discussion. Their results showed that in some cases the abstract nature of the images caused confusion, whilst in others the images were interpreted too literally. User interpretations of graphical cues also varied according to their religious and cultural backgrounds.

Parikh, Ghosh and Chavan [124] used paper prototypes to gather feedback on their initial user interface designs for a micro-finance application. Initially the participating villagers were confused by what they were shown. After more explanation by the designers and intermediaries, the users were able to understand the concept and provided some valuable design feedback. The authors then used their findings to produce a higher-fidelity prototype that was presented to villagers on a laptop computer. This prototype was able to elicit specific feedback relating to interface elements such as the information layout and colour schemes.

Blake et al. [12] used a slightly different approach for the design of Cybertracker, a mobile data capture tool that allowed semi-literate animal trackers to gather information on the distribution and behaviour of wild animals in a game park. Instead of starting with low-fidelity prototypes, the authors constructed a high-fidelity prototyping environment that could be adjusted or extended after each usability test with the trackers. After each session the authors consolidated the usability data and then used the Cybertracker interface designer (a component of their Cybertracker PC application) to adjust the existing icons, captions, screen flow and navigation before the next session. While this increased the time to complete each design cycle – programming takes longer than sketching – it enabled the designers to develop a successful artefact.

Blake et al.'s work highlights two important points:

- Target users (the trackers) were directly involved in the design of the user interface. The designers (the authors) immediately factored feedback and suggestions into the

design process and the changes were evident in the subsequent prototype. Most importantly, the trackers were able to witness the effect their input had on the design of the prototype – their voices were encouraged and acknowledged.

- The authors opted to prototype on the Apple Newton device, side-stepping the ambiguities associated with paper prototyping. Design communication was therefore grounded in a first-hand experience of the technology rather than in the users' imaginations.

#### 2.4.3.2 Summary

User centred designers typically employ prototypes of varying degrees of fidelity to establish a platform for design communication and to gather feedback from users. Low-fidelity prototypes can be produced quickly and cheaply – but tend to introduce a degree of ambiguity that can cause misunderstandings and limit their effectiveness.

Tohidi et al. [154] note that low-fidelity paper-prototypes are most effective within a collaborative design environment. Such a process relies on effective communication – which is also needed to determine whether the design (encapsulated in the prototype) is moving in an appropriate direction. Effective communication is also necessary for explaining the reasoning behind the design process and the various design activities. 4Dev designers have described situations where the participants were confused as to the purpose of the paper-based design activities and additional explanation was required [58, 124]. Blake [12] et al.'s work showed that a malleable, high-fidelity prototyping approach was effective at establishing a collaborative environment in which users with low levels of education and literacy were able to contribute to design activities.

Thus, existing prototyping methods have proved to be useful in 4Dev design processes provided that they are supported by a solid communication platform. Such a foundation enables the designer to:

- Remove ambiguity by explaining the reasoning behind the design process.
- Create a collaborative environment in which users are able to provide design feedback through words or actions.

Establishing such a communication platform is challenging within a 4Dev environment, all

the more so when the designer must overcome language barriers, cultural differences and knowledge or skills deficits among users, intermediaries and the designers themselves.

#### 2.4.4 Evaluating the solution against the requirements

The evaluation phase of a UCD process requires the designer to validate the designed solution against the user and organisational requirements that were specified. To do this, the designer must first develop a set of evaluative metrics against which the design will be tested.

Existing UCD evaluation methods attempt to validate the quality of a design based on users' ability to complete a series of tasks. If users are able to complete the tasks, designers can be satisfied that users' mental models coincide with their conceptual models and that the underlying design is appropriate. Traditional task-based usability studies are often conducted in controlled laboratory settings where users' actions and behaviour are recorded and coded for analysis. Designers are primarily concerned with evaluating the usability of the prototype.

ISO 9241-11 [10,76] breaks quality in use (usability) down into three measures:

1. Efficiency, defined as the accuracy and completeness of the goals achieved.
2. Productivity, defined as efficiency versus the resources expended (including mental effort and time).
3. Satisfaction, defined as acceptability and comfort in use.

To implement these metrics, a usability evaluator would typically derive a set of tasks from the envisioned scenarios of use for an artefact, then ask the target users to complete the tasks using the prototype. The evaluator would then measure the users' efficiency, productivity and satisfaction whilst completing the tasks. If the measures fall within an acceptable range, the design passes; if not, the evaluator needs to identify the causes of the problem and correct them during the following design iteration.

Whilst such an evaluative process supplies experimental rigour, it fails to factor in the effects of the broader social and environmental context, which 4Dev researchers believe must be considered [16]. An interactive technology destined for 4Dev deployment must be evaluated at two levels: First, the designer must check that the technology is usable by the target users and fits their immediate context of use. If these preliminary conditions are found to be 'good enough', Cockton [29,30] believes that the design should then be validated according to its

ability to deliver value – the second level. Cooper, Reimann and Cronin [32] believe user needs will be satisfied and value delivered if they are able to achieve their goals, which are subject to a variety of socio-cultural and environmental forces. If so, the technology can be considered both useful and appropriate.

#### 2.4.4.1 Accounts from 4Dev literature

Parikh, Ghosh and Chavan [124] evaluated the navigation of a PC-based user interface in rural India. They attempted to assess users' ability to associate a number, icon or image with an abstract concept or related action, by asking them to identify screen elements and to complete a series of tasks using the interface. While the authors did not mention the specifics of the evaluative protocol they followed, their account makes it clear that they attempted to:

1. Develop trust and rapport with the target community so as to encourage feedback and criticism.
2. Conduct evaluation sessions in a familiar, non-threatening location that accurately modelled the usage context.
3. Use trusted local intermediaries for language translation and joint facilitation.
4. Encourage participants to ask questions, make suggestions and offer recommendations at any point during the session.

Pawar et al. [126] evaluated the use of computers with multiple mice ("MultiMouse") in Indian schools. They considered both the educational value of MultiMouse versus single mouse configurations and how the supporting software should be designed to encourage the most learning with MultiMouse. The complexity of measuring deeper educational impacts such as comprehension or knowledge synthesis would have required a longitudinal study, so the scope of their evaluation was limited to simple memory retention tasks. The authors settled on a basic multiple-choice, image-word matching test of memory retention, due to its simplicity and objective measurability. Most importantly, the study was conducted in a rural classroom, thereby simulating a regular educational setting for the students.

Parikh et al. [122] evaluated the design of their CAM micro-finance system (discussed earlier) by combining the results from various task-based assessments. The results were used to determine whether certain usability qualities were satisfied, including efficiency, accuracy and accessibility. Parikh et al. made a concerted effort to conduct the assessments with target users *in situ*, to simulate a real micro-finance transactional setting and thereby factor in the

effects of the wider context.

Other 4Dev frameworks [74, 50] take a broader evaluative approach, focusing for example on the social and economic impact of ICT deployments. Outcomes Mapping [74] assesses a development program's effectiveness in terms of observed changes in local behaviour, relationships, actions and activities of the people with whom the program works directly ("boundary partners"). The method suggests a shift of evaluative focus: Instead of trying to measure a direct causal impact, the researcher seeks outcomes that can be logically linked to the program's activities.

Outcomes Mapping encourages designers to think about the changes they would like to support at a macro level, and then to plan the strategies they will use to achieve these changes. The outcome of a strategy is measured according to a set of progress indicators negotiated between the designer and the boundary partners, ensuring that the program is directed towards changes that the boundary partners want to bring about.

The International Development Research Centre (IDRC) believes that setting the evaluative focus on 'changes in behaviour' is important because it emphasises that, to be effective, development programs must go further than simply creating and disseminating information. Rather, their goal should be for boundary partners to apply and adapt the development information within their daily lives. Heeks' information chain [63] emphasises a similar point in that it is not enough to simply deploy an ICT that provides access to information. The target users (boundary partners) need to be able to assess, apply and ultimately act on the information they consume. Heeks notes that this progression can only take place if the necessary social and economic resources are in place, such as money, skills, motivation, confidence and knowledge. Hudson [68] adds that 4Dev researchers must ensure that their partners fully understand the purpose of the evaluative activities; these should be presented as a learning activity, not a judgement of individual performance. This is in line with the SLF's [40] recommendation that researchers should focus evaluative activities on identifying and building on positives and strengths.

A UCD process within such a development program, then, would form part of one or more of the strategies -- in our case the design of an interactive technology -- that contribute towards achieving the desired outcome. In this case technology can only be deemed appropriate if it progresses the indicators. Quality in use and contextual fit are implicit qualities that need to

be, in Cockton's [29,30] words, 'good enough' not to degrade the delivery of value, which is a contributing factor to a positive outcome.

At present, IDEO's [72] Human Centred Design (HCD) methodology is the only widely reported way to integrate interface-level evaluative activities with those operating at a macro-framework level. HCD introduces a pattern of iterative learning in which design and evaluation are a seamless process; there is no clear line between implementation and evaluation and monitoring. IDEO's approach builds on the understanding that a designed artefact will have an effect on people's lives, whether positive, negative or neutral. Designers therefore need a feedback mechanism and a baseline measure to determine whether the artefact is effective and appropriate (i.e. both useful and usable within context).

HCD proposes a learning loop that consists of Stories, Feedback, Indicators and Outcomes. The loop starts with Stories: the designer must consolidate all the available information, including data from evaluation sessions, and present it to the rest of the design team as stories. These are then used to measure the solution's livelihoods impact, against a baseline established initially through a detailed assessment of local needs and context. Once an implemented solution is available, the Story phase is used to modify the measurement criteria.

The Feedback phase, as its name suggests, focuses on gathering feedback from people in the community who have interacted with various prototypes. The purpose is to rapidly and iteratively evaluate ideas that have been prototyped; from these evaluations the field of possible solutions is narrowed and a small number are selected for higher-fidelity prototyping or implementation.

The Indicator phase provides a slightly broader evaluative perspective. This phase is for choosing between ideas or iteratively evaluating a solution by tracking its progress according to a set of livelihoods indicators. Another important role of this phase is to identify unintended consequences. HCD provides a list of indicator types:

1. Leading indicators: The desired livelihoods outcomes might take months or even years to achieve. Designers are encouraged to define sub-indicators that measure the presence of prerequisite or leading activities, behaviours or actions.
2. Analogous indicators: It may be difficult to define an indicator for the desired livelihoods outcome. Designers are encouraged to define analogous or proxy indicators that allow

them to logically deduce or conclude if an outcome has been achieved.

3. Awareness indicators: If the livelihoods outcome requires the community to engage with or use a new technology, awareness is a useful leading indicator to predict its impact.
4. Engagement indicators: The level of engagement is an important determinant of impact. If community members are actively seeking out and participating in design activities, the designer can be confident that the technology is creating a 'buzz' and generating interest.
5. Dynamic changes: It is important to track changes in the community, whether positive or negative, from an early stage. Unintended consequences must be noted and explored in order to fully understand the impact and future potential of the technology.

The Outcomes phase closes the iterative cycle: It assesses the impact of the solution on the community and various stakeholders, and gauges progress towards the desired livelihoods outcome. The designer is required to reflect on the results of the feedback and indicator cycles. The findings will be used to:

- Adjust the baseline values defined in the Story phase.
- Suggest changes to the design of the technology.
- Contribute to the generation of knowledge for the design community.

#### 2.4.4.2 Summary

User-centred designers typically evaluate an interactive technology in terms of its ability to communicate the designer's conceptual model of how the user should employ it to complete a set of tasks and ultimately achieve the desired goal. This assumes that the designer is able in the first place to generate a conceptual model that is appropriate for the tasks and class of user defined in the scenarios [119,120]. The designer then attempts to evaluate the user's ability to complete a series of tasks en route to their goal. If the user is able to successfully achieve the goal, it implies that the user's mental model of the technology matches, or at least sufficiently coincides with, the designer's conceptual model.

At this point the designer can be confident that the technology is at least usable at the most fundamental level. Next, the designer needs to determine whether the technology fits the intended context of use. 4Dev designers believe that a technology must be evaluated *in situ*, thereby testing the design amongst all the wider contextual forces. The designer needs to

choose evaluative instruments that are able to determine both whether the target users can complete the tasks necessary to achieve their immediate (short-term) goals, and whether those successes have in some way contributed towards the achievement of broader livelihoods goals.

4Dev researchers have successfully used *in situ*, task-based evaluative techniques to evaluate the usability and short-term impact of ICT solutions [122-124]. Traditional UCD techniques are able to validate the appropriateness of a technology design, in terms of its usability and fit within the immediate context of use. This is, however, not enough. 4Dev evaluative frameworks, such as Outcomes Mapping, require designers to evaluate the appropriateness of a technology at a much broader level: Does it have the ability to promote positive actions and changes in behaviour that collectively lead to a positive livelihoods outcome? The changes and outcomes are measured through a set of progress indicators negotiated with local project partners.

From Cockton's [29,30] perspective, a positive change in behaviour and repeated use of a technology indicates that value is being delivered and that the target users are achieving a goal or satisfying a need. The goal specified in the designer's conceptual model therefore matches, or at least coincides, with user goals – the technology design can be deemed appropriate.

If we trace the origin of the conceptual model back through the UCD process, we notice that its success relies on the designer being able to:

- Correctly identify a locally relevant livelihoods problem.
- Successfully interpret and translate the contextual findings and associated livelihoods problem into a comprehensive requirements specification.
- Design an appropriate technology solution that addresses users' livelihoods problems or needs.
- Communicate sufficient design reasoning to users that they are able to understand the purpose of the technology and use it effectively and efficiently to address their problem or needs.

- Gather sufficient feedback and measurements to be able to determine whether the design is appropriate for the target users in their context, and whether it delivers real value. If not, the designer needs to make appropriate modifications to his design.

## 2.5 Participatory design

Throughout this chapter it has become increasingly evident that 4Dev researchers utilise participatory activities throughout their UCD processes. In fact, DFID [40] believes that a 4Dev initiative will be ineffective unless conducted in a participatory manner. Participation is therefore at the heart of their Sustainable Livelihoods Framework, which suggests using participatory activities to:

1. Establish people's real livelihood objectives, without prejudgement from the designer as to what those may be.
2. Identify and build on community strengths.
3. Determine the influence of macro-level policies on livelihoods.
4. Negotiate local impact indicators and metrics.

These activities help to factor the real needs and desires of target users into the development processes and strategies, thereby giving these strategies the best chance of achieving the intended positive livelihoods outcome.

UCD is compatible with the SLF in that both are human-centric, but UCD does not require active user participation. Methods such as contextual inquiry [11] encourage designers to employ user participation in understanding context, but not necessarily in the remainder of the design activities [56]. 4Dev designers have thus turned to tools and techniques from Participatory Design [28,110,111] (PD) to achieve a stronger participatory design environment in other areas of a UCD process. PD provides tools, techniques and practices for including the target users as participants throughout the design process. The rationale behind the methodology is that users need to be able to express their views and to negotiate various design decisions as equal partners.

But as Heeks [64] points out, the term 'participatory' defies tight definition and the intended meaning is often vague. In some instances it has been used to imply that the designer and target users worked as co-designers; in others, the users played a merely informative role. Typically the type or level of participation is chosen according to the designer's discretion or

is a result of external forces e.g. language, political or social barriers. Grisdale, Graves and Grunssteidl's [58] work included users in the design process by building on their familiarity with existing paper documents and work flows. Parikh, Ghosh and Chavan [124] used key informants to engage villagers as participants to provide specific feedback, suggestions and constructive criticism on a design prototype.

Clement and van den Besselaar [28] remind designers to validate participatory practices in terms of Kensing's [80,81] three basic requirements:

1. Target users must have access to **relevant information**. If they lack information regarding the aim of the design process, the associated technologies or the design activities, participation will be difficult to achieve.
2. The target users must have the possibility of taking an **independent position**, expressing their own opinions and views. Social, political and even physical forces may prevent certain people from participating fully. Users who feel intimidated are unable to engage in meaningful design-related dialogue.
3. Users must in some way participate in **decision-making**: They must be confident that their contributions are valued and will shape the outcome of the design process.

Achieving a level of participation that satisfies all three criteria within a 4Dev design environment is often difficult. Puri et al. [132] note that participatory activities are subject to localised socio-economic, cultural and political forces. They found that in South Africa participatory practices were heavily influenced by local cultures that affected how participatory workshops were organised, the topics negotiated and who attended the sessions.

Medhi, Sagar and Toyama [101] found that Indian women living and working in the slums of Bangalore often lacked the capacity to participate effectively and were nervous and easily intimidated when engaging with the designers. When 4Dev designers are able to engage with marginalised or disempowered people, Heeks notes, they often opt for weaker forms of participation due to language, cultural, political and knowledge barriers [64].

Scaife et al. [141] present an informant-based variation of PD that compensates for factors that may prevent people from working as co-designers. They describe a design scenario in which children and designers had to work together in a single participatory design

environment. The initial vision was that both parties should be equal design partners, but inequalities of knowledge, skill, experience and authority between the children and the designers made this impossible. Given these obstacles to full partnership, their recommendation was rather to view the children as native informants, in the same way they might be viewed in an ethnographic study. This response acknowledges that there were aspects of the context and of the design process that the designers could not be aware of; they had to rely on the children as informants to show or tell them.

This approach restores some equality to the relationship, as well as allowing for the inclusion of other informants such as teachers. Using children as native informants helped the researchers to discover what they did not know, rather than try to confirm what they thought they knew [141].

4Dev designers often face similar issues. Scaife's solution requires designers to be smart, by devising design techniques that can leverage native informants' knowledge and factor it into the design process. Ramachandran et al. [134] applied Scaife's native informant concept to a 4Dev design space in which the target users had little or no prior exposure to technology, but possessed a wealth of local knowledge. They modified the approach to include simple pieces of technology, called technology probes, to attract potential users and catalyse technology-related discussion and participation.

## **2.6 Technology probes**

The use of technology artefacts as probes was first documented by Hutchinson et al. [70]. They describe a technology probe as a simple, flexible and adaptable piece of technology that is deployed in a real-world setting with the goal of:

1. Understanding the issues surrounding the use of a technology in a complex environment, such as a home.
2. Field testing the technology to determine its suitability for the deployment context.
3. Inspiring both users and designers with visions for new applications and design directions.

Ramachandran et al. [134] noted that the perspectives and social dynamics surrounding technology deployments in developing regions were often complex. Technology probes are

therefore attractive because:

- They can be deployed early in the design process.
- They are easy and quick to learn and understand.
- They are able to accommodate broad, diverse user groups.

Technology probes, unlike a low-fidelity prototype, are not an abstract representation of a design concept. Instead, the design is made tangible and affords the participants hands-on experience early in the design process, similar to a high fidelity prototype.

Technology probes are also a cost-effective way to explore the impact of a technology before significant resources are invested in a particular design solution. This makes them an ideal tool for gathering information about local perspectives on technology and how these change over time.

Ramachandran et al. [134] used simple technological artefacts as tools around which observations and interviews were conducted in India and Uganda. Their goal was to demonstrate the utility of the artefact to elicit a response and to stimulate technological discussions. The activities helped establish a local technological baseline, extract and build upon existing knowledge within the target community and discover the local community's perspective and attitude towards the technology artefacts.

Three technology artefacts were used:

1. The Combadge, a mobile device that supported asynchronous voice messaging through a speech-based interface and wireless networking feature. The authors adapted the device to support the local language, Tamil, by changing the output voice prompts.
2. The Lipman Nunt 8000, an off-the-shelf point of sale device that enabled micro-finance transactions to take place in rural villages. The mobile device provided GSM (Global Standard for Mobile) network connectivity, a printer for transaction receipts and a smart card reader to enable secure transactions.
3. The Concord 1200X and DSC Pro digital cameras were used by village school children to document their daily lives. They were then asked to share and describe

their photos and their experiences with the researchers.

Ramachandran et al. [134] noted that an important part of their approach was to treat artefact demonstrations as a community event, opening up the potential user base to any community members that were curious and intrigued. Their belief was that eager individuals would ultimately become future co-designers, experts and technological intermediaries within the community.

Their approach is noteworthy because it:

1. Extracts and builds upon users' existing experiences of and perspectives on familiar technological artefacts.
2. Helps the designer gain an understanding of the social networks and key players within the community.
3. Extracts valuable contextual information early during the design process.

## Summary

Technology probing strives to deploy a working prototype as early in the design process as possible, and then to extract user perspectives of and visions for the technology probe. 4Dev designers have focussed on deploying off-the-shelf technologies that were able to demonstrate simple and immediate utility to novice users. Their purpose is to allow a wide range of users an opportunity to experience technologies in situ, and then to observe the effects on the social dynamics of the community. The designer is then able to learn about the types of people who would be interested in such a technology and to extract inspiration for possible design directions.

By contrast, an empathic UCD process uses the initial design cycles to try and develop a detailed understanding of the local context and livelihoods needs, and then to identify a livelihoods problem that could be addressed through the design of an ICT.

The livelihoods impact of a technology probe is emergent. That is, the designer cannot know in advance what its possible livelihoods impacts might be. Instead, the probe is deployed within a particular social setting to learn how the users perceive it, how they interpret its utility and how they might apply it within their daily lives. By consolidating multiple perspectives, designers are able to gain an understanding of the probe's potential impact on social dynamics, behaviour and livelihoods. Early design decisions can then be based on user

interpretations of a technology *in situ*, rather than the designer's interpretation of the social setting.

## 2.7 Technology appropriation

A technology probing approach to UCD presents a shift in design thinking. Recall that we started this chapter by discussing an empathic approach, in which the designer's focus was on understanding a social problem experienced by a group of people and then producing a design based on an interpretation of this problem. Technology probing, by contrast, encourages a designer to think about how a given technology gets appropriated by a group of users over time. Ramachandran et al. [134] further encourage 4Dev designers to maximise the potential user base and to use probes as a platform for *in situ* design communication.

Dourish's [37] description of technology appropriation likewise draws our attention to the topic of technology adoption and adaptation: How users fit technologies into their work practices or evolve their work practices around them. An important point here is that in Dourish's study, users' work behaviour changed or was transformed based on their experiences with a technology that was not entirely appropriate: It was not entirely usable or did not fit their context of use. Design methodologies such as Contextual Design [11] focus on understanding these changes and using them as input for a technology redesign.

Ramachandran's [134] work on technology probes can be considered as an attempt to establish a design environment similar to those described in CD, in which the designer is able to discuss user experiences of a technology and how they apply it in their daily routines. Of course, such conversations are not possible if the participant has never encountered the technology under discussion. Ramachandran et al. [134] addressed this problem by introducing a simple technology into a previously technology-poor social setting to foster a platform for inquiry. The inquiry is then able to develop the designers' understanding of how and why users might appropriate the technology.

For Dourish [37], technology appropriation is more than just technology adoption: It happens when users ascribe meaning to their technology interactions, or in other words appropriate the technology into their system of meaning. Dourish believes appropriation happens in two ways:

1. *The features of the technology itself become meaningful:* Users develop an

understanding of how the technology could be applied to their work or social lives.

2. *The technology conveys meaning*: The technology is a means by which users see, interpret and understand the actions of others.

Harrison, Tatar and Sengers [60,145] add that interactions with a technology are a form of meaning-making in which the technological artefact and the context are mutually defining. The construction of meaning is subject to the situated viewpoints, histories, prior interactions and local resources that exist. The way in which an interactive technology is appropriated is similarly dependant on several contextual factors.

Donner's [38] work shows how simple technologies, such as the missed call service on a GSM network, can be interpreted and appropriated in interesting ways. A missed call is a simple service, included as part of the GSM protocol, that is intended to alert a subscriber when someone has attempted to establish a call that was not answered. He describes how mobile phone users in developing regions use the service as a message that has acquired several negotiated meanings. 'Beeping', as he describes it, happens when a user places a call to a mobile phone but cancels it before it can be answered. He found evidence of missed call recipients variously interpreting the messages as:

1. A callback request (most common).
2. A pre-negotiated message, where the sender and recipient have negotiated a shared meaning to a missed call. These were found to be highly contextualised.
3. A relational sign - the sender wants to reinforce or strengthen a relationship by showing that they are thinking about the recipient.

GSM has, mainly by accident, thus placed a highly accessible and affordable ('free') communication service in the hands of even the most resource-constrained people. Donner's work highlights how users from all over the developing world have appropriated the missed call service into their daily lives.

## **2.8 Polyphonic assessments**

If Harrison, Tatar and Sengers [60] are correct, then the *in situ* evaluation of an interactive technology requires a way to capture multiple user perspectives and to determine the value (meaning) that they have ascribed to it. This signals a profound shift in focus: Instead of

trying to evaluate how well users' mental models match designers' conceptual models, designer must attempt to shape their own conceptual models to fit users' mental models.

Gaver's [53] polyphonic assessment of design presents an evaluative technique that meets these requirements. He proposes the use of cultural commentators, people whose profession it is to inform and shape public opinion, as resources for evaluating a technology probe. Gaver believes the value of employing cultural commentators is that they work outside designers' usual community of discourse and are often accustomed to reflecting on issues of aesthetics, emotions, social fit or cultural implication that are difficult to assess through traditional UCD evaluative approaches.

Cultural commentators such as journalists help focus and articulate people's accounts of their experiences, extrapolating narratives from incomplete information, and dramatising relationships to create powerful and provocative stories. In so doing, they create the grounds for a multi-voiced or polyphonic assessment of technology interactions, in which the multiplicity of perspectives encourages a multilayered assessment. [53]

Polyphonic assessment is particularly attractive in a 4Dev design environment where it is unlikely that the designer is a native of the local community, society or culture. The use of local cultural commentators can:

- Help to overcome language barriers between users and designers.
- Encourage users to convey honest feedback.
- Introduce a degree of evaluative objectivity or independence.

## **2.9 Conclusion**

4Dev designers [58,101,124] have applied a traditional user-centric approach to good effect. Their approach can be described as empathic UCD [86], in that it requires designers to immerse themselves within the intended context of use to develop an appreciation for local problems and needs.

One popular method is to use contextual design and to execute a contextual inquiry (CI). A CI suggests using observational and interview techniques to learn about the target users and their daily lives. The scope of a CI can be extended to appreciate a wider range of factors, but it remains the designer's responsibility to consolidate the contextual findings and to generate a

set of requirements. The designer, at this point, has to make a commitment to a problem to be addressed. Once this has been made, it becomes difficult to move between problem spaces (design pathways) unless the designer explores more than one. Tohidi et al. [154] believe such approaches don't sufficiently emphasise the importance of exploring multiple design alternatives in the early stages of the design process – in most cases industrial time constraints simply won't allow it.

To reduce the risk associated with committing to an incorrect design path, user centred designers typically adopt an iterative approach and low cost, low-fidelity prototyping to explore the problem space. The difficulty for 4Dev designers is that low-fidelity prototypes often contain ambiguous elements and are open to multiple interpretations. Their effectiveness, as a 4Dev design tool, is largely dependent on the designer being able to foster a solid participatory environment, which in turn requires a solid design communication foundation. But there are often language and cultural barriers between designer and user, making it difficult to establish a working participatory design environment. Failure to establish such an environment may result in the user being unaware of the purpose of the design process and their role in it. The underlying design concept may thus remain untested until late in the design process, and ultimately an inappropriate final product may be produced.

Another shortcoming of empathic UCD is that, even if a designer does explore and persist down an inappropriate design path, the final solution may still satisfy the given requirements specification. This is due to the narrow scope of user-centric evaluative techniques. Quality is verified within the immediate interaction space, without considering the broad context of use and the associated forces at work. Evaluative techniques within the 4Dev space, on the other hand, tend to focus on impact measurements at a much higher level, leaving a gap in the evaluative spectrum of traditional UCD. The Human Centred Design (HCD) handbook from IDEO [72] presents a single evaluative process that describes how micro-level evaluative methods and macro-level evaluative frameworks can work together.

To summarise, an empathic user-centred approach has several benefits:

1. It encourages the designer to develop a deeper understanding of the local context and not to rely on assumptions.
2. It provides the possibility of discovering unique design pathways and practical

ways of applying technology to daily life.

3. It allows the design process to execute even if the design team is unable to find, or prevented from finding, a suitable project partner within the community.

It also has several shortcomings:

1. It requires a design team with suitable ethnographic skills.
2. It requires extensive time in the field to gather contextual data.
3. The design team interprets the contextual data and chooses the problem or need that the technology will attempt to address.
4. A high fidelity version of the designed solution is often deployed only late in the process. The wider social impact of the deployed technology may thus only be realised late in the design process [134].

Technology probes address several of these shortcomings by drawing out local perspectives on the deployed technology as early as possible. In most cases the technology will be a novelty that will, as Ramachandran et al. put it, “create a buzz in the community” [134]. The designer is able to start learning about the wider impact of the technology immediately, and can begin to build a participatory design environment around the probe. The community’s experience of the probe then serves as a catalyst for design communication, local resource development and the extraction of local knowledge and skills. The designer is able to extract ideas and observe emergent usage patterns before choosing a future design direction.

Since several design ideas may emerge, it is the designer's role to choose a design pathway that will result in a solution that will have the most impact. Hopefully an idea with a notable livelihoods impact will emerge -- but there is no guarantee of this occurring, due to the limited scope of the technology probe. At present, there are no techniques available, apart from Gaver’s [53] polyphonic assessments, for measuring the effectiveness and impact of a technology probe. This is primarily due to it being an explorative tool without any defined user goals or quality metrics to measure against.

In summary, the benefits of a technology probing approach to design are:

1. It deploys a technology prototype early on in the design process so that the wider impact of the technology is revealed at an early stage.
2. It reduces ambiguity through a direct demonstration of a technology’s utility.

3. It serves as a catalyst and provides a common platform for design communication.
4. It has the ability to generate a buzz within the community, allowing the designers to meet interested parties who could become design intermediaries.

Its shortcomings include:

1. Technology probes may create expectations that need to be carefully managed.
2. It is challenging to measure the effectiveness of a technology probe.
3. It requires careful partner selection.
4. The design direction is heavily influenced by the technology. Important livelihoods needs may be overlooked due to the narrowing of the scope.

Technology probing is a promising technique that will be explored in this thesis, evaluated alongside a more traditional, empathic UCD approach. In the next chapter we will describe the research design and methodologies used, before moving on to detailed accounts of the application of each method in Chapters 4 and 5.

### **3 Research design and methodology**

This chapter describes the design of the research and the methods and practical tools used to address the research questions presented in the Introduction. Recall the primary intention of this research: To assess the suitability of different UCD processes, tools and techniques in a developing-world context, by actually attempting to design appropriate ICTs.

The literature review presented the two alternative UCD processes that will be applied. The first leverages an empathic [86] approach to user-centred design. The second uses a technology probe to extract user perspectives on a technology experience. As well as describing research methods and design, this chapter also describes the methodologies, tools and techniques used to design and evaluate the resultant artefacts.

The chapter begins with an overview of Design Research, the overarching framework for the current research.

#### **3.1 Design Research**

Very little has been published regarding the suitability of UCD for ICT4Dev initiatives. This thesis aims to address this gap by embedding UCD within the framework of Design Research (DR), which is concerned with improving the theory and practice underpinning design [121]. This adds important additional steps to the UCD process, namely reflection and iteration, which we will show are essential to the task of assessing methods, rather than just designing artefacts.

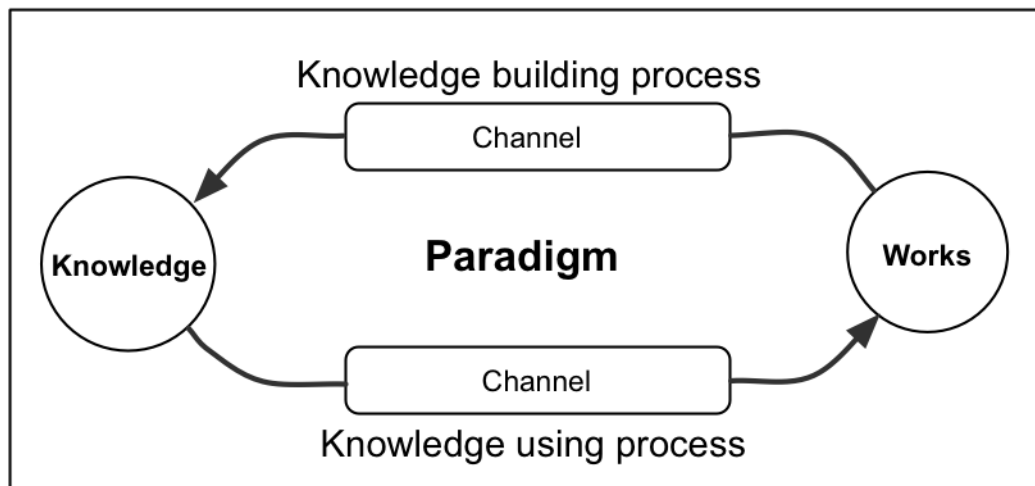
##### **3.1.1 The DR process**

DR [48, 121,159,163,165] is an interventionist research method that aims to generate knowledge through action, thus making it complementary to other interventionist methodologies such as Action Research [4, 41,87] (AR). AR [4, 41,87] is a research method in which a researcher collaborates with a group of people, community or organisation to study a social phenomenon and facilitate the progression of the social situation from an undesirable state to a more desirable state – a progression shared with the tradition of design.

DR differs, however, in that the progression is achieved through a constructive intervention, in our case through the introduction of a designed artefact. Owen [121] describes DR as an iterative “knowledge using – knowledge building” [121:3] process in which the designer uses

existing knowledge to construct an artefact, then evaluates the results of the design intervention to build the knowledge base (see Figure 3-1). DR therefore aligns well with the objective of this thesis – to build knowledge regarding the application of the UCD methodology within a new domain of research, namely ICT4Dev design initiatives.

**Figure 3-1: Owen’s general model for generating and accumulating knowledge**



This brings us to a second attractive feature of DR. DR is particularly appropriate for use in complex, multivariate social situations that typically characterise ICT4Dev design initiatives. The method encourages researchers to construct and deploy technological artefacts within real world rather than laboratory settings. This achieves two objectives: First, designers can assess the artefact’s in-situ performance, use and effect on the social situation. Second, they can at the same time reflect on the in-situ execution of the design process. This dual focus of DR effectively bridges the gap between research and practice.

### 3.1.2 Philosophical assumptions

The combination of DR with UCD yields a fundamentally interpretive method in which researchers learn by accessing perspectives on, and interpretations of, the social situation and effects of the planned actions from all participants, including themselves [41]. The underlying philosophical assumption is that language, consciousness and shared meaning offer valid access to the users’ reality [159]. The primary data collection instruments for an interpretive method are therefore qualitative tools such as participant observation, semi-structured interviews and inquiry. The UCD processes described in this thesis will leverage these tools to understand users and their context and to evaluate the designed artefacts created.

### 3.1.3 Potential shortcomings of DR

Baskerville and Wood-Harper [4] remind us that interventionist approaches have been criticised for their lack of rigor and impartiality. DR addresses the issue of rigor by operating within a set of structured processes and using well-documented rules, conventions and best practices based on the results of previous empirical research. In addition, this research wraps DR around UCD processes that are, as we will show in this chapter, themselves highly structured.

The problem of impartiality, and the effect of the designer on the validity of results, is common to most user-centric design projects where the designer engages directly with the target users. This can never be entirely overcome, but over time a clear and widely accepted set of mitigating tools and practices has evolved. The most useful is the practice of triangulating multiple quantitative and qualitative data sources, which we have adopted for this research [4].

### 3.1.4 A DR framework for UCD

DR is a necessary research framework within which to wrap our UCD processes, as UCD on its own does not include a learning phase within each design cycle. The learning phase is important because it encourages the designer to reflect on the execution of the design methods, tools and techniques used in each cycle and to combine the results of that reflection with the results of the findings produced in the evaluative phase of the cycle ('Evaluate the design against the requirements'). DR also enforces iteration on the design process that it frames. UCD is often applied iteratively, but this is not a requirement.

More specifically, the DR framework to be used follows Zimmerman, Forlizzi and Evenson's [165] model, which consists of the following phases:

1. Identify and engage with a problem.
2. Integrate existing design knowledge into the process (rules, best practices, conventions).
3. Design a prototype and evaluate it in situ.
4. Use findings to reframe the problem, reflect on the design process and iterate back to first phase.

The outputs of the model are a concrete framing of the problem, a detailed articulation of the preferred state and a description of the appropriateness of the artefact and the suitability of the

design process. The outputs of the design research cycles are then packaged and presented as a knowledge contribution [165].

A basic UCD process can be mapped onto a DR framework. The resultant process is as follows (see Table 3-1):

**Table 3-1: DR mapped to a UCD process**

DR	UCD
Identify and engage with a problem	Understand and specify the context of use
Integrate existing knowledge	Specify user and organisational requirements
Design a prototype	Produce a design solution
Evaluate the prototype in situ	Evaluate the design against the requirements
Use findings to learn (reframe) the problem, reflect on the design process	Inherited from DR: Reflect on the designed solution and the methods used to produce it'
Iterate back to first phase	Inherited from DR: Iterate back to first phase

As noted above, we will explore two variants of UCD, presenting two alternative ways of understanding the social situation and integrating the resulting data into the design process. The first, an *empathic UCD* process, encourages the designer to observe the target users performing their daily tasks in their ordinary social situation [86]. The second, a *technology probe* approach, exposes users to a high-fidelity technology prototype early on in the design process. Community uses and interpretations of the probe then serve as a catalyst for further design iterations.

The next section of this chapter detail each approach in turn. We will start by describing the empathic UCD process within its wrapping DR framework. We will also describe how several of the methods, tools and techniques described in the literature review were incorporated into the design process. These include Millen’s [103] key informants, the formation of local partnerships and a selection of tools from Participatory Design [81,82,110,111] to strengthen the author’s understanding of the context and to enhance communication, negotiation and buy-in amongst the local stakeholders.

### 3.2 An Empathic UCD process

Before describing the details of the empathic UCD process, it is necessary to provide some background regarding the design initiative that preceded the current body of work and the

design situation to be addressed.

### 3.2.1 The MuTI Mobile project

The MuTI Mobile project was an ICT4Dev initiative based in the Eastern Cape province of South Africa that aimed to provide a flexible multi-media platform to support communication and collaboration between district hospital doctors and rural clinic nurses. It was a redesigned version of a tele-consultation system, MuTI (Multi-modal Telemedicine Intercommunicator) [14], that failed to achieve the goal of local appropriation by its users. The author employed an empathic, user-centric approach to guide the MuTI Mobile design process and to create the resultant technology artefact.

### 3.2.2 Background

The MuTI and subsequent MuTI Mobile projects were conducted in the Eastern Cape province of South Africa (see Figure 3-2). The Eastern Cape is one of the poorest of South Africa's nine provinces, with a population of ~6,5 million just over 7% of South Africa's total (2008) [152]. The rural Eastern Cape suffers from severe under-development and poor service infrastructure. Bank and Minkley [7] report deepening levels of poverty and economic disconnection, citing 'visible poverty' and 'imploding small towns'. The latest reports from Statistics South Africa (2007 Community Survey) [153] highlight the severity of the situation: 29,8% of Eastern Cape inhabitants are listed as unemployed, 8% live in informal settlements, 27% have to travel to a shared access point for water and 23,5% have no flush toilet facility.

Given these statistics, it is understandable that the demand from the rural people of the Eastern Cape is for economic upliftment, waged employment and rural transformation through state action and investment [7]. Healthcare delivery, in particular the treatment of HIV/Aids and TB (tuberculosis), is a critical part of this transformation [34].

The latest statistical information (2009) from the World Health Organisation (WHO) [160] provides evidence that treatment programmes are proving effective at prolonging the lives of those infected with HIV/Aids; and TB patients are able to make a full recovery if they adhere to their TB treatment programme [161]. The challenge for the healthcare sector, particularly in the rural parts of South Africa, is to accurately manage and administer the treatment programmes. It is essential that the diseases are accurately diagnosed and that patients adhere to their drug schedules. A lack of reliable information regarding the treatment and

management of the diseases hinders effective patient care and prevention. Bridges.org [16] believes ICTs can play an important role – but reminds researchers that the solution is not as simple as deploying computer systems and providing Internet access. A holistic solution requires a locally appropriate and accessible ICT in combination with a supportive physical, social, political and economic environment. This belief served as motivation for the work described in this thesis.

**Figure 3-2: The Eastern Cape in South Africa**



Source: [http://mapsof.net/south\\_africa/static-maps/png/south-africa-eastern-cape-map](http://mapsof.net/south_africa/static-maps/png/south-africa-eastern-cape-map)

### 3.2.3 The MuTI project

As mentioned, MuTI Mobile was a refinement of a networking research project already in progress. MuTI (Multi-modal Telemedicine Intercommunicator) [14] is a remote medical consultation system that aimed to connect rural clinics to district hospitals in the Eastern Cape. The prototype MuTI system connected the Tsilitwa clinic with the Nessie Knight district hospital, at Qumbu in the OR Tambo District, via a long distance WiFi network (see Figure 3-3).

The OR Tambo district municipality is one of the poorest in the province [131]. Its

development strategy is derived from the Provincial Growth and Development Plan and outlines six development goals [131]:

1. Speed up delivery of basic services.
2. Improve public services (schools, clinics etc).
3. Create jobs and livelihood opportunities.
4. Build and maintain infrastructure.
5. Fight poverty.
6. Augment municipal capacities and co-operation.

The MuTI initiative aimed to reduce unnecessary patient referrals by enabling remote consultation between the clinic nurses and hospital doctors, reducing the need for patients to travel long distances for a physical consultation at the district hospital. This would have a positive livelihoods impact on patients. The research goals for the MuTI project were therefore well aligned with the first two goals of the wider provincial and municipal development strategy.

**Figure 3-3 The OR Tambo District Municipality in the Eastern Cape**



Source: [http://www.sagovernment.co.za/eastern\\_cape.html](http://www.sagovernment.co.za/eastern_cape.html)

In the initial context, a patient referral would typically occur when a nurse felt that she was

unable to diagnose a patient's condition or was unable to treat it given the available resources. A paper-based referral process required the nurse to document the patient's condition and reason for referral in their medical history book before sending them to the hospital. On arrival, the hospital doctor would consult with the referred patient, make a diagnosis and then either provide the necessary treatment or document the treatment plan in the patient's book.

The MuTI researchers identified two major problems with the existing referral process. First, the average turnaround time for each referral was between 24 and 48 hours. The major causes of delay were long travel times and excessive patient loads at the district hospital. Secondly, many of the referrals were unnecessary, further compounding the problem of large patient loads at the hospital. In these cases the patient's condition could have been diagnosed within a few minutes if the nurse had been able to consult with a doctor. The researchers believed that by addressing these two problems they would be able to improve the quality and timeliness of health care at the Tsilitwa clinic. The resulting MuTI prototype included a custom, PC-based application providing two modes of communication. The first mode, 'online' communication, provided a single synchronous, multimedia-messaging tool, namely a voice call via wireless VoIP (Voice over Internet Protocol). The second, 'offline' communication, provided an interface for creating and sending rich multimedia messages asynchronously.

In late 2004 a conflict of interest with another research team working at the Tsilitwa deployment site resulted in the MuTI project being moved to a new research site near the village of Ngqeleni in the Nyandeni district, roughly a two-hour journey to the southeast (see Figure 3-4). The project manager had flagged the area as a potential research site during an informal visit.

The MuTI research team carried out the transition from the old research site at Tsilitwa to the new research site at Ngqeleni between September 3<sup>rd</sup> 2004 and May 21<sup>st</sup> 2005. The transition process involved completing their last research cycle at Tsilitwa, identifying a new clinic and hospital pair in the Ngqeleni area and designing and building a new wireless network. It was during this period that the MuTI researchers invited the author, an HCI researcher, to join the research team. The MuTI project manager, BT, believed that the current MuTI system, in particular the user interface, was inappropriate for the rural nurses and that usability issues needed to be addressed. Evidence from the original field trial showed that despite 32 attempts, the Tsilitwa nurses only managed to establish three successful synchronous calls within the

three-month trial period. They did not attempt to create any asynchronous, multi-media messages. BT's observations from the Tsilitwa training programme convinced him that the asynchronous messaging interface and message creation process was overly complex.

The author joined the MuTI project on March 1<sup>st</sup> 2005 with the goal of improving the usability of the MuTI user interface. The author proposed the use of an empathic UCD process with the dual purpose of designing an appropriate MuTI artefact and exploring the suitability of UCD within a wider ICT4Dev initiative. The resulting MuTI artefact would later be renamed MuTI Mobile, as the MuTI functionality was ported to a mobile phone.

It should be noted that the collaborative nature of the MuTI Mobile research project imposed some constraints on the author's research:

1. The project situation and problem space were already defined.
2. The project location, users, collaborators, objectives and time horizons were determined before the author joined.

BT, the MuTI project manager, had chosen the site and nature of the project according to his own research needs. The redesign of the MuTI user interface (later MuTI Mobile) was an addendum to his research. The author's contribution to the MuTI Mobile project was as follows:

- Execution of contextual inquiry and ethnography
- Construction of contextual models
- Assistance in the construction of a long range Wi-Fi (wireless fidelity) network
- Design of MuTI Mobile system (mobile client and server)
- Implementation of MuTI Mobile system (mobile client and server)
- Testing of MuTI Mobile system
- Deployment of MuTI Mobile system
- Planning and execution of evaluative activities.

### 3.2.3.1 Time horizons

Table 3-2 lists the time horizons and major research activities for the MuTI Mobile project.



# Eastern Cape

# Local Municipalities

**Legend**

- Major Towns
- Metropolitan Municipality**
- Nelson Mandela Metropol
- Local Municipality**
- Buffalo City
- District Municipality**
- DC10 - Western
- DC12 - Amatole
- DC13 - Chris Hani
- DC14 - Ukhahlamba
- DC15 - Oliver Tambo
- DC44 - Alfred Nzo
- ECDMA District Management Area**



Source: <http://www.ecdc.co.za/files/documents/120608151855.jpg>

**Table 3-2: MuTI Mobile project timeline**

<b>Iteration</b>	<b>Dates</b>	<b>Summary of major activities</b>
First	March 1 2005 – May 8 2005  March 16-22 2005	Understand local context, generate contextual models  <i>Field trip #1</i> <ul style="list-style-type: none"> <li>• Ethnography</li> <li>• Contextual inquiry.</li> <li>• Participatory workshop (March 18 2005)</li> </ul>
Second	May 8 2005 – March 19 2006  May 8-21 2005  July 12-19 2005  August 31 – September 9 2005	Build wireless network, deploy MuTI system  <i>Field trip #2</i> <ul style="list-style-type: none"> <li>• Building wireless network</li> <li>• Test network and deploy MuTI system.</li> <li>• Participatory workshop (13<sup>th</sup> May 2005)</li> </ul> <i>Field trip #3</i> <ul style="list-style-type: none"> <li>• Ethnography</li> <li>• Contextual inquiry</li> <li>• Test MuTI system</li> <li>• Participatory workshop (July 14 2005)</li> </ul> <i>Field trip #4</i> <ul style="list-style-type: none"> <li>• Observe MuTI training sessions</li> <li>• Participatory workshop (September 8 2005)</li> </ul>
Third	March 20 – August 6 2006  March 20-24 2006	Generate scenarios and paper prototypes, build and test MuTI Mobile high fidelity prototype  <i>Field trip #5</i> <ul style="list-style-type: none"> <li>• Paper prototyping session</li> </ul>
Fourth	August 7 2006 – March 18 2007  August 7-13 2006  September 18-27 2006  October 4-8 2006  March 12-18 2007	Deploy MuTI Mobile prototype, test system, conduct interviews and AS to conduct task-based evaluation  <i>Field trip #6</i> <ul style="list-style-type: none"> <li>• Demonstrate MuTI Mobile and train key informants.</li> </ul> <i>Field trip #7</i> <ul style="list-style-type: none"> <li>• Deploy MuTI Mobile system (handsets and server)</li> <li>• Deliver training materials (MuTI Mobile Manual)</li> </ul> <i>Field trip #8</i> <ul style="list-style-type: none"> <li>• Complete deployment and test MuTI Mobile system</li> </ul> <i>Field trip #9</i> <ul style="list-style-type: none"> <li>• Deploy MuTI Mobile update</li> <li>• Conduct interviews</li> </ul>

The MuTI researchers had planned to deploy the system at their chosen clinic and hospital pair during the first UCD cycle. The deployment was, however, delayed to the second cycle

by the need to acquire not only the necessary wireless networking hardware but also a licence to deploy it. The delay allowed the author to assess the local work and social context prior to any technology intervention. The contextual findings were used to assess the appropriateness of the existing MuTI design, in particular qualities such as contextual fit. If the design was found to be inappropriate, the author would design, build and deploy a new system, namely MuTI Mobile. The original MuTI system would however not be abandoned, as it was a key data collection tool for the project manager and one of his students. The author would use the findings from the MuTI deployment and training programme as additional input for the MuTI Mobile design process.

### 3.2.4 The MuTI Mobile design process

As mentioned, the MuTI Mobile design process utilised an empathic UCD process wrapped in a DR framework. The purpose of the DR wrapper was to enforce an iterative application of UCD and to introduce a learning phase to each design cycle. This would encourage reflection on the suitability of the UCD process, in particular the effectiveness of the tools and techniques used.

In addition to DR, the ICT4Dev best practices described in the Literature Review and knowledge of the local development activities shaped the choice of methods, tools and techniques including the formation of local partnerships, the use of key informants and the use of tools and techniques from Participatory Design [56,81,82].

#### 3.2.4.1 Local partnerships

ICT4Dev researchers recommend identifying a local project partner to serve as a mediator between the researchers, the local community, government departments and municipalities [124,132,133]. This allows researchers to identify and communicate with relevant stakeholders and to ensure that research activities complement existing and future development initiatives in the area.

The MuTI project manager, BT, had identified Transcape [156], a non-profit organisation (NPO) operating in the Ngqeleni area (see Figure 3-5), as a suitable project partner for MuTI. Transcape and the researchers shared a mutual desire to improve local healthcare and a belief that participatory development was key to achieving this. Transcape's goal is to help implement development projects that meet the immediate needs of the surrounding

communities. The organisation believes community members should participate actively in the creation, development and management of local development initiatives and in establishing livelihoods goals. Transcape staff act as facilitators: This allows community members to take ownership of projects, while providing access to necessary resources of knowledge, finance and training that will empower them to face challenges, make informed decisions and help make their projects sustainable.

Transcape was facilitating several community projects during 2005:

- Its primary initiative was the stimulation of the local economy through product creation, tourism and agricultural development. Staff members were assisting the local community to build and sell furniture, musical instruments and beadwork; staff and manage a restaurant; and establish tourist activities such as canoe and horse riding trips.
- Transcape members working at the Canzibe hospital established a holistic and systematic HIV and Aids prevention, support and treatment program involving local communities and existing health and social services. The program included awareness and prevention days to inform community members and learners about HIV/Aids through performance and educational talks. Attendees were encouraged to take HIV tests; if positive, they would be drawn into Transcape's HIV/Aids support and treatment program.
- The Health Infrastructure Maintenance project saw Transcape and community members help the local government maintain and upgrade the Canzibe district hospital and the surrounding rural clinics.

Partnering with an organisation rather than an individual was also attractive from a project management perspective. The design of the MuTI Mobile system would take at least eighteen months, making a reliable long-term project partner essential. With Transcape's vision and direction being steered by a board of executive members who lived and worked in the Ngqeleni area, the team was confident that they could commit to a long-term research relationship.

The terms of the partnership were that Transcape would provide access to its members and community projects, while the research team would provide technical support, PC training

and wireless networking infrastructure.

#### 3.2.4.2 Key informants

Transcape directed the MuTI research team towards AS, a 35-year-old Dutch engineer who was living and working in the Canzibe area. AS was immediately interested in the MuTI project due to his engineering and IT background and the fact that his wife, SS, was the mobile doctor at the Canzibe hospital. As mobile doctor, she was tasked with visiting all clinics in the district on a rotation basis. AS was assisting with maintenance at the Canzibe hospital and at the clinics that his wife visited. His efforts led to the establishment of Transcape's Health Infrastructure Maintenance project. AS and SS became our key informants [103] as they had significant knowledge about the local clinics and had already established trust and rapport with several communities within the area.

Further discussion with AS, SS and Transcape led to the identification of a suitable clinic-hospital pair in the area. They recommended the Lwandile clinic and the Canzibe district hospital (see Figures 3-5 to 3-7). The Lwandile clinic was nominated for two major reasons:

- It lacked reliable communication infrastructure. The clinic had erratic cellular coverage, since the building was at the bottom of a valley in a cellular shadow.
- It was poorly serviced by tarred roads and far away from the nearest city and the Canzibe district hospital. On average it would take forty-five minutes to drive to the hospital and three hours to drive to Mthatha, the nearest city.

The team believed that an effective tele-consultation system to reduce unnecessary patient referrals between the Lwandile clinic and Canzibe hospital would have positive livelihoods impacts on the local community:

- Eliminating unnecessary long-distance travel would save money for patients.
- Access to up-to-date medical knowledge and information would improve patient care at the clinic.
- A reliable communication platform would allow the nurses to request medical supplies so that the storeroom was always adequately stocked and necessary medications were available.

This was the provisional desired design state that the MuTI Mobile system would enable.

**Figure 3-5: Inside Canzibe Hospital**



**Figure 3-6: The layout of the Canzibe Hospital grounds**

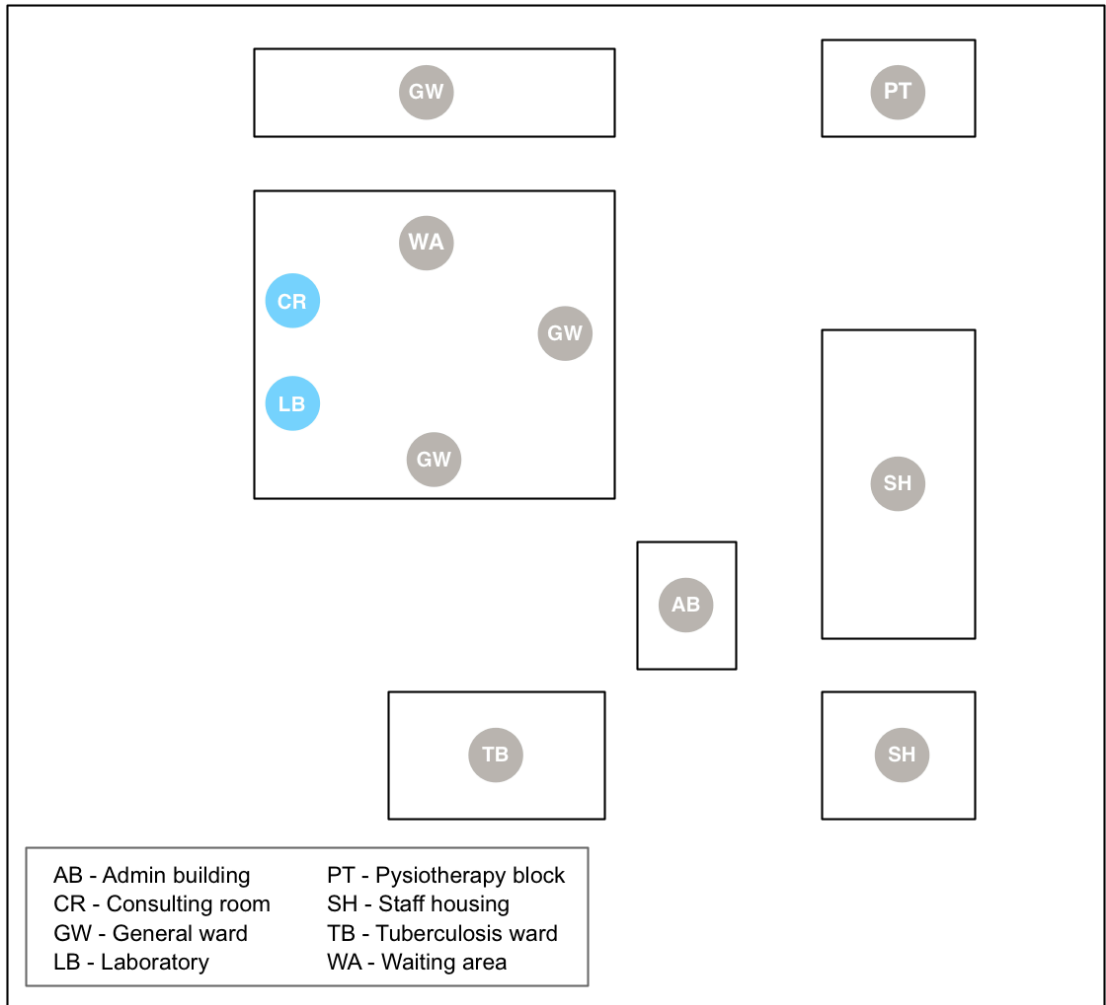


Figure 3-7: Lwandile Clinic



3.2.4.3 Participatory design

A noteworthy feature of Transcape's projects was that they were all participatory: community members were actively involved in their planning, execution and management. Recall that DFID's SLF [40] specifies that development initiatives that aim to have a significant livelihoods impact must be participatory if they are to be effective. The author needed a way to build upon the participatory development foundation established by Transcape.

Participatory design (PD) [81,82,110,111] provides a set of tools that allow designers to include participatory activities throughout a technology design process such as UCD. The intention is to empower all participants, creating a democratic platform on which all voices can be aired and equally valued. The success of such an environment relies on effective communication and engagement between all participants. This in turn requires that participants develop their knowledge of the present situation, the available technology options and the future system [81]. Without such knowledge, it becomes difficult to design a technology that satisfies user needs and fits their context of use.

PD offers several tools and practices for capturing and developing such knowledge. Those chosen for our empathic UCD process were:

- Ethnography
- Contextual inquiry
- Workshops
- Capacity building and training
- Prototyping

It is important to note that these tools and practices are not unique to PD. Our Literature Review highlighted that ethnography, contextual inquiry, capacity building and training and prototyping are recommended practices within the fields of UCD and ICT4Dev, making them shared practices with PD and therefore attractive for our purposes.

### 3.2.5 Description of the UCD methods, tools and techniques

#### 3.2.5.1 Contextual design and ethnography

Contextual design [11] and ethnography [2, 103] were used in tandem to develop an appreciation and understanding of the local context and needs.

The process involved the author adopting the role of apprentice and immersing himself in the

local environment at the Lwandile clinic (see Figure 3-7). AS, the key informant, introduced the author to the two nurses stationed at the Lwandile clinic, Sister S and Sister B. Sister S was a Xhosa woman in her early 40s and Sister B was a Xhosa woman in her mid 50s. The Xhosa-speaking networking researcher (one of BT's students), XV, then briefed the nurses about the author's background, why he was at Lwandile and what the study was about. The team also visited the house of the village headman, TS, for a similar introductory session, facilitated by XV who had a good understanding of the local customs and social protocol. The team believed that a good relationship with TS was vital to ensure local buy-in and support for the MuTI initiative. XV explained who the author was, the background of the MuTI project, the research agenda and that we wanted to improve health care in the Lwandile area. TS was glad to help and approval was granted and we were able to proceed with our research.

The first tool, a contextual inquiry, was used to try and understand the nurses' perspectives on their work environment, their daily tasks and relevant processes. The inquiry revealed details of the daily work activities at the Lwandile clinic and Canzibe hospital and the physical work environment at each location. It should be noted that the CI was highly focused: only key individuals (Lwandile and Canzibe nurses and the Canzibe doctors) were observed and interviewed, with an emphasis on understanding the regular work processes that were part of their daily routine. Due to the high patient loads and busyness of each workday, much time was spent simply observing the clinic and hospital workflows and communication patterns. When the nurses had time available, the researcher asked questions about the work setting, processes and existing work artefacts.

It quickly became apparent that while hospital staff were willing to answer questions, the Lwandile nurses were suspicious of the process and its motives – probably as a result of the inquisitive nature of the questions, combined with language barriers. To address these misunderstandings, the contextual inquiry was facilitated by our Xhosa-speaking team member, XV.

The initial research goal was to compare the Lwandile nurses' descriptions of how they performed their daily work, gathered through the CI, with the behavioural observations from the ethnographic study of the same work activities. Simonsen and Kensing [147] describe the combined use of these two techniques as a way to develop a thorough understanding of current practices within a work setting. The ethnography also aided the author's

understanding and knowledge of the rural Eastern Cape and the Xhosa culture.

### Data capture techniques

The data from the contextual inquiry was captured by documenting observations and responses to the semi-structured interviews in a notebook. The use of audio or video recording equipment was judged impractical as the hospital and clinic environments had limited space and no physical separation between staff working areas and patient working areas. The intrusion on patient privacy and the additional time required of staff were felt to be unjustifiable.

Observations from the wider ethnographic study were, however, captured in a series of field notebooks, photographic albums and video snippets.

### Data analysis

The data from the contextual inquiry was consolidated with the assistance of our key informants, AS and SS. The purpose of these activities was to clarify the finer details of the work processes observed, how they fit into the wider health care system and if there was anything unusual or unique about the way a particular process or task was executed. The consolidated data was then used to generate five different work models [11,67] that provided perspectives on how work at the clinic and hospital was done. Such models are typically described as:

1. *Physical*: A physical model shows the physical environment as it supports work.
2. *Artefact*: An artefact model depicts how various artefacts are utilised and arranged in doing work .
3. *Flow*; A flow model shows the responsibilities, communication and co-ordination required to perform a task and is particularly useful when analysing collaborative activities .
4. *Sequence*: A sequence model is a step-by-step recording of the tasks observed during the contextual inquiry.
5. *Cultural*: A cultural model depicts local culture and policy within the work place.

The models provided a concrete representation of how work at the Lwandile clinic and Canzibe hospital was done and how the nurses and doctors collaborated. The work models were then used to determine how an ICT system could be incorporated into the daily work processes to improve health care at the Lwandile clinic. The re-designed work processes were captured in a series of user-centric scenarios, which served as the foundation for the specification of an ICT solution.

The data from the ethnographic study was analysed using the RA/RI criteria and collaborative sessions with the key informants, AS and SS, to bring pertinent observations, patterns and trends into focus and to gain additional insights and understanding.

### 3.2.5.2 Workshops

To further develop the nurses' understanding of the design process and strengthen local participation, six workshops were held with the project stakeholders. The first two workshops were organised by the MuTI researchers prior to the author joining the project, but are described here as part of the MuTI project background. The meetings were all held at a meeting room at the Canzibe hospital. The MuTI project manager facilitated the workshop by initiating a series of semi-structured discussions. The workshops are listed below (see Table 3-3):

**Table 3-3: Workshops held at Canzibe Hospital**

Workshop	Date	Participants
1	October 21 2004	Four Canzibe hospital doctors (Drs MS, AL, IA and KB), Matron MW and three researchers (excluding the author).
2	November 9 2004	Dr AL, Matron NW, three researchers (excluding the author) and HZ from Transcape.
3	March 18 2005	Information Officer MK, MF the Libode district manager, ND (acting) Canzibe hospital manager, clinic supervisors SY and MD, key informant AS, Dr SS and four researchers (BT, XV, BS, including the author).
4	May 13 2005	Six representatives from the regional Department of Health (DoH), Canzibe Manager GW, Information Officer MK, MF the Libode district manager, MY from Libode DoH office, a representative from the Canzibe nurses and two researchers (including the author). No Canzibe doctors or Lwandile nurses could attend.

Workshop	Date	Participants
5	July 14 2005	Two Lwandile nurses (Sister Z and B), three Canzibe hospital doctors (Drs SS, MS and AL ) and three researchers (BT, XV and the author)
6	September 8 2005	Canzibe hospital doctors (Drs SS and MJ), Lwandile nurses (Sisters S and B), key informant AS and two researchers (BT and the author)

### Data capture techniques

The author documented the workshop discussions and minutes on a laptop computer.

### Data analysis

The outcomes and findings of the workshops were summarised and used as an additional source of contextual data to inform the re-designed work models.

#### 3.2.5.3 Capacity development and training

4Dev researchers [16,50,132] believe effective ICT solutions must be supported by local capacity development and training programs. Designers must ensure that the necessary knowledge, skills, confidence, motivation and trust are available within the community and if not, establish programs for their development. Our contextual inquiry revealed that the nurses had no prior PC experience or training and were hesitant to discuss or engage with technologies that they knew little about.

Our key informant, AS, was tasked with developing a training program for the Lwandile clinic nurses. The program included a weekly, hour-long training session that covered the basic operation of a computer, an introduction to Windows XP and how to use the MuTI system. A typical session would include a demonstration followed by a hands-on practical component where the nurse was able to practice using the computer and attempt a MuTI interaction. It was important for AS to conduct the training program because we wanted the expertise gained through the process to remain within the community. AS would then be empowered to train additional nurses in the future. Shifting capacity development processes onto the key informants meant that the training sessions could happen regularly over a longer period of time. This allowed the nurses to learn at their own pace and at a time that was suitable for them (negotiated with AS on a weekly basis). Most importantly, AS was sensitive to the local activities at the clinic, particularly the patient load. The training session would only take place if the patient load was manageable by a single nurse. If it was, the nurses

would be trained on a rotation basis thereby ensuring that at least one nurse was on duty at all times. The training sessions would be rescheduled or cancelled if the patient load was deemed to be too high.

AS employed TV, a Xhosa-speaking local woman in her early twenties, to assist him with conducting the training program. TV was bright, talented and very interested in technology. She had been involved in Transcape's after school enrichment program where she had received basic computer training. AS was unable to speak Xhosa fluently and therefore needed TV's assistance, especially in situations where the nurses were unable to understand his English instructions.

### Data capture techniques

Data from the training program was captured through a series of semi-structured interviews and debriefing sessions with AS and TV. The sessions discussed their observations from the training program and probed issues relating to the usability of the MuTI system. The responses were recorded in a notebook and the relevant usability problem demonstrated on the computer.

A task-based usability study was not feasible as the nurses only demonstrated tasks that they were able to complete successfully; they would not attempt tasks that they were less familiar with for fear of making a mistake in front of the researchers. To get the nurses to attempt the more complex asynchronous MuTI features it was necessary to derive the usability data from the practical sessions that followed the training/learning component.

### Data analysis

The interview and debriefing data was then triangulated with the feedback from the workshop and an expert review of the MuTI system conducted back at the author's research lab. The result was a consolidated list of usability problems to be addressed by the MuTI Mobile design.

#### 3.2.5.4 Prototyping

The DR-UCD approach requires the designer to evaluate the proposed solution at the end of each design cycle. Following such an approach encourages testing of the solution early and often, thereby validating it according to the degree that it satisfies the proposed user requirements. Testing yields learning in two areas: The appropriateness of the solution, and

the livelihoods problem, users and their context. Depending on the results, the designer may need to adjust the conceptual model that unpins the design, to modify the user and organisational requirements, or in some cases do both.

Prototyping, from a UCD perspective, therefore consists of three important steps:

1. The conceptual model must be embodied within a physical artefact.
2. The prototype must be presented to the target user for interpretation.
3. The target user must then try to use the prototype to complete a series of tasks derived from the scenarios of use. Successful completion of the tasks should in turn lead to the user achieving their goals and thereby contribute towards solving an underlying livelihoods related problem, either directly or indirectly.

### Data capture instruments

We used a combination of low and high fidelity techniques when translating our conceptual model into a physical prototype. Here fidelity is used to describe the degree to which the prototype resembles the final product in terms of form and function. Low fidelity prototypes, such as paper prototypes [148] don't resemble the final product but are recommended for use during the early stages of a UCD process as a quick and cost effective means of gathering feedback from the target users and evaluating a proposed solution [11]. Nielsen [116] describes the use of scenario-based, paper prototyping as one of his three discount usability engineering techniques. His scenario-based approach saves time and costs by focussing on prototyping, and therefore evaluating, only the features and functionality associated with the most important scenarios of use and not the entire system.

We followed Nielsen's [116] approach, attempting to embody our initial concept model as a set of low fidelity, paper prototypes and then to use them to gather feedback from the target users. Semi-structured interviews were used to probe user interpretations of the paper prototypes (mental models) and capture how they might use the technology to complete the tasks associated with the scenarios of use derived from the work models. The findings from the interview were recorded in a field journal. The paper prototyping session attempted to validate the following:

1. The appropriateness of the underlying MuTI Mobile design concept in terms of its usability and contextual fit.

2. The ability of paper prototypes to communicate design reasoning within a developing world context.
3. The users' interpretation and subsequent mental model of the MuTI Mobile concept.

The findings from the paper prototyping session would be used as empirical evidence to either consolidate the MuTI Mobile design or to suggest modifications and adjustments to, in Tohidi et al.'s [154] words, 'get the design right'. The resultant design solution would then be factored into a higher fidelity prototype consisting of the MuTI Mobile application running on a cellular handset.

Two high fidelity prototypes were produced. The first was a horizontal prototype [116], described as one that presents the user with a wide range of user interface features but is limited in terms of the amount of underlying functionality that has been implemented. This technique allowed us to present users with an interactive version of MuTI Mobile without requiring the networking services to be implemented and tested. The horizontal version was used primarily for demonstration purposes in an attempt to elicit feedback from our key informant AS, his assistant TV and the clinic and hospital nurses.

The findings from the horizontal prototype demonstration served to refine the second, fully functional prototype with all the functionality implemented, including the networking services. This prototype was used by AS for training purposes. The MuTI Mobile in-situ, training programme was held once a week at the Lwandile clinic and Canzibe hospital, based on the material described in the MuTI Mobile user manual. It included:

1. A basic introduction to the MuTI Mobile handset (the i-mate SP5)
2. A basic introduction to MuTI Mobile
3. Scenario-based training covering all the necessary skills to use MuTI Mobile.

AS was then tasked with observing the nurses using MuTI Mobile and documenting any usability issues that arose. He was directed to give particular attention to the following factors, based on Nielsen's definition of usability [117]:

1. *Learnability*: The system should be easy to use and the user should be able to rapidly start getting some work done.
2. *Efficiency*: The system should be efficient to use so that once users have learned how to use the system they can reach a high level of productivity.

3. *Memorability*: The system should be easy to remember so that a returning user does not have to learn how to use the system all over again.
4. *Errors*: The system should have a low error rate, users should make few errors whilst using the system. If they do make errors they should be able to recover.
5. *Satisfaction*: The system should be pleasant to use

We then conducted semi-structured interviews with AS, TV, the Canzibe doctors and Lwandile nurses to gather evaluative feedback regarding the usability of MuTI Mobile and the i-mate SP 5. The triangulation of the feedback from the trainers AS and TV, the users and the author's training session observations was used to provide an objective perspective on the usability of the MuTI Mobile system.

The MuTI Mobile prototype was then deployed to determine the full appropriateness of our design, in particular its contextual fit and delivery of value. Appropriateness was judged according to two indicators:

1. *Communication between doctors and nurses*: This indicator, derived from system log files, measured the frequency and direction of communication between the Lwandile nurses and Canzibe doctors.
2. *Number of patient referrals*: This indicator measured the number of patients referred over a monthly period and was derived from semi-structured interviews with the clinic and hospital staff. It was used to determine whether there was any reduction in the number of monthly patient referrals from the Lwandile clinic to the Canzibe hospital during the period when MuTI Mobile was deployed and available for use.

### Data analysis

The usability of the MuTI Mobile prototype was determined by triangulating all the feedback gathered from the paper prototyping, demonstration and training sessions. The focus was on determining whether the nurses were able to complete the scenarios documented in the MuTI Mobile training manual effectively and efficiently.

Contextual fit and value delivery was determined by triangulating the data in the system log files, the monthly performance indicators captured in the clinic and hospital log books and the semi-structured interviews with hospital and clinic staff to determine whether MuTI Mobile

was able to reduce the number of patient referrals.

The ethnographic study continued to run over the course of the MuTI Mobile deployment period to determine if there were any changes in the attitude or behaviour of the doctors, nurses or hospital staff. These findings were consolidated through semi-structured interviews with our key informants, AS, SS and TV. This data helped the researcher evaluate the MuTI Mobile system holistically and provided a mechanism for identifying outcomes beyond the scope of the two primary indicators, namely communication between doctors and nurses and the number of patient referrals.

### 3.2.5.5 Experimental bias

One potential bias was the payment agreement between the researcher and the key informants AS and TV. AS and TV were motivated to pursue the MuTI Mobile project goals, in part, due to the employment opportunity on offer and their role as change agents. There was a possibility that their feedback could be biased due to their desire for the project, and with it their employment contract and regular source of income, to continue. We addressed this issue by triangulating their feedback with the feedback from the doctors and nurses and the system log files.

## 3.3 A technology probing approach to UCD

Experience gained from the MuTI Mobile project enabled the identification of two crucial factors that influenced the design process and the appropriateness of the final artefact. First, the designer needed a way to explore social and culturally shaped perspectives on a new technology early in the design process. Second, the nature of CD meant the design focus remained on a handful of key users throughout the design process. We needed a way to open up and maximise the potential user base so as to explore multiple perspectives. The MuTI Mobile project showed that if the core user group lacked the necessary social resources such as motivation, and did not see the potential value of using the technology, it would be underutilised.

Ramachandran et al. [134] suggest introducing a simple, off-the-shelf technology artefact into a social setting to stimulate discussion about its utility and possible future applications. In Ramachandran's study these activities were part of a series of community events at which passers-by could both observe and try out the new technology, creating a buzz in the

community and attracting a wide range of potential users. The MuTI Mobile project showed, however, that socially shaped perspectives on a new technology take time to emerge. For this reason, it was decided to give the target user group the necessary time and space to explore the technology artefact without the researchers being present.

Hutchinson et al.'s [70] technology probing approach provides a way of achieving this. They encourage designers to build simple, flexible and adaptable pieces of technology to probe complex environments of use. Probes are to be deployed in the complex environment over a longer period of time, to explore what users ultimately make of it. The goal of the technique is to use the findings of the probe to inspire the design of new interactive technologies to support people in similar environments and address an emergent need. (For our purposes the resulting technology can be deemed “appropriate” if the emergent need is livelihoods related and the technology an ICT.) Hutchinson et al.'s [70] probes were deployed in specific locations, with specific users for periods from six weeks to several months. Their probes were self-logging and their use was designed to be open-ended to encourage users to re-interpret and use them in unexpected ways.

We wanted to explore a hybrid of Ramachandran et al.'s and Hutchinson et al.'s approaches, by deploying a technology artefact that was both publicly accessible (to explore the social dynamics surrounding the technology use), and deployed over a longer period of time. Our hybrid approach is referred to as “public technology probing” to differentiate it from Hutchinson et al. [70]'s technology probing approach.

To implement this public technology probing approach, we needed to decide what technology artefact to use as a probe and what environment to deploy it in. We were still interested in the notion of multi-media sharing within a rural community setting and believed an appropriate multi-media sharing technology could have a significant livelihoods impact. Our goal, therefore, was to design and develop a technology probe that was simple to learn, easy to access and displayed immediate utility so that it could be quickly demonstrated to a group of observers, who could in turn become users. Importantly, use of the technology probe also had to be affordable – the Eastern Cape project had demonstrated the extreme price sensitivity of our rural users. Affordability and accessibility were therefore identified as key requirements for our technology probe. The prioritisation of these requirements successfully constrained the design space and led to the production of the novel SnapAndGrab probe.

### 3.3.1 Probe design and field deployment

The design process consisted of an overarching DR framework as described in Section 3.1, wrapped around a technology probing approach to UCD. The structure of the UCD cycles was identical to those used in the empathic approach, that is, an iterative process consisting of the following steps:

1. Understanding and specifying the context of use
2. Specifying the user and organisational requirements
3. Producing design solutions
4. Evaluating the design against requirements.

A technology probing approach to UCD requires the designer to create and deploy a technology artefact as a means of probing a complex social setting early in the design process. We developed and lab tested our probe during the iteration preceding the start of the UCD process (see timeline in Table 3-4 below).

The designer then has to assess the appropriateness of the technology probe based on user interpretations of it and how they apply it within their daily routines. This was achieved through the triangulation of three data sources: A key informant diary, a polyphonic assessment and analysis of the system log files.

The findings of each cycle served as valuable design feedback that inspired future modifications and extensions to the probe and possibly, at the end of the evaluation, completely new technological systems.

Within the UCD cycles, we utilised the following tools and techniques:

- Contextual analysis
- Constraint driven design
- Task-based evaluation
- Local partnerships
- Polyphonic assessments

#### 3.3.1.1 Project timeline

**Table 3-4: Probe development, deployment and evaluation timeline**

Iteration number	Field trip dates	Summary of activities
0	October 2006 – January 2007 March – May 2007 June 12-14 2007	Contextual analysis, design and production of SnapAndGrab technology probe. Longitudinal testing of SnapAndGrab in laboratory setting. Laboratory evaluation.
First	March 17 2008 April 16 and 24 2007	Zakhele volunteer recruitment (volunteers received a new Samsung E-250). Introductory workshop Bluetooth and camera training workshops.
Second	May 20 2008 May 28 2008	Deployment of SnapAndGrab technology probe at Learn to Earn. Media concept workshop.
Third	June 4 2008 June 11 2008 June 17-18 2008 June 18 2008 June 25 2008	1 <sup>st</sup> update of SnG editorial media packages. 2 <sup>nd</sup> update of SnG editorial media packages. Polyphonic assessment. Log file collection. Closing workshop.

### 3.3.1.2 Contextual analysis

The requirements for the technology probe were not derived from an in-depth contextual inquiry of the kind that informed the MuTI project. Rather, we began with a design objective: to create a simple service that would allow its users to download and share rich multi-media content. Instead of trying to determine user requirements in advance and in isolation, the technology probe was to serve as an exploratory tool that would allow requirements to emerge during use. The constraints of maximising affordability and accessibility, rather than the drive to satisfy an observed problem or need, shaped the design of the probe.

A broad level contextual analysis was, however, performed to determine the most affordable and accessible technology platform within a South African context. The ethnographic data from the MuTI Mobile project and recent statistical data (2007) highlighted the ubiquity of cellular phones in the Eastern Cape, one of South Africa's poorest provinces [149]. A recent statistical survey confirmed that the cellular phone is the most ubiquitous computing platform available in South Africa [54]. Retail trends showed that the prices of multi-media phones (with a Bluetooth radio, colour display and camera) were dropping and therefore becoming increasingly accessible to lower-income communities. When the research was conducted, the

price of a multimedia phone (the Samsung SGH-E250) started at ~R1500 (equivalent to ~\$205). At the time of writing, the price of the phone has dropped significantly to R689 (equivalent to ~\$95) [46]. We therefore concluded that cellular phones were an accessible computing platform in South Africa and that building on the ubiquity and robustness of available mobile technologies, and making use of existing skills and knowledge, would improve the overall accessibility of the technology probe.

### 3.3.1.3 Constraint driven design

Our findings from the MuTI Mobile project emphasised the need for technology interactions within a developing world context to be accessible and affordable. We therefore decided that these qualities should constitute the primary design drivers and be prioritised above other qualities such as efficiency. Our goal was to design a general multi-media sharing platform that was accessible and affordable to the widest user base possible. This effectively constrained the design space and shaped the basic requirements specification for our multi-media sharing technology.

We elected to develop a technology that would allow users to download and share multi-media content using the Bluetooth capabilities of their camera phones. Most importantly, system usage did not require any software installation, nor did the user have to go through any setup procedures (such as Bluetooth device pairing). Any person with a Bluetooth enabled camera phone could walk up to the display, snap a photograph of the media package they desired (Snap), send it to the system and accept the returned media items (Grab). Hence, the prototype was named SnapAndGrab and earmarked as a candidate technology probe.

### 3.3.2 Description of SnapAndGrab

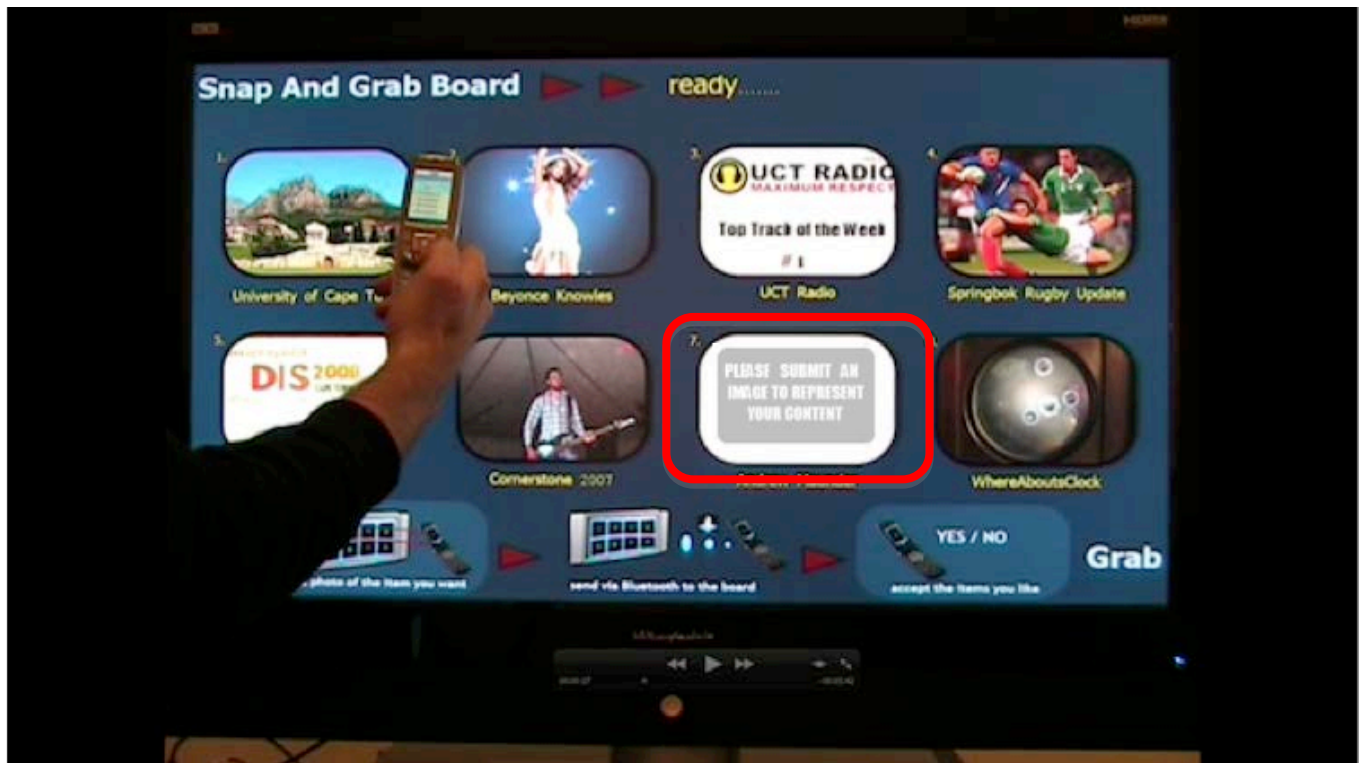
SnapAndGrab (SnG) (see Figure 3-8), is a multi-media sharing platform that allows users to upload and download digital content using the Bluetooth capabilities of their cellular phones. To download content, users take a photograph of the desired image on the SnG display using their camera phones, then Bluetooth the photograph to the SnG system. SnG then processes the submitted image and attempts to match it to one of the eight images shown on the display. If a successful match is made, the associated multi-media package is then sent to the user's phone where it can be stored and viewed.

**Figure 3-8: The SnapAndGrab system**



Users who want to share content for others to download begin by creating an empty media package – this is achieved by sending a vCard (a file format standard for an electronic business cards) via Bluetooth to the SnG system. The new media package is immediately created and displayed on the SnG screen with a default cover image (see Figure 3-9) saying “Please submit an image to represent your content”. The users are then encouraged to submit a cover photograph to customise their media package and make it uniquely identifiable. Any multi-media (music, video, photographs) submitted after that is appended to the user’s media package and available for download in exactly the same way as a pre-loaded SnapAndGrab media package. The system uses a basic randomisation algorithm to rotate the cover images of the various media packages, one at time at fixed intervals (usually set to 5 minutes).

**Figure 3-9: SnapAndGrab with a newly created media package**



### 3.3.3 Research overview

#### 3.3.3.1 Task based evaluation

A short laboratory study was conducted on June 12<sup>th</sup> - 14<sup>th</sup> 2007 to explore user reactions to the SnapAndGrab concept and to evaluate its usability. The experiment assessed whether new users were able to access and use the core features of SnG without any prior training. We sought to answer the following questions:

1. Could the users complete an interaction based on the visual instruction set shown on the display?
2. Did the users know where and how to find and access the returned multimedia on their handsets?
3. Did they find the interaction too time consuming?

#### Experimental subjects

We recruited eight University of Cape Town (UCT) students, all between 18 and 24, who

owned Bluetooth-enabled camera phones. None were computer science students, nor did they have any prior knowledge of the SnapAndGrab system. According to Nielsen's [118] research, a usability study with eight subjects will theoretically uncover ~90% of underlying usability problems – a value deemed acceptable by the author for a pilot study. Of the eight students, none were studying Computer Science, none had seen the SnapAndGrab technology before and all had prior PC and Internet experience (all had completed UCT's computer training programme in their first year of study).

### Laboratory setup

The experiment was conducted in a small usability laboratory that housed a single SnG deployment. The SnG screen was clearly visible upon entry and was seeded with a variety of content, most of which was chosen due to its general relevance for UCT students. The content covered international celebrities, campus radio, university information and popular South African sports.

### Data capture instruments

The laboratory experiment aimed to capture data showing whether users were able to complete a basic interaction with SnapAndGrab (SnG) without prior training i.e. based on their interpretation of the visual instructions shown on the SnG screen alone. As mentioned, a SnG interaction relied on the user being able to effectively use the Bluetooth and camera features of their cellular phone. It was therefore necessary to gain an understanding of the each user's Bluetooth and camera-phone experience levels to assist the analysis of the task based data gathered in the study. We achieved this by requiring the subjects to complete a pre-questionnaire (see Appendix A).

The pre-questionnaire included a consent form, gathered basic demographic information (age, occupation, gender and home language) and probed the following topics:

1. Had the subject ever used their mobile phone's camera and Bluetooth features before the study?
2. How often had they used their camera?
3. For what purposes had they used their camera?
4. If they had ever shared pictures or video via Bluetooth?
5. If they had ever been sent a file via Bluetooth?

6. Did they know where to find the files after receiving them?

The subject was then asked to complete a simple task, which required the subjects to download three media packages from the SnG system. The users were not briefed or trained regarding the use of SnG. Instead, they had to rely on a simple three-step instruction displayed along the bottom of the screen (see Figure 3-8). The subjects were given a maximum of fifteen minutes to complete the task. If the subjects were unsuccessful, the facilitator (the author) would provide the necessary clarification and assistance before asking them to attempt the task again until success was achieved. The results were captured in the system log files and documented on a laptop computer and in the post-questionnaire.

The subjects were then required to complete a post-questionnaire (see Appendix A).

The questionnaire probed the following topics:

1. Did the user understand the SnG concept and have an idea how they might use it in real life?
2. Was there anything about SnG the user would change?
3. Did they know where to find the files that SnG sent to them?
4. Did the users feel that a SnG transaction took too long for what it was worth?

The resultant data was analysed to determine whether:

1. The users were able to successfully complete a SnG interaction.
2. From the user's perspective, an SnG interaction was efficient enough to be of practical use.
3. Users were able to find and consume the content they downloaded.

### Data analysis

The experimental data was analysed to:

1. Determine whether there was a correlation between the subjects' prior Bluetooth and camera experience and their ability to complete an interaction with the SnapAndGrab system. Prior experience was determined according to a usage frequency value captured either as a yes/no question or a value on a five-point scale numerical scale (1 = rarely... 5 = a lot).

2. Determine the usability of the SnapAndGrab system in terms of the properties outlined by Nielsen [117]: Learnability, efficiency, memorability, error rate and satisfaction. Learnability was determined by the subjects' ability to complete an interaction unassisted. If assistance was required, we were interested in how many demonstrations were necessary. Efficiency was judged by the subjects' reports on whether the interaction was efficient compared to the perceived value of the interaction. Satisfaction was determined according to the feedback captured in the post-questionnaire and post task debrief. Memorability and error rate were not evaluated in the pilot study as there were no repeated tasks.

### 3.3.3.2 Local partnerships

For the field deployment phase, we needed to identify a target context and local mediator [124, 132, 133] with whom to form a research partnership. Our experiences from the Eastern Cape encouraged us to look for a deployment site closer to Cape Town (where the author was based) to ensure a quicker turnaround time on technical issues and to enable regular site visits, particularly during the earlier stages of the initiative. The author's research supervisor recommended partnering with an NGO operating in Ilitha Park, a suburb of the Khayelitsha township, which is situated 32km from Cape Town's central business district. Learn to Earn [85] provides unemployed community members with access to affordable skills development courses and actively facilitates job creation through their Business Resource Centre (BRC).

The BRC aims to support graduates by facilitating business opportunities, creating local jobs and providing access to economic support. An important aspect of Learn to Earn's objective is to develop people (especially unemployed people) socially, economically, emotionally and spiritually. The Learn to Earn ethos is captured in their slogan: 'A hand up, not a hand out'. From an SLF [40] perspective, Learn to Earn made an ideal project partner for several reasons: its focus on people, its holistic view on livelihoods development, the way it builds on creative strengths of the community, the linking of micro-level graduates with macro-level businesses opportunities, support for dealing with a dynamic economic environment and the fact that Learn to Earn's projects are sustainable and not dependent on external support and funding.

At Learn to Earn community members are able to access a wide range of skills development courses including:

- Woodwork
- Baking
- Business Achievers
- Computer Training
- Home Management
- Life
- Sewing

After a conducting a rapid contextual inquiry at the Learn to Earn offices and BRC, it became clear that some of the courses provided their students with the necessary skills and training to use ICTs. For example, Learn to Earn's computer training department offered courses in computer basics, office administration and graphic design. The skills learned empowered students to access ICTs outside of the training course environment at, for example, an Internet cafe.

One business development opportunity of particular interest was Khanya Creations, which creates own-label fashion garments and accessories as well as custom products for industry clients. Khanya Creations was founded and staffed by the Zakhele team, all local women who were either participating in or graduates of Learn to Earn's sewing course. The Zakhele team worked from the sewing section of the BRC, a building next to the Learn to Earn main offices in Khayelitsha. The core team consisted of 32 women, ranging in age from their early twenties to late sixties; beyond this core the team varied according to the level of production demand.

The Zakhele team had not received any computer training at Learn to Earn and only one group member had prior computer training and experience. Our initial understanding was that the group lacked the knowledge and skills to access valuable information available via an Internet enabled computer. We believed that the SnapAndGrab (SnG) technology could provide the team members with access to rich multi-media services.

Three guiding research questions helped narrow our research focus:

- Was SnG appropriate for the Zakhele team and wider Learn to Earn community?
- Could SnG be used successfully as a technology probe to inspire modifications and extensions to SnG or even completely new interactive systems for users living and

working in similar environments?

- Could SnG reveal new or existing social practices, patterns and attitudes towards SnG and technology in general?

The rapid contextual inquiry also identified two contextual factors that needed to be addressed before deploying the probe. Firstly, we needed to assess the ubiquity of Bluetooth enabled cellular phones within the Learn to Earn community. We found that most target users had access to cellular phones; but the handsets available ranged from models released in the late 1990s to entry-level handsets from local retailers. Only two handsets were compatible with SnG, which required an integrated camera and Bluetooth radio. This requirement ruled out most of the handsets owned by the target users.

To address this problem, we planned to provide volunteers with a basic Bluetooth-enabled camera phones. The Samsung SGH-E250 was chosen due to its low price, availability and compatibility with the SnG system. It was our belief that low-priced handsets, such as the E-250 and other Bluetooth enabled handsets, would soon disseminate into the community through the second hand market.

Secondly, we needed to identify a suitable key informant who could help us communicate with the Zakhele ladies and assist with developing local capacity (knowledge and skills) to access the basic services offered by SnG. The Learn to Earn management team nominated a member of the Zakhele team who had recently completed the basic computer training and office administration courses. NV was a twenty-three year old Xhosa-speaking woman whom the managers believed possessed the right qualities to assist us in our research: she was bright, lively, confident and showed a strong sense of leadership. Most importantly, she was literate in both Xhosa and English and would assist us with language translations, focus group facilitation, capacity development within the community and act as the spokesperson for the Zakhele team.

We arranged a meeting with the Learn to Earn management to brief them on the purpose of the SnG project and the details of the probe, and negotiated a longitudinal ICT partnership program between the author's research group and Learn to Earn. Learn to Earn would provide access to research volunteers, in this case the Zakhele team, while the research group would provide ICT support for the Learn to Earn computers, printers and servers. The research

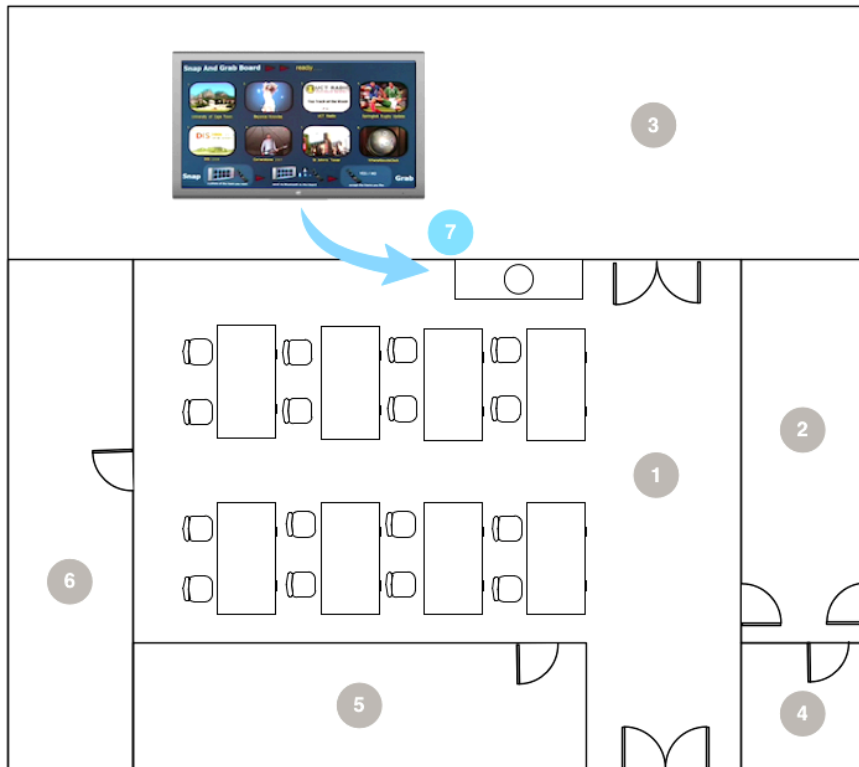
partnership was beneficial for Zakhele volunteers, who were allowed to keep the Samsung cellular phones they would receive as compensation for their participation. This action alone was empowering and ensured a positive impact by providing them with an ICT (see Chapter 5 for details of the impact). Some of the team members had never possessed a cellular phone and most had never owned a new one. The volunteers were also empowered through the various training sessions that formed part of the SnG project.

The Business Resource Centre (BRC) building, in which the Zakhele team worked, provided a secure location to deploy the SnG technology probe (an LCD screen and a Mac Mini) and supply power (see Figure 3-10).

**Figure 3-10: The Zakhele tea area**



**Figure 3-11: Plan view of the Learn to Earn Business Resource Centre**



Key:

1. Zakhele sewing centre
2. Khanya Creation show room
3. Wood work centre
4. Kitchen
5. Zakhele training room
6. BRC offices
7. Zakhele tea area and SnapAndGrab system

### Ethical considerations

Two obvious issues of concern arose. The first was that Zakhele team members who did not receive phones felt excluded from the research initiative. We addressed this by emphasising that there would be future opportunities to participate in similar cellular phone research projects. The author's research group established a long-term research relationship with Learn to Earn and ran a cellphone banking study at Learn to Earn shortly after the inception of the SnG field trial.

The second issue of concern was the sustainability of the SnG initiative and the need for an exit strategy. As mentioned, the SnG project was part of a wider research relationship with Learn to Earn, which meant that technology-related activities would continue beyond the SnG project. Of particular concern was the excitement and expectation built up by the SnG technology and the livelihoods impact it had on the community. To address this issue we ensured that the volunteers were informed as to the purpose and future of the project through informative introductory and closing workshops held on March 17<sup>th</sup> and June 25<sup>th</sup> 2008:

1. The opening workshop introduced the project, its purpose, why the help of community members was needed and what would be expected of them. We then handed out the cellular phones.
2. The closing workshop served as a platform to thank team members for their participation, to inform them that the project had drawn to a close and to communicate the successes of the project.

Most importantly, all SnG research activities were subject to the consent of the Learn to Earn and Zakhele management and all activities were channelled through them to ensure that they were ethical, including participant recruiting. That said, participation was entirely voluntary and this was emphasised to the Zakhele volunteers.

### 3.3.3.3 Capacity development and training

Key informant NV's tasks were to:

1. Perform the role of local SnG intermediary and trainer.
2. Spearhead the generation of local media packages via SnG's user generated content interface.
3. Maintain a diary documenting the SnG story from her perspective. She was asked to document the Zakhele team's comments and attitude towards their cellular phones and the SnG system.

NV was also given a SnG compatible cellular phone, similar to the Samsung SGH-E250 that was provided to the Zakhele volunteers, and compensated financially for maintaining the diary and providing training and support.

### Experimental biases

A possible concern was that NV might act as a gatekeeper, controlling access to SnG. We addressed this by placing the SnG probe in a semi-public space (the Zakhele team tea area - see Figure 3-10), making it physically accessible to a wider group of people. We also trained the Zakhele team manager to use SnG, thereby ensuring that the skills and knowledge needed to use it were available through an alternative source at Learn to Earn.

A second potential source of bias was the service agreement shared between NV and the research team. NV was employed as the SnG local support and trainer and may have been tempted to skew the results in a positive direction (e.g. overtly positive diary feedback or exaggerated usage patterns) in an attempt to extend her employment contract. To address this possible bias, we triangulated her feedback with the feedback gathered from other members of the community (via a polyphonic assessment and our key informant's diary) and the system log files. The use of data source triangulation ensured that the SnG system was evaluated as objectively as possible.

#### 3.3.3.4 Field evaluation of SnG

##### Evaluative plan

The SnG evaluative plan was built on Heeks' information chain [63] and utilised the triangulation of three data sources, namely the polyphonic assessment, NV's diary and the system log files, to determine whether the Zakhele volunteers were able to access, assess and apply SnG within their daily lives. The evaluative findings were used to inspire modifications and extensions to SnG, whilst simultaneously assessing whether the SnG technology probe, as it stood, was locally appropriate. For our purposes, we returned to Salovaara [140] and Dix's [42] description of an appropriate technology – one for which the user shows vision, understanding and application of a designed artefact. An appropriate technology is thus one that the user can envision a use for and then successfully apply.

##### Data capture instruments

As mentioned above, we utilised three data capture instruments to determine whether the Zakhele volunteers were able to access, assess and apply SnG within their daily lives, namely a polyphonic assessment, NV's diary and the system log files.

Gaver's [53] polyphonic assessment of a designed artefact was one of the methods used to extract the users' interpretation of an interaction with the SnG probe. We employed two

cultural commentators and tasked them with gathering personal accounts from the Zakhele volunteers and compiling two independent narratives.

Our two cultural commentators, MY and LS, were 20-year-old Xhosa-speaking men who were studying film and media studies at the University of Cape Town (UCT), South Africa. The two students came highly recommended by a lecturer within the Film and Media Studies Department and both had completed a 'Writing and Editing in the Media' course as part of their three-year degree. We deliberately chose commentators whose first language was Xhosa to eliminate potential language barriers. We hoped that the strengthened communication platform, combined with the cultural commentator's film and media background, would enable them to extract honest feedback from the Zakhele volunteers and compile an objective assessment of SnG's impact.

We were particularly concerned to avoid putting the Zakhele women in a position where they felt they had to give overtly positive feedback for fear of 'hurting the feelings of the person conducting the test', giving 'the impression that they are negative people' or 'their ratings reflect negatively on their ability to use computer-based technology' (quoted from Wiklund, Thurrott & Dumas [162: 403]). We believed that the use of independent commentators, such as MY and LS, would address this concern.

The commentators were deployed at Learn to Earn over the course of two days (June 17-18 2008). They were tasked with the following:

1. To learn about the SnG system and how to use it from the Zakhele volunteers and not from NV, our key informant. Our commentators had never seen or used SnG prior to the assessment.
2. To assess whether, in their opinion, the team members were able to complete a basic interaction with the SnG system.
3. To assess each Zakhele volunteers' interpretation of the SnG system, the impact the system had on their lives and any potential uses or applications that emerged during the study.

The two commentators each interviewed the ten Zakhele volunteers that were available for the assessment and produced a written narrative documenting their findings. The remaining four volunteers were unavailable for the assessment as they had taken up contract sewing

work at another location, despite the author's request that all the volunteers be present at Learn to Earn on at least one of the two assessment days.

The second data capture instrument was NV's diary. NV was asked to document the Zakhele team's experience of SnG, including her own. We were particularly interested in the following:

1. The Zakhele team's initial perspective on SnG (prior to experiencing an interaction).
2. The Zakhele team's perspective on SnG after experiencing an interaction.
3. General SnG related action, events or comments made by the team (particularly those relating to the content of the SnG media packages).
4. Any usage or application ideas that NV or any of the other team member may have had over the course of the study.

The third data capture instrument was the system log files, which logged every interaction with SnG. The logging mechanism consisted of two parts: the interaction log file and the submission repository. The interaction log file captured the date and time of an interaction, whilst the submission repository stored the multi-media that was uploaded on a per user basis. The uploaded multi-media included selection photos (selection photos are photos that were submitted by the user in an attempt to download a media package) and multi-media that was uploaded as part of a user generated media package.

### Data analysis

The accessibility of the SnapAndGrab system was determined by applying Bridges.org's [16] RA/RI impact criteria as an analytical lens to our triangulated data sources: the polyphonic assessment, NV's diary and the system log files and then reflecting on the issues that were brought into focus. The RA/RI criteria are repeated below:

1. Physical access to technology.
2. Appropriateness of technology.
3. Affordability of technology and technology use.
4. Human capacity and training.
5. Locally relevant content, application and services.
6. Integration into daily routine.
7. Sociocultural factors.

8. Trust in the technology.
9. Local economic environment.
10. The macro-economic environment.
11. The relevant legal and regulatory framework.
12. Public support and political will.

From an UCD perspective, we were interested in two particular qualities that affected local access to the SnG technology probe: its usability and contextual fit. The Bridges.org [16] framework addresses issues relating to these two qualities in criterion two, “Appropriateness of the technology” and four, “Integration into daily routine”. The evaluation of these two qualities in particular was used to determine whether SnG was accessible at a micro level: the immediate interaction space [29, 30]. The remainder of the RA/RI criteria were used to determine if there were any other barriers to access beyond the immediate interaction space – the macro level.

More specifically, the usability of SnG was evaluated according to the properties outlined by Nielsen [117]: Learnability, efficiency, memorability, error rate and satisfaction.

We started the usability analysis by working through the cultural commentator’s narratives and identifying events, actions or comments that were logically related to one of Nielsen’s [117] five usability properties. We then used the organised data to determine the degree to which SnG supported the five usability properties, and whether they were sufficiently supported to enable the Zakhele volunteers to complete an interaction with SnG. We then analysed NV’s diary and the system log files for evidence that either supported or contradicted the findings from the analysis of the commentator narratives.

Next, the remainder of the RA/RI criteria were applied to commentator narratives in an attempt to identify events, actions or comments that were related to macro-level accessibility issues. Of particular interest was the degree to which SnG integrated into the Zakhele team’s daily routine. Evaluating this criteria would allow us determine the contextual fit of SnG, which would, when combined with the usability and application assessment, enable us to determine if SnG was locally appropriate. Again NV’s diary and the system log files provided additional evidence that either supported or contradicted the findings from the narrative analysis. The consolidated findings were then used to determine whether SnG was accessible

by the Zakhele team within the Learn to Earn context.

Our analytical focus then shifted from the access to the assess and apply links of Heeks information chain [63]. We were now concerned with analysing the Zakhele volunteers' interpretation of their SnG interactions and the uses, social practices and patterns that emerged during the course of the study. Again the commentator narratives, NV's diary and the system log files were triangulated and used as the data source for analysis. This time we were looking for events, actions or comments made by the Zakhele team that showed understanding, vision and application of SnG within their daily lives. The findings were codified and categorised according to the uses, patterns and practices (themes) that surfaced. We then used the data from NV's diary and the system log files as evidence that either supported or contradicted the findings from our analysis of the commentator narratives. The result was a consolidated set of findings highlighting:

- The emergent needs of the Zakhele group and the wider Learn to Earn community.
- Inspiration for new interactive systems to support people in similar environments.
- Underlying social attitudes towards SnG and technology in general.

### **3.4 General ethical considerations**

#### **3.4.1 Ethical research practice**

All the local design activities were conducted under the umbrella of the NGO partners' community work. The research plan and activities were discussed and cleared by the NGO managers and steering bodies and research practices adhered to their ethical guidelines. All research participants were always kept informed as to the research agenda and it was made clear to them that participation was entirely voluntary.

The Lwandile clinic and Canzibe hospital staff all signed consent forms acknowledging that participation was voluntary and that they agreed to participate. The MuTI Mobile project was a subsidiary of the wider MuTI project and thus fell under the official ethical clearance obtained by the project manager BT.

Participant recruitment for the SnapAndGrab project was managed by the Learn to Earn senior management and all project activities were approved by them, thereby ensuring ethical research practice.

### 3.4.2 Ethical use of longitudinal prototypes

Both the MuTI Mobile prototype and SnapAndGrab technology probe were rigorously tested in the laboratory prior to deployment in the field. The aim was to prevent system crashes and malfunctioning during field trials, which would negatively impact the user experience and outcome of the project.

The full MuTI Mobile system was tested in the laboratory for a period of four weeks during August 2006. The SnapAndGrab technology probe was deployed as a digital notice board within the author's Computer Science Department during October and November of 2007 in preparation for the field study the following year. SnapAndGrab was also deployed for four days at the *SIGCHI Conference on Human Factors in Computing Systems (CHI '08)* [49] held in Florence, Italy during April 2008 in preparation for field deployment.

We also provided onsite training and support for both the MuTI Mobile and SnapAndGrab projects through our key informants, AS and NV, thereby ensuring that the necessary skills and knowledge to use the technologies were available within the community. The key informants also relayed any technical problems back to the author so that these could be addressed in a timely manner.



## **4 The design of the MuTI Mobile system**

### **4.1 Introduction**

This chapter presents a detailed discussion of the redesign of the MuTI tele-consultation system. The redesign process, which became the MuTI Mobile design process, employed an iterative, empathic UCD process wrapped in a Design Research (DR) framework. This enabled the researcher to reflect simultaneously on the design of the MuTI Mobile artefact and on the suitability of the UCD methods, tools and techniques used.

In the next section we briefly review some relevant ICT and healthcare literature to fill out the context, before discussing the field study and design of MuTI Mobile in detail.

### **4.2 Related literature**

A review of relevant ICT and healthcare literature was undertaken before the design project began. In this chapter we highlight the works that were most relevant to the design of MuTI Mobile, beginning with two prominent African ICT4Dev initiatives that aimed to support the capture and dissemination of healthcare information. We then review general literature relating to the information needs of medical workers, finishing with a recap of the MuTI system on which the MuTI Mobile system was based. Topics of particular interest are:

- The types of technologies used
- The reasons for choosing them
- The healthcare activities that the ICT supported

#### **4.2.1 Satellife**

The Satellife project [18] is an ICT4Dev initiative that explored the application of a mobile technology, namely PDAs (Personal Digital Assistants), within the healthcare sectors of Ghana, Uganda and Kenya. The goal of the study was to determine whether PDAs were appropriate ICTs that could be used to improve healthcare within these and other developing countries. The Satellife researchers believed PDAs could link healthcare professionals in developing regions to each other and provide access to reliable medical information sources. They were particularly interested in assessing the usefulness of PDAs for collecting and disseminating locally relevant medical data and information.

The PDAs were found to be a viable alternative to PCs, with several practical advantages over

desktop systems: In particular, they were mobile, battery powered, robust and lightweight. Healthcare workers also found the PDAs easy to learn and use, even by those who had little or no previous computing experience. The effectiveness and efficiency of the PDA solution was highlighted by the speed with which workers captured measles survey data during a pilot study in Ghana. However, large-scale deployment after the pilot was hampered by the cost of PDAs.

#### 4.2.2 CellLife

CellLife [22] uses GSM (Global Standard for Mobile) cellular technologies to support those affected by HIV/Aids in South Africa. Their Cellphone4HIV initiative encourages patients to adhere to antiretroviral (ARV) treatment programmes by sending SMS (Short Messaging Service) reminders to take their medication and attend clinic appointments. Cellphone4HIV also uses SMS to broadcast informative messages on HIV and sexual health. CellLife believes these messages can help change local attitudes towards the disease, dispel negative stigmas and remind all citizens that Aids is treatable and HIV preventable.

Another CellLife product, iDART, supports public sector pharmacists in managing their ARV stocks, printing reports and labels and managing the collection of ARV medication by patients via SMS reminders. In 2007 17,500 HIV positive patients were being monitored via iDART.

#### 4.2.3 Information needs of healthcare workers

Several researchers have explored the information needs of medical workers within a developed-world context. Eisenstadt et al.'s [45] work highlighted the need for timely access to patients' medical information within a hospital environment. They found that existing fixed terminal access was insufficient and interrupted daily workflow. Their analysis yielded a requirements specification that documented the need for:

- Information to be pushed to hospital staff;
- A mobile interface for consuming the information;
- A fail-safe delivery mechanism; and
- A low overall maintenance cost.

The solution utilized a two-way paging system to send medical alerts and results to hospital staff, who could respond in one of three ways: Specify a particular course of action, comment

on the message or request further information to be sent via email or nearby network printer.

The research findings showed that a mobile two-way paging solution was appropriate for certain types of information; in particular, information that might significantly change the care strategy for a patient (e.g. laboratory reports). They also identified the need for a general-purpose communication service. Shortcomings of the two-way paging system included the limited length of messages (500 characters) and the inefficient I/O (input-output) mechanism.

The ‘Ward in Hand’ [1] project explored practical applications of mobile computing devices in a hospital setting to address the inefficiencies associated with paper-based information practices. The research aimed to improve the overall quality of medical service delivery by providing hospital staff with access to vital patient information at the point of care via PDAs connected to the hospital databases through a wireless LAN.

Muñoz et al. [112] also describe the need for a mobile communication platform for managing hospital information work. They found that an appropriate solution would need to support contextually aware messaging, that is messaging where the sender does not have to specify an individual recipient. Rather, their system allowed messages to be sent and delivered according to contextual criteria such as “the next doctor to come on duty” or “the nurse that comes on duty after lunch”. Contextual messaging catered for hospital settings where work scheduling is complex and information work is less well defined.

#### 4.2.4 The MuTI project

MuTI (Multi-modal Telemedicine Intercommunicator) [14] is a remote medical consultation system that aimed to connect rural clinics to district hospitals in the Eastern Cape. MuTI began as a networking project to explore the developmental possibilities of Voice over IP (VoIP); as research progressed and local needs became clear, the researchers identified a need to reduce unnecessary patient referrals by enabling remote consultation between clinic nurses and hospital doctors, thereby reducing the need for patients to travel long distances for a physical consultation at the hospital. The prototype MuTI system connected the Tsilitwa clinic with the Nessie Knight district hospital via a long distance Wireless Fidelity (Wi-Fi) network.

Other researchers working in the Tsilitwa area, prior to the arrival of the MuTI researchers, had installed a communications system that utilised Voice over Internet Protocol (VoIP)

telephones and web cameras to enable remote consultation between the Tsilitwa clinic and Nessie Knight hospital. The MuTI team began their research by evaluating the existing communication system. They found that the system only supported synchronous communication, which was problematic for two reasons. First, the electrical supplies to both the hospital and clinic were erratic, whereas synchronous communication depended on both hospital and clinic systems having uninterrupted electricity supply. Second, the MuTI researchers found that hospital doctors struggled to assign time for synchronous consultation sessions due to staff shortages and overloaded work schedules.

The MuTI researchers then gathered feedback from medical staff on their experiences with the existing system. In one example, the hospital doctor stated that the image quality of the video call was poor. This led to the specification of a new requirement: “Improve video quality”. Further exploration revealed that the doctor needed to see finer details of the patient’s condition, not necessarily motion -- for example, images of dermatological conditions needed to be clear and of high resolution to support an accurate diagnosis. For this reason the MuTI researchers decided to explore the use of high quality still images together with video.

The MuTI researchers decided to develop a new version that would maintain the functionality of the existing system, while enabling asynchronous forms of communication. The new tool would also to capture high-resolution static images and high quality audio clips. The requirements specification listed the following synchronous and asynchronous features: Make Call, Receive Call, End Call, Create Message, Send Message, Receive Message, Add Contact, Delete Contact, and View Contact Availability.

The resulting MuTI system included a custom PC-based application that provided two modes of communication. The first mode, ‘online’ communication, provided a single synchronous, multimedia messaging tool, namely a voice call. The second, ‘offline’ communication mode, provided an interface for creating and sending rich multimedia messages. Upon loading the MuTI application, the user was presented with the main interface screen and two primary interface components:

1. A contact list that grouped the user’s contacts according to their current status – online or offline (see Figure 4-1). The nurses were trained to refer to the status flags when

choosing a messaging mode.

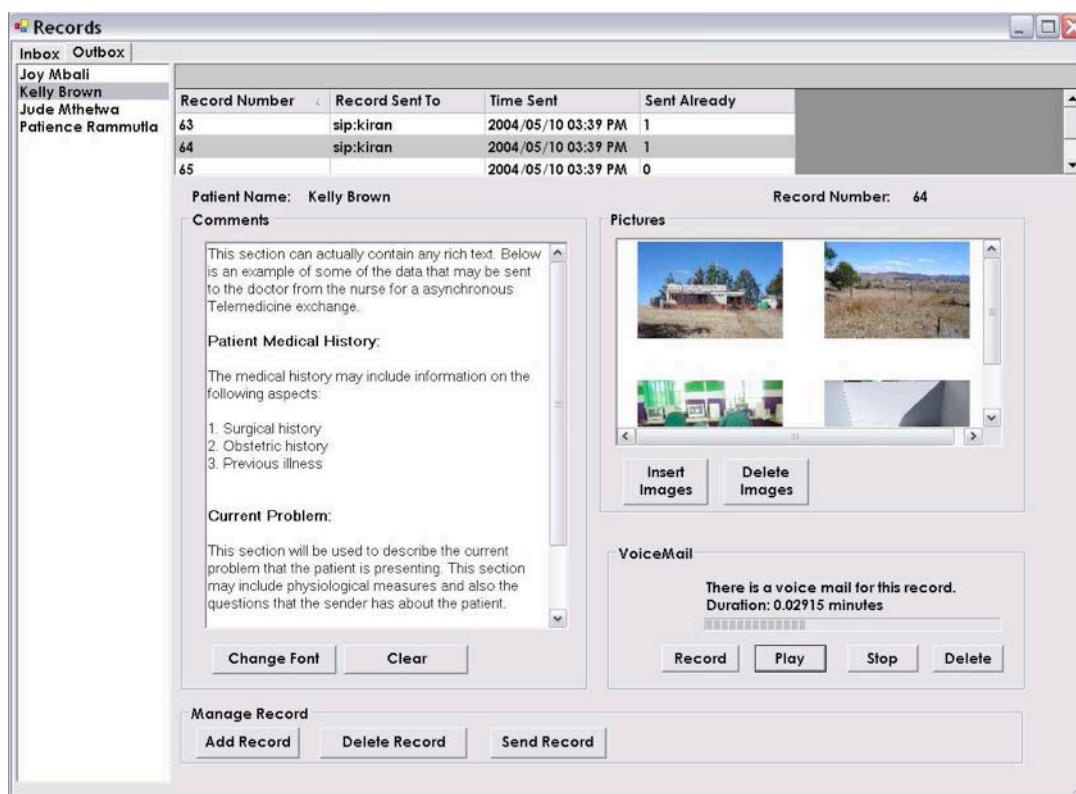
**Figure 4-1: The MuTI contact list**



2. A voice chat widget that presented the controls for mediating a voice conversation.

If a contact was listed as 'online' users were able to initiate a synchronous voice call session by right-clicking on the contact and selecting the desired form of communication. If the contact was listed as 'offline', the user would have to construct and send an asynchronous message (see Figure 4-2). The MuTI system was installed at the two locations and users received both PC and MuTI training.

Figure 4-2: MuTI's asynchronous messaging interface



#### 4.2.5 Summary of findings

Mobile technologies were found to be particularly appropriate for both developed and developing world healthcare environments. PDAs proved to be practical in Ghana, Uganda and Kenya due to their portability, robustness, use of battery power and ease of use when compared to desktop computers. Cellular phones and cellular technologies, such as SMS, were used to good effect in South Africa due in part to the ubiquity of cellular handsets and the widespread coverage provided by local network operators.

Eisenstadt et al. [45] and Ancona et al.'s [1] work highlighted the importance of a mobile interface for medical information systems. Muñoz et al. [112] added context-aware messaging as a desirable feature within hospital settings where the synchronisation of work activities is a constant challenge. Chetty, Tucker and Blake's [24] work on the MuTI system revealed the need for a multi-modal messaging solution between nurses working at a remote clinic and doctors working at a district hospital. If the doctors were unavailable for a synchronous voice call nurses could prepare an asynchronous message with voice, text or image elements. The

hospital doctors would then be able to access the message when their schedule allowed.

In conclusion, ICTs have been used within healthcare to support the following activities:

- General purpose messaging platform between staff members
- Capture of medical data
- Dissemination of laboratory reports
- Medication and appointment reminders
- Remote consultation

### **4.3 The MuTI Mobile design process: First UCD iteration**

As noted in Section 3.2 above, the author joined the MuTI team to address usability problems at a stage when the research site had recently moved. The first UCD iteration, from March 1 to May 8 2005, focussed on developing an understanding of the work and social contexts at Lwandile and Canzibe, and capturing the findings into a series of contextual models. The cycle included the first field trip (March 16-22 2005) and the third participatory workshop on May 13 2005 (see the timeline in Table 3-2).

Contextual design and ethnography were used to gain a detailed understanding of the local context and the clinic and hospital workflows. In particular, the author wanted to establish whether there was in fact a need for a remote medical consultation system between the Lwandile clinic and Canzibe hospital -- and if so, whether the MuTI system, in its current state, was an appropriate solution. At the same time, the author was assessing whether an empathic UCD approach was a suitable design method for evaluating and redesigning the MuTI system.

#### **4.3.1 Understanding and specifying the context of use**

The process started with a detailed ethnography and contextual inquiry, running in parallel, to analyse the way staff at Lwandile clinic and Canzibe hospital worked and collaborated. The goal was to compare staff members' descriptions of how they performed their daily work, gathered through a contextual inquiry, with behavioural observations from an ethnographic study of the same work activities. Simonsen and Kensing [147] describe the combined use of these two techniques as a means to develop a thorough understanding of current practices within a work setting. To perform a contextual inquiry, Holtzblatt, Wendell and Wood [67]

recommend that the designer adopt the role of an apprentice. The designer-user relationship then takes the form of a partnership in which the designer asks relevant questions and learns, while the user adopts the role of expert with regards to their daily work. An ethnographic study, by contrast, attempts to describe and understand the behavioural patterns associated with the work context through a wider lens [147].

The author started the contextual inquiry by spending a significant amount of time simply observing the clinic and hospital workflows and communication patterns. Once a degree of familiarity and trust had been established he began asking questions about the work setting, processes and existing work artefacts. Staff members were always willing to answer questions but the clinic nurses, in particular, struggled to understand the purpose of the contextual inquiry despite prior explanation by XV, a Xhosa-speaking member of the MuTI research team (see below). The inquisitive nature of the process, in combination with language and culture barriers, led the nurses to be suspicious of the author's motives. As Hudson [68] points out, researchers must be sensitive to the fact that participants may feel threatened by evaluative, or in our case analytical, activities and fear that they are being judged. We addressed this issue and strengthened the participatory nature of the design process by focussing on improving communication between the nurses and the designer.

#### 4.3.1.1 Enhancing design communication

XV, a networking researcher working on the MuTI project and student of the project manager BT, served an important role in the contextual inquiry. He had grown up in the Eastern Cape town of Dutywa, roughly 153km or a three-hour drive from the Lwandile clinic. With Xhosa as his first language and a shared cultural background, he was able to communicate effectively with the nurses at Lwandile clinic to explain the purpose of the MuTI project, how it would benefit the community and how the research was connected to the team members' postgraduate studies. His communication included making analogies with familiar technologies (e.g. the voicemail service on GSM cellular networks), interpreting comments made by the nurses and providing the village headman, TS, with project updates.

We later employed TV, a young Xhosa-speaking woman in her early twenties, to assist our key informant AS with training and capacity building at Lwandile. TV had completed a basic PC literacy course at the Transcape offices and was therefore an ideal candidate to assist AS with the training programme, especially with activities that required additional explanation in

Xhosa. AS taught TV how to use the MuTI system, ensuring that the necessary skills would be available locally and providing access to an additional ‘user’ for design activities if the nurses were unavailable. This was important because the patient load at the Lwandile clinic was known to be high, limiting the time available for design consultation and participation outside the regular training programme. TV was able to meet with the designers more frequently and discuss her observations from the training programme, including which features the nurses were struggling with, which features were easy, whether the nurses understood the purpose of the MuTI application, and so on. Her availability, depth of insight and her ability to communicate in English led to the designers using her as a proxy for the nurses when they were unavailable.

TV became a local champion [17] in that she understood the MuTI project’s objectives and the need to train the nurses to use the MuTI technology effectively. She had a very positive attitude towards technology and was keen to learn alongside the nurses. This researcher hoped this enthusiasm would rub off on the nurses and dispel any fear regarding the use of computers.

#### 4.3.1.2 Key informants: JS, HZ, AS and SS

Working with key informants was an important part of the wider ethnography and was pivotal in helping the researcher collaboratively analyse [103] and understand his ethnographic observations. JS and HZ were the founders of Transcape and operated the Mdumbi backpacker’s hostel near the Mdumbi river mouth. Their existing local relationships, understanding of the local culture, technology skills and links with the Canzibe hospital made them invaluable access points. JS’s father was a minister at the Canzibe chapel and their house was on the hospital property. He was able to introduce BT to the Canzibe hospital staff and assist him in setting up the research relationship.

They also introduced BT to AS, a Dutch engineer who was married to one of the Canzibe hospital doctors, SS. AS became an important informant: His local presence, technical ability, motivation and personal transport would prove to be a key component in the successful execution of the MuTI and MuTI Mobile design processes. His various roles and project inputs included:

1. **Building trust and rapport.** AS’s wife SS was the mobile doctor who visited the clinics serviced by the Canzibe district hospital. The trust and rapport she enjoyed with the

Lwandile nurses provided a platform for AS to foster a working relationship with them. This included establishing the PC training and clinic maintenance programmes at Lwandile, as well as other support services such as medical deliveries when required.

2. **Local presence:** AS lived at the Canzibe hospital, which meant he was available to conduct the general PC and MuTI training programmes and provide on-site technical support when needed. This proved to be a critical service, as researchers could only visit the site every six to eight weeks.
3. **Local champion:** AS became a local champion in that he was motivated to take charge of the training and capacity development activities at Lwandile and Canzibe, which were core components of the design process and key to producing an appropriate technological solution.
4. **Collaborative data analysis:** The researcher consulted with SS and AS when consolidating observations and findings from the hospital and clinic. Their insights helped develop his understanding of the role of the doctors and nurses, their daily responsibilities and how these integrated into the wider healthcare system.

#### 4.3.1.3 Participatory workshops

The participatory workshops (see Table 3-2) fed valuable information into the MuTI Mobile design process and were important steps in developing design communication, local buy-in and wider support for the MuTI and MuTI Mobile projects. The first two workshops, held on October 21 and November 9 2004, occurred before the author joined the MuTI research team. The outcomes of these are therefore as background information. The author actively participated in workshops three to six.

##### First workshop

**Date:** October 21 2004

**Participants:** Four Canzibe hospital doctors (MS, AL, IA and KB), matron NW and three researchers from the MuTI project (excluding the author).

**Overview:** The objective of this workshop, held at the Canzibe hospital, was to introduce the MuTI project, discuss the legacy CB (citizen band) radio service that used to be in place between the hospital and various clinics, and compile an overview of the ten clinics that the Canzibe hospital served. The group decided that Lwandile would be the most appropriate

clinic partner for the MuTI project, as it was close to the Mdumbi hostel for support purposes.

### Second workshop

**Date:** November 9 2004

**Participants:** AL, NW, three researchers from the MuTI project (excluding the author) and HZ from Transcape.

**Overview:** The group discussed the MuTI project and decided that the researchers should learn more about the Canzibe hospital and Lwandile clinic. NW then took the researchers on a guided tour of the Canzibe hospital and accompanied them on a visit to the Lwandile clinic and local village leader (headman), HK. NW introduced the researchers to HK and gave him an overview of the MuTI project and the wider research agenda. He was very supportive and agreed that an antenna could be mounted on one of his buildings. Part of the long-term agreement was that he could utilise the solar power array for his radio and other electronic devices. Next, the group visited the Lwandile clinic where NW introduced the research team to Sister SC. NW provided an overview of the MuTI project and explained the purpose of our research to SC. The research team was able to demonstrate the existing MuTI system using two laptop computers and an ad-hoc wireless network. SC's response was reported to be very positive.

### Third workshop

**Date:** March 18 2005

**Participants:** Information officer MK, MF the Libode district manager, ND the (acting) Canzibe hospital manager, clinic supervisors SY and MD, AS, SS (mobile doctor) and four members of the research team (including the author).

**Overview:** It was decided that AS would start training the Lwandile nurses on basic PC literacy with the assistance of MK, the Libode information officer, who had previously indicated her willingness to assist during a meeting at the Libode Department of Health offices. Unfortunately, MK did not in the end deliver the promised assistance, leaving AS to develop the training course material and conduct the lessons on his own. This was problematic as AS was unable to communicate with the Lwandile nurses effectively. To remedy the situation, he hired TV to assist him every Thursday.

## Fourth workshop

**Date:** May 13 2005

**Participants:** Six representatives from the regional Department of Health (DoH) who focused on telemedicine application and research accompanied our two contacts within the group, Dr RV and Dr SP. Other participants included new Canzibe manager GW, information officer MK, MF the Libode district manager, MY from Libode DoH office, a representative for the Canzibe nurses and two researchers including the author. No Canzibe doctors or Lwandile nurses could attend the meeting.

**Overview:** The DoH representatives showed interest in the MuTI project's ability to reduce patient referrals from ten surrounding clinics to the Canzibe hospital. They explained that the DoH relied on performance indicators to gauge the state of health care in the province and were keen to support initiatives that could improve the indicators.

### 4.3.2 Specifying user and organisational requirements: Generating work models

Work modelling, as described in Beyer and Holtzblatt's Contextual Design [11], provided a language for representing the findings from the contextual inquiry, ethnography and participatory workshops. The models described the doctors' and nurses' daily work and represented the various tasks, processes and activities. They revealed important distinctions and patterns surrounding work communications, collaborations, actors and artefacts. The following models were constructed:

1. Physical model: Represented the physical work environments of the clinic and hospital.
2. Sequence model: Provided a step-by-step recording of the various tasks observed.
3. Flow model: Depicted doctors' and nurses' responsibilities along with the communication and coordination required.
4. Cultural model: Mapped the influences on individuals, both internal to the organisation and external.

#### 4.3.2.1 The physical model

The physical model captured the actual layout of the nurses' physical working environment, including the space in which they performed their daily tasks. Although a physical model need not be limited to the immediate work environment, we focussed our initial analysis on

this area and used the ethnographic study to understand the wider context and how the work models fitted into the wider social and organisational environment. The main physical characteristics of the Canzibe hospital and Lwandile clinic are:

### Canzibe Hospital

- Situated on a hilltop.
- Significant distance between hospital and clinic (45 minute drive).
- High patient load.
- Doctors primarily located in consulting room, hospital wards or their homes.
- Provides a mobile clinic and doctor service for the district.
- Includes a third party laboratory service.

### Lwandile Clinic

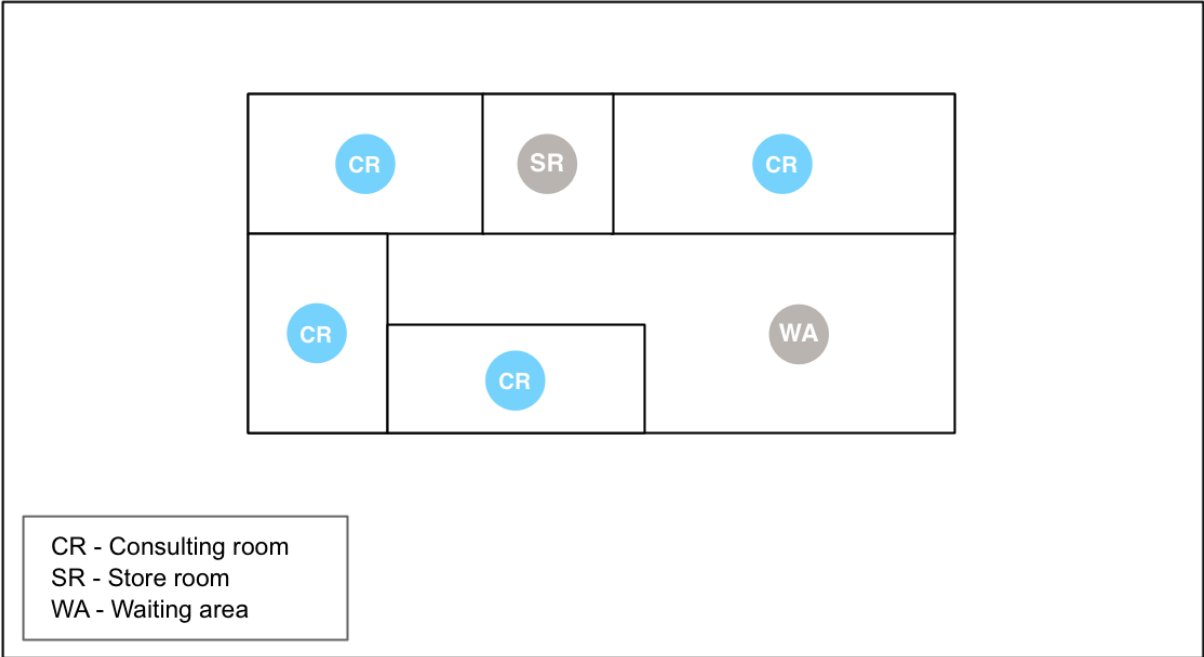
- Remote location.
- Located at the bottom of a valley.
- Intermittent cellular network coverage.
- High patient load.
- Two full time nursing sisters.
- Two part time assistants.
- Solar power charged battery array.

The Lwandile clinic is a small, six-roomed building (see Figures 4-3 and 4-4) situated at the bottom of a coastal valley about 45 minutes' drive (15km on poor roads) from the Canzibe hospital. The clinic building consists of four basic consulting rooms, a store room/dispensary and a waiting area used for pre-consultation activities. The building is bordered by a water reservoir on one side and the nurses' housing block on the other. There is no fixed-line telephonic or electrical infrastructure. Electricity is supplied through a solar panel array that charges a battery pack housed in the clinic storeroom. When researchers visited there was evidence of a CB (citizen band) radio system, but when asked the nurses told us that the 'over' system (as they called it) was no longer used and in fact no longer worked. The only communication channel was the GSM cellular network, but coverage at the clinic was erratic at best and barely suitable for text messaging.

Figure 4-3: Lwandile Clinic



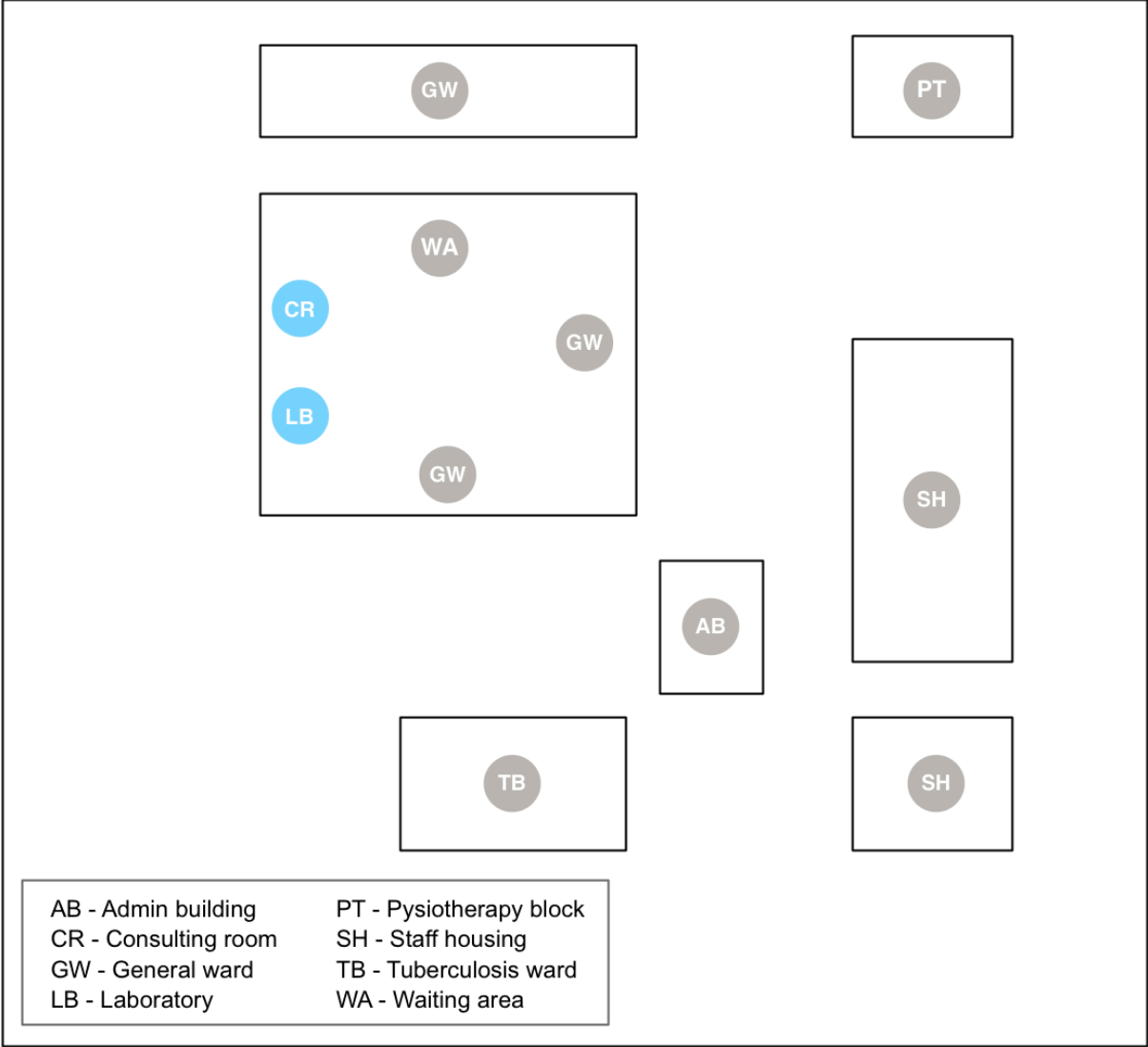
Figure 4-4: The physical layout of Lwandile Clinic



The Canzibe hospital compound (reproduced in Figure 4-5 for easy reference) consists of several buildings including the main wards, consulting rooms, laboratory, tuberculosis ward, physiotherapy rooms, administration offices and staff housing. There is reliable fixed-line electricity and telephony infrastructure. Reliable wireless telephony and data connectivity is

provided via two cellular network providers. It is situated on a hilltop within line of sight of the Lwandile village headman’s hilltop home, but not the clinic

**Figure 4-5: The layout of the Canzibe hospital compound**



**4.3.2.2 The sequence model**

A sequence model represents a step-by-step recording of the tasks observed during the contextual inquiry [11,67]. Our sequence model captured patient assessment, diagnosis, treatment and referral activities.



any of the following:

1. Prescribe a treatment programme based on her diagnosis.
2. Send the patient for a private assessment and detailed examination in a private consulting room.
3. Refer to a laboratory result should one be available for the patient.
4. Ask the patient to return for a consultation with the mobile doctor, who visited the Lwandile clinic once every three weeks.
5. Refer the patient to the Canzibe district hospital.

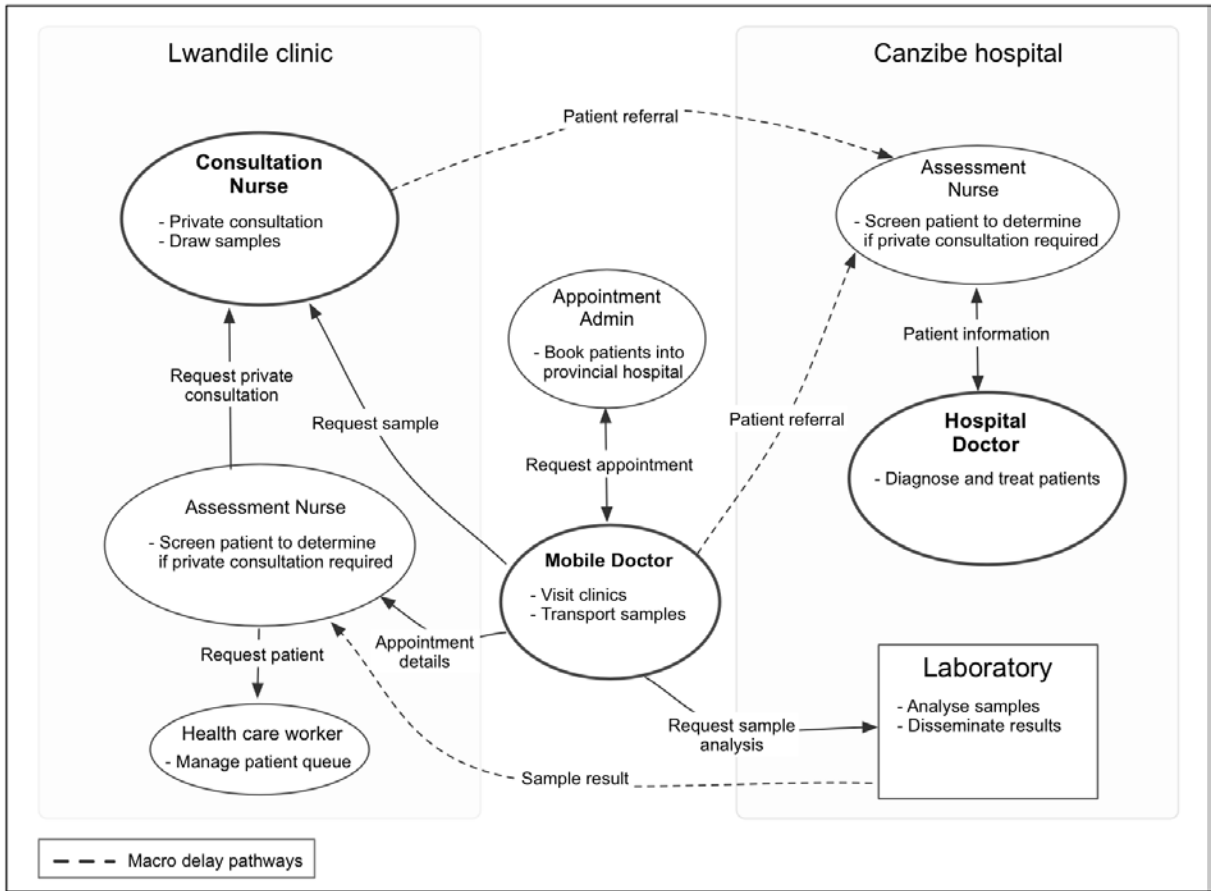
### Phase two

The second clinic nurse worked in a private consulting room and performed all the private assessments. Her assessments covered any sensitive aspects of the examination process that required privacy, such as a body examination. If a urine, blood or sputum sample was needed, the private consultation nurse was in charge of obtaining the samples, labelling the containers and preparing them for transit. The samples would be transported back to the Canzibe hospital laboratory when the laboratory driver, regional clinic manager or mobile doctor next visited the clinic. Once the sample had been analysed in the laboratory, the results were sent back to the clinic via one of the same three transport options. Due to the large number of samples to be analysed at the hospital and the high number of clinics to be visited, the turnaround time for the analysis and delivery of a sample test result was between three days and three weeks. Once delivered, the nurse would refer to the sample result before prescribing a treatment for the patient in question. If the result was inconclusive or the nurse was unable to treat the patient's condition, the patient would be referred to the Canzibe hospital.

#### 4.3.2.3 The flow model

A flow model depicts the responsibilities, communication and co-ordination required to perform a task and is particularly useful when analysing collaborative activities [67]. Our flow model (see Figure 4-7) successfully mapped out all the communicative and collaborative pathways between the clinic and the hospital.

**Figure 4-7: Flow model for Canzibe and Lwandile**



The three most important pathways are discussed below:

**Sample result pathway:** The turnaround time for analysing samples once they arrived at the laboratory was 24–72 hours. This seemed reasonable, but the flow model revealed that results were only sent back to the clinic when the laboratory driver, clinic manager or mobile doctor visited. These visits took place once every three weeks, depending on work schedules and the availability of transport (flagged as a macro delay path – see Figure 4-7). Lwandile clinic staff could thus expect lab results within three days at best, or three weeks at worst. This was a serious concern as it meant delaying the patient’s treatment, during which time their condition might deteriorate.

**Role of the mobile doctor:** The mobile doctor acted as a communication proxy for several key collaborations between the clinic nurses and the provincial and regional hospital staff. Her first role was to consult with patients at the clinic and, if necessary, book them in for

specialist medical treatment at the Canzibe or provincial hospitals. The mobile doctor would then attempt to send the appointment details to the clinic nurses via the clinic manager or laboratory driver.

**Referral process:** Nurses were also able to refer patients directly to Canzibe hospital, without sending a sample for testing, if after a private consultation the nurses felt they were unable to treat the patient's condition at the clinic.

#### 4.3.2.3 Model consolidation and redesign

The contextual inquiry and ethnography made the researcher keenly aware of the challenges posed by the rural environment of the Eastern Cape. The most obvious related to the rugged terrain, undulating hills and the lack of reliable fixed-line electrical and communications infrastructure. These factors would have a direct impact on the requirements specification and needed to be factored into the physical model. Our physical model resembled the list of challenges documented by Parikh and Lazowska [123] after their work in rural India. They cited intermittent power and connectivity, long travel times, variable population density and lack of secure storage as major physical obstacles.

The contextual overlaps encouraged us to consider a 'store-and-forward' messaging solution, similar to Parikh and Lazowska's CAM system [123]. CAM used the multi-media and wireless networking capabilities of a cellular phone to capture micro-finance data in rural Indian villages. If a CAM field agent travelled to a village that lacked cellular network connectivity, the application would temporarily store the financial data on the handset until connectivity was restored. At that point the application would forward the pending data to the CAM servers.

The flow model identified workflows that incurred a macro delay of more than 72 hours and those that required a degree of mobility within the physical environment, including notably the sample result workflow. The flow model also suggested that a synchronous, point-to-point solution would not accommodate the doctors' daily routine and schedule. When doctors were in their consulting rooms, between 10am and 3pm daily, they were unavailable for remote consultation due to high patient loads; outside these hours they were away from their desks. In both cases the doctors were unable to interact with the MuTI system in its current form.

The sequence model was instrumental in gaining an understanding of doctors' and nurses'

existing daily tasks and how these were executed. The model once again highlighted the importance of the sample result pathway: the availability of a sample result was an integral part of the diagnosis and treatment process. A typical sample result consisted of a small printout showing the actual test result and an identification code. Further analysis revealed that the sample result pathway consisted of three distinct stages, namely:

1. Transportation of the physical sample from the clinic to the hospital.
2. Laboratory analysis of the sample.
3. Dissemination of paper results from the hospital to the clinic.

The latter was immediately identified as a pathway that could be augmented by an ICT solution. If chosen, it would require a mechanism for allowing hospital staff to capture sample results, for transmitting the results over a wireless network and finally for presenting them to the clinic nurses.

The sample result pathway was particularly attractive because it could use an ICT in a supportive role, augmenting an existing information pathway that was already part of the nurses' daily workflow. The turnaround time for sample results could be decreased from days and weeks to a matter of seconds. The DoH had cited the turnaround time for information dissemination as a valuable performance indicator during the workshop.

#### 4.3.3 Generating a design solution

The contextual inquiry and ethnography revealed the need for a portable solution that could easily be moved and shared between the hospital staff on duty. The findings highlighted that the existing MuTI solution, running on a laptop PC, was not flexible enough to be of practical use – the security chain, wired headphones and webcam made the laptop cumbersome to move. This led the author to explore hardware solutions with integrated multi-media features [123]. A redesigned solution would also need to scale to allow multiple devices to connect and communicate simultaneously. The vision was to provide two shared devices at the hospital and one at the clinic to start with, then to allow devices to be added as needed. For example, if more clinics were added to the network, the system would need to be able to support additional devices. The existing MuTI design only supported a single point-to-point connection between two laptop PCs.

#### 4.3.4 Learning outcomes

#### 4.3.4.1 The artefact

The proposed solution (MuTI Mobile) would be a modified implementation of the MuTI system designed to run on a cellular phone with integrated multi-media features such as a camera, microphone and audio speaker. The solution was attractive as both clinic and hospital staff were familiar with cellular technologies. The author believed nurses would be less intimidated by the cellular handsets and that the solution would leverage past experiences with their own handsets (e.g. their familiarity with the alpha-numeric keypad and four-way navigation buttons for navigation and text input).

#### 4.3.4.2 The process

The contextual inquiry and work model generation executed successfully within a rural healthcare environment – although the success of these processes relied heavily on the key informants JS, HZ, AS and SS. The result was the identification of an alternative design pathway focussing on sample result dissemination, in addition to the existing need to reduce unnecessary patient referrals. The wider ethnographic study captured important contextual information about the clinic and hospital communities, in particular the history of the areas and the inherent challenges of daily life in the rural Eastern Cape. It was too early to identify patterns of activity that may have had a significant implication on the redesign of the MuTI system, but we did take note of the poor socio-economic conditions, long travel times between villages and towns and the lack of basic municipal services such as a reliable electrical supply, water supply and flush toilets. Social instabilities and security surfaced as major concerns for community members and we were often warned about areas that were notorious for roadside attacks.

Even in this first cycle, the ethnographic and participatory workshop data produced important design information. Analysis of workshop outcomes confirmed the DoH's interest in reducing unnecessary patient referrals and their belief that an ICT solution could play a significant role in achieving that goal. The contextual models revealed that the existing PC-based MuTI system would not be appropriate for the Canzibe hospital context. This was because it relied on several wired peripheral devices such as a security lock, headphones and a video camera, making it cumbersome to move —it effectively became a fixed terminal in the doctor's consulting room. The level of mobility provided did not fit the doctor's daily workflow.

The RA/RI criteria [16] and the work of Eisenstadt et al. [45] highlighted the lack of

workflow integration and contextual fit as an area of concern. Our work models revealed two ways this problem could be addressed:

1. The existing paper-based sample results produced at the Canzibe Laboratory could be digitised and sent via MuTI to the Lwandile clinic. This solution was attractive because the work activities associated with sample result production were limited to a single location. The consumption of sample results was also already part of the nurses' existing workflow. Applying MuTI in this way would ensure a tighter workflow integration and contextual fit.
2. The MuTI system could be re-designed to support the required degree of mobility and thereby better support the doctor's workflow.

Further investigation revealed that the Canzibe Laboratory was operated by a third party laboratory service provider. The service provider refused a proposed research relationship: A senior manager emphasised that the company was not open to any form of systems integration and asked that we refrain from interacting with laboratory staff. The first option was therefore not a viable design pathway.

The author then focused his attention on the re-design of MuTI to better fit the doctor's workflow and enable consultation between the Lwandile clinic nurses and the hospital doctors. Recall that the twin purposes of these design activities were to produce a locally appropriate solution that addressed the problem of unnecessary patient referrals and at the same time to reflect on the suitability of the empathic UCD design process.

#### **4.4 Second UCD iteration**

The second UCD iteration covered the period from May 18 2005 to March 19 2006. It focused primarily on the construction and testing of a long range wireless network (on which the author assisted), deploying the MuTI system, observing the MuTI training sessions and facilitating three participatory workshops held on May 13, July 14 and September 8 2005. Recall that the deployment of the MuTI system at Lwandile clinic and Canzibe hospital was an integral part of project manager BT's PhD research and therefore had to continue despite the contextual inquiry findings that flagged the PC-based solution as not providing adequate contextual fit.

We start this section with a description of the construction of a long range Wi-Fi (Wireless

Fidelity) network that connected the Lwandile clinic to the Canzibe hospital, before describing the in situ usability evaluation of the MuTI application.

#### 4.4.1 Understanding and specifying the context of use

Lwandile clinic and Canzibe hospital are situated 15km apart, so that a long-range wireless network was a viable option; however, the clinic building lies at the bottom of a valley and is occluded by a small forest. A direct, point-to-point wireless connection was thus not feasible. The researchers had to consider a multi-point network design with at least two additional network nodes.

#### 4.4.2 Specifying user and organisational requirements

Further analysis revealed that a minimum of two primary and two secondary nodes were required. The primary nodes would form the backbone of the network, establishing the long link between the Lwandile village and Canzibe. The secondary nodes would serve as network end points and would be located on the actual clinic and hospital buildings. One of the primary nodes was located on an existing telecommunications tower near the hospital, an ideal location as the tower was highly visible and had a reliable power supply. The second primary node was located at the headman's home on top of a hill in the Lwandile village. Again, the location was ideal as the headman's home was highly visible and he was already a stakeholder in the project, making him keen to assist.

The nodes were required to be fault tolerant and maintenance free. The primary node at the headman's house had an additional requirement in that there was no electrical supply available.

#### 4.4.3 Producing a design solution

Each node in the MuTI wireless network consisted of five major components: a Linux powered mini computer, 802.11 Wi-Fi card, gel cell battery pack, power regulator and an antenna. The Linux operating system and Wi-Fi card were responsible for establishing the wireless network and routing the data packets to the appropriate nodes. The 802.11 wireless networking protocol had been modified by the networking researchers to tolerate the longer delays incurred when transmitting data packets over longer distances. The power regulator ensured a consistent and clean power supply for the computing equipment and controlled power supply switching. Each node included two power sources: a gel cell battery and a solar

or fixed line power supply. Under regular conditions, the solar or fixed line supply would supply sufficient electricity to power the node and charge the battery. If these were unavailable, the node would draw power from the battery. The antennae were responsible for transmitting the two-way data signals between the nodes. The primary nodes included two antennae: a high-powered grid antenna for transmitting data over the long link and a low powered flat panel to route data to the end point.

#### 4.4.4 Evaluating the solution

The evaluative process started with the deployment of the MuTI system (laptop, webcam, headset and MuTI software application), rigorous training on Windows XP and the MuTI software application and testing of the new Wi-Fi network. The training sessions, run by key informant AS, aimed to provide the clinic nurses with the necessary knowledge and skills to use the laptop computer and MuTI software.

The author was able to gather observational data and conduct an interview with AS, both of which provided valuable usability feedback. The training sessions revealed that the nurses were comfortable with the online interface but less so with the offline interface. They spent a significant amount of time (20 minutes or more) creating offline messages and often required assistance from key informant TV. She identified this feature of the MuTI system as a real problem despite the nurses attending several training sessions. A subsequent heuristic evaluation, conducted by the author according to Nielsen's 10 usability heuristics [115], showed that:

1. The MuTI interface presented unnecessary and often meaningless information such as IP addresses.
2. Unfamiliar database metaphors such as "records" and "tables" were used.
3. Messages were ordered numerically and filtered according to the sender's name. An incoming message would be placed into the message list according to its message ID number rather than at the top of the list, even if it was unread or the newest message.
4. There was no way of changing the filtering or viewing rules; thus users were made aware of a new message but had no idea how to find it.

5. Users needed to access the file system to attach multimedia to a message.
6. The status flag was unreliable and often displayed the incorrect status.
7. Users had to choose whether to use online (synchronous) or offline (asynchronous) messaging.
8. There was limited visual feedback with regard to media attachments. Users could see their photos, but voice and video had to be previewed to confirm that they had been attached correctly.
9. It was not possible to search for a message. The user was forced to manually browse for a message by viewing each one individually.

The evaluation confirmed that the usability of the asynchronous features was problematic and discouraged the nurses from creating and sending offline messages if a synchronous call attempt failed. The training sessions also revealed a critical bug in the MuTI software: The Canzibe hospital status would often be displayed as 'offline' in error, leading the nurses to believe that the doctors were never available for consultation. This status bug had to be rectified quickly as it had the potential to break down the nurses' trust in the technology. Applying the RA/RI criterion 'Trust in ICT' to the contextual findings emphasised the critical nature of trust-related issues.

The data from the training session and heuristic evaluation were then triangulated with feedback from the sixth participatory workshop.

#### 4.4.4.1 Participatory workshops

AS and TV had been training the nurses to use the laptop computers and the MuTI software once a week since approval had been granted at the workshop held on March 18. The MuTI synchronous voice and video features had been operational since May 18. The fifth and sixth workshops, held in July and September 2005, therefore covered decisions regarding the practical use of the MuTI system and a significant amount of evaluative feedback and suggestions.

##### Fifth workshop

**Date:** July 14 2005

**Participants:** Two Lwandile nurses (Sister Z, Sister B), Three Canzibe hospital doctors (SS, MS and AL) and three researchers (BT, XV and the author).

**Overview:** The workshop aimed to further develop the nurses' understanding of the wider MuTI project and strengthen participation between the doctors, nurses and designers. The meeting also discussed the work practices and equipment associated with the MuTI system. The main outcomes of the meeting included:

1. An agreement that the doctors and nurses would leave the MuTI system on every day, instead of setting it up on the laptops when they feel a need to use it.
2. An agreement that the equipment would be formally loaned to the Canzibe hospital and Lwandile clinic and added to the asset register. This was to address concerns about the cost of the equipment, its safety and what would happen if it got stolen.
3. Participants reported that the real-time communication features of MuTI were more useful than the store-and-forward features.
4. The Canzibe and Lwandile participants would have to sign consent forms if they wished to participate.
5. After discussion of the doctors' and nurses' work schedules, it was agreed that the best time to use the MuTI system was between 11:00 and 13:00.

### Sixth workshop

**Date:** September 8 2005

**Participants:** Key informant AS, Canzibe hospital doctors MJ and SS, Lwandile clinic nurse Sister S and three researchers (XV, BT and the author).

**Overview:** The workshop started with an open discussion regarding the current MuTI system. The researchers emphasised that we wanted to design a system that was appropriate – that worked for everyone and met their needs. It was agreed that the MuTI system was not part of the Lwandile nurses' daily routine. Not only did high patient loads meant that there was little time available for MuTI consultations, the interface was difficult to use.

The group then discussed several ways to integrate the system into the nurses' routine, make it easier to use and encourage usage. These included:

1. Provide a quick, accessible overview of MuTI messages that need to be read (doctors).

2. Make it work like GSM voice mail: If the doctor or nurse doesn't answer, the caller can leave an asynchronous message.
3. AS suggested that the laptops and MuTI application be turned on and off automatically. This would remove any setup or shutdown burden from the doctors and nurses.
4. SS gave several useful suggestions including using the system to book patients into Mthatha regional hospital directly from the clinic, making requests for medical supplies and calling for an emergency vehicle.
5. Using the laptops for other activities such as watching movies, games or talking to other sisters at Canzibe.
6. Calling the Lwandile nurses to support them and to stay in touch.

Three of the suggestions made during the workshop were immediately acted upon, namely encouraging the Canzibe doctors to call the Lwandile nurses, automatically switching the MuTI PC and application on and off and allowing the nurses to use the laptops for watching movies. The first suggestion did have a positive impact and led to some of the Canzibe hospital staff using the MuTI system (their attempts served as leading indicators outlined in Section 3.2) but these occasions were few.

AS reported one situation in which a Canzibe nurse was treating a patient referred from the Lwandile clinic. There was a discrepancy in the patient's medical history book and the Canzibe nurse was unable to provide medical care until she obtained clarity with regards to the patient's current treatment program. AS encouraged the nurse to use MuTI to call Lwandile. She did so and the situation was resolved. Although this incident was encouraging, we wanted to see improved usage statistics and believed that MuTI Mobile would provide a way forward. The remainder of the suggestions (1, 2 and 4) were factored into the design of the MuTI Mobile system.

After the workshop, a private conversation between one of the Canzibe doctors and the MuTI manager, BT, revealed that the nurses' motivation and overall work ethic was declining. Upon reflection, the researchers recalled that the nurses were, on several occasions, not in residence at the Lwandile clinic (recorded in BT's field journal). We also began to notice unusual patterns of behaviour: Notably, that the nurses were reluctant to let us visit the clinic on Mondays. These findings were documented in the author's field journal but the meaning and full scale of the finding would only be realised later in the design process (discussed in detail

below in Section 4.6.4).

## 4.4.5 Learning outcomes

### 4.4.5.1 The artefact

These findings provided further evidence that the existing MuTI system was not an appropriate solution for a rural health care environment. Apart from its lack of mobility, the process of asynchronous message creation was far too complex for novice users. Yet it remained an essential mechanism for dealing with workflow synchronisation problems that were identified in the first cycle. The findings supported the author's belief that a cellular phone with integrated multi-media features would be a more appropriate technology platform. The challenge would be to find a cellular phone that supported text, voice and video capture, 802.11 Wi-Fi networking, a regular alpha-numeric keypad and a rich application programming interface (API) that provided access to these features.

### 4.4.5.2 The process

The findings from the training sessions supported Satellife [18] and Bridges.org's [16] belief that an adequate ICT training programme is key to the success of any ICT4Dev initiative. We found that the nurses were hesitant to use the MuTI system before they had received adequate training for fear of making a mistake and looking foolish in front of their peers and their trainer, AS.

Our key informant, AS, played a pivotal role in the sixth participatory workshop. Upon later reflection we realised that the Lwandile nurse, Sister S, did not actively participate in the workshop. It became clear that there were forces relating power, hierarchy and knowledge that prevented the nurses from communicating and participating actively. AS intervened and provided valuable insights regarding aspects of MuTI that the nurses were struggling with. He also provided suggestions that were supported by his contextual and technical knowledge e.g. the voice mail idea. AS acted as a proxy for the nurses during the workshop, essentially becoming their voice in the design process. His contextual knowledge gathered from weeks of training the nurses provided him with unique insights into their work and social lives and the ability to empathise with their situation, while his technical knowledge allowed him to formulate relevant suggestions. Two of these had a direct influence on the MuTI Mobile design:

1. Provide a quick, accessible overview of MuTI messages.
2. Make it work like GSM voice mail: If the doctor or nurse doesn't answer, the caller can leave an asynchronous message.

## 4.5 Third UCD iteration

The third UCD iteration ran from March 20 to August 6 2006 and included a fifth field trip that from March 20-24 2006. In this section we will describe how the work models, findings from the workshops and findings from the MuTI usability evaluation were consolidated and transformed into a requirements specification that included a set of usage scenarios that depicted the new MuTI Mobile workflow. Thereafter, a low fidelity prototype of the MuTI Mobile system was produced and evaluated.

### 4.5.1 Specifying the user and organisational requirements

The requirements were considered at two levels: The user and the organisation requirements at the higher level, and functional requirements at the lower level. We started by listing the requirements followed by a description of the scenarios of use. The major requirements and their mapping to the MuTI Mobile design are shown in Table 4-1 below:

**Table 4-1: MuTI Mobile design requirements**

Requirement	Traceable origin	Quality impact	Implication for design
Mobility and portability – to enable device sharing amongst staff and support movement within the work environment.	Flow model	Improve contextual fit	Use mobile device (i-mate SP5)
Flexible collaboration –to support workflow synchronisation (time).	Sequence model	Improve contextual fit	Support synchronous and asynchronous messaging
Familiarity and learnability	MuTI usability evaluation	Usability	Simplified user interface utilising commonly used mobile (phone) interaction design patterns.
Efficiency in use	MuTI usability evaluation	Usability	Use mobile phone with integrated multi-media features
Cope with unreliable power supply	Physical model, RA/RI criteria	Contextual fit	Battery powered mobile device, support asynchronous messaging

Minimise cost to end user and community	Ethnography, RA/RI criteria	Contextual fit	User Wi-Fi enabled mobile phone instead of GSM mobile phone.
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At a user and organisational level, we needed to develop a version of the MuTI system that ran on a cellular phone: ‘MuTI in your pocket’ (this requirement was traceable back to the work models derived from the contextual inquiry findings). Our conversations with the nurses led us to believe that they would be more familiar with a cellular technology, find it less daunting and potentially easier to learn. Migrating the MuTI functionality onto a cellular phone would address several of the mobility and portability issues associated with the laptop solution. The MuTI training observations showed that during the message creation process, the tasks associated with media capture and attachment took the longest for the nurses to complete. For example, if a nurse wished to attach a photo to a MuTI message, she would have to take a photo with a standard digital camera, import it onto the PC and then use the file browser to attach it. We addressed the problem by utilising the integrated multi-media features of a cellular phone, thereby simplifying the media attachment process. Our vision was that a nurse should be able to capture and attach any media type within two to four button clicks.

At a functional level, the MuTI Mobile system was required to scale beyond two client devices (this requirement was traceable back to AS who pointed out that Canzibe needed four MuTI Mobile handsets, one for the hospital nurses to share and one for each doctor). To achieve this we migrated from a point-to-point to a client-server connection model. The new model would provide the necessary scalability, whilst allowing one-to-many and role based messaging.

The requirements and redesigned workflows are captured in the following scenarios:

#### 4.5.1.1 Scenario 1: Call a hospital doctor on duty

A patient arrives at the Lwandile clinic complaining of an irritating skin condition. Sister Z examines the patient but is unable to make a diagnosis. She attempts to call the hospital and Doctor LZ answers. Sister Z describes the condition and Doctor LZ recommends that the nurse apply a topical ointment to the irritated piece of skin. The doctor further recommends that the patient continue treatment for five days and then return to the clinic for a check up.

The nurse ends the call and treats the patient.

#### 4.5.1.2 Scenario 2: Send a message to the hospital doctor on duty

A patient arrives at the Lwandile clinic complaining of an irritating skin condition. Sister Z examines the patient but is unable to make a diagnosis. She attempts to call the hospital but there is no answer. The MuTI Mobile system switches to asynchronous messaging and presents the nurse with the “create a multi-media message” interface. She proceeds to take a photograph of the patient’s skin condition and attach it to the new message. Next, she records a voice message to describe the condition in more detail and appends that clip to the message. The nurse then sends the message to Canzibe hospital, where the doctor on duty will receive it via MuTI Mobile.’

#### 4.5.1.3 Scenario 3: Send a message to a specific clinic

A hospital nurse is assessing a patient that has arrived at the Canzibe hospital. The patient does not have a medical history book. The nurse questions the patient verbally to gain a better understanding of his condition. The patient claims he was referred to Canzibe by a nurse at the Lwandile clinic. Before sending the patient for a private consultation with the Doctor LZ, the nurse uses MuTI Mobile to call the Lwandile clinic. There is no answer. The MuTI Mobile system switches to asynchronous messaging and presents the nurse with the “create a multi-media message” interface. The nurse attaches a voice mail message in Xhosa and a picture of the patient.

#### 4.5.1.4 Scenario 4: Send a message to all the clinics

Doctor SS needs to inform all the clinics of a measles outbreak in the Libode district and query whether they have the necessary vaccines and medication. If not, she requests that they inform her and specify the stock items they require so that she can bring them on her next visit or deploy a driver if the situation is urgent.

### 4.5.2 Generating a design solution

The low-fidelity prototype (see Figures 4-8 and 4-9) explored user reactions to two important features of the proposed design: The migration to a cellular handset and the integration of multimedia features.

Figure 4-8: Paper prototype of the original MuTI user interface

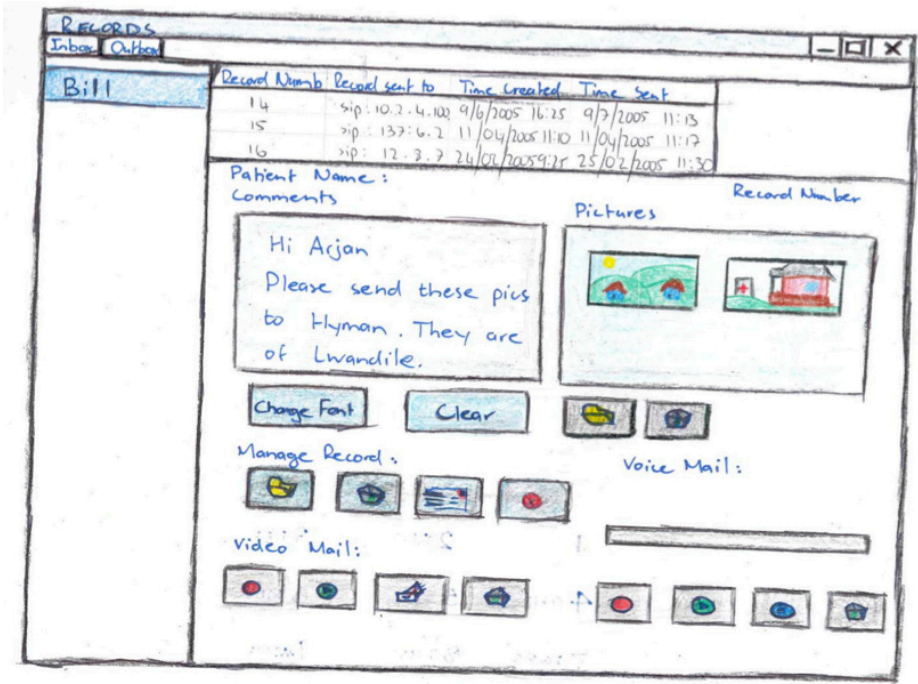
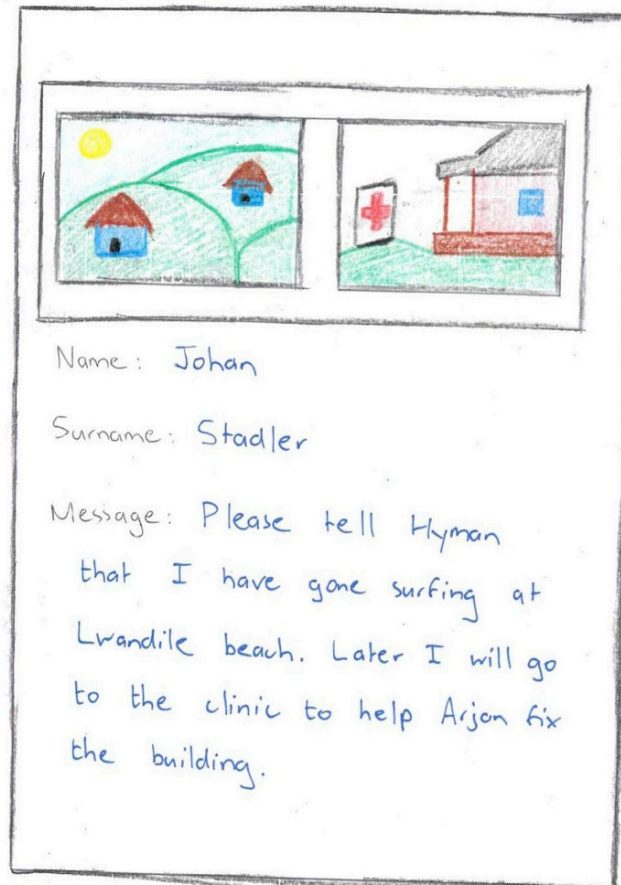


Figure 4-9: One of the sketches from the paper prototype of the MuTI Mobile system



### 4.5.3 Evaluating the solution

Low-fidelity paper prototypes were used to introduce TV to the MuTI Mobile concept early on in the design process and to capture her reactions, feedback and comments. Evaluating the paper prototype with TV, as opposed to the nurses, was not the author's first choice, but was the only available option due to the busy work schedule of the clinic nurses. This was another example of using an informant as a proxy to represent the nurses' voice in the design process.

The prototyping session began with a discussion of a paper version of the existing MuTI system. Next, we explored the concept of moving MuTI onto a cellular phone with the help of Figure 4-9 and other sketched prototypes. As the session progressed the author noticed that the TV appeared disturbed, and it became clear that she was concerned about any changes to the MuTI system. She said the nurses had just become familiar with the existing MuTI software application and how to use it. She suggested that instead of moving the application to a mobile phone platform, the author should improve the offline messaging feature, making it easier to use but still keeping it on the laptop computers.

The session failed to extract any significant feedback on the MuTI Mobile design concept; what was evident was the nurses' sensitivity to change.

## 4.5.4 Learning outcomes

### 4.5.4.1 The artefact

The wider ethnography provided two possible interpretations of TV's reaction to the paper prototype. The first interpretation was based on her involvement at the Lwandile clinic, which she would often visit to use the laptop and practice using Windows and Microsoft Word – it is possible that her reaction was partly based on fear that the laptop would be taken away once MuTI Mobile was implemented. It is worth noting that Transcape had provided TV with an opportunity to attend additional IT classes in Mthatha and she would spend time practising on the MuTI laptop every Thursday when the nurses were busy with patients. She would also travel for almost three hours to get to the clinic if AS could not provide her with transport. This was an indication of how dedicated she was to the training programme, how much she needed the income she generated from the training sessions and how valuable time with the laptop was. Taking the laptop away was not the research team's intention and with hindsight it was clear that this should have been made clear during the introduction to the prototyping session.

The second possible interpretation requires us to consider that TV may have been confused as to the purpose of the prototyping session and what we were trying to achieve by discussing paper drawings. As Lim et al. [89] point out, this confusion may have been an effect of the prototype itself rather than the underlying design concept that we wished to convey. Stacey, Eckert and McFadzean [151] remind us that sketches are often ambiguous and open to multiple symbolic interpretations. Taking the abstract nature of the paper prototyping session and her fear of losing the laptop together, it was no wonder TV rejected the redesign process.

### 4.5.4.2 The process

Low-fidelity prototyping sessions were not very effective at capturing meaningful design feedback on the underlying MuTI Mobile concept. Our original design assumptions were therefore perpetuated into the next design iteration, effectively committing us to travelling further down the design path without gathering any significant design feedback from the target users or a proxy user. These findings are consistent with those of other ICT4Dev researchers. Parikh, Ghosh and Chavan [124] reported that rural Indian villagers were initially

very confused by the paper prototypes they were shown. The researchers needed to explain the broader purpose of their visit, what they were working on and why they were doing it before the villages understood the paper prototype. Despite the confusion being cleared, the researchers did not report any significant design feedback emerging from the paper prototyping session. Medhi, Sagar and Toyama [101] reported similar findings: Heavily abstracted imagery caused confusion when demonstrating interface concepts to illiterate woman in Indian slums.

Communicating design intent and reasoning in the early phases of a design process is one of the major challenges facing 4Dev designers. Inability to elicit meaningful concept or usability feedback from target users means the designer may commit significant resources to the exploration of a solution that may ultimately neither be found to be usable nor interpreted as being useful. Worse still, it may not even address a relevant problem.

## **4.6 Fourth UCD iteration**

### **4.6.1 Overview**

The evaluation of the paper prototypes failed to yield significant findings regarding the appropriateness of the underlying MuTI Mobile concept. The design team therefore had to utilise the existing requirements to generate a higher fidelity prototype.

### **4.6.2 Generating a design solution**

The findings from the paper prototype session encouraged us to build a higher fidelity prototype of the MuTI Mobile concept that ran on the target device. Our goal was to present the users with a prototype that had the look and feel of the final product, in an attempt to remove any abstractions that may have caused confusion. The device of choice was the i-mate SP5 (see Figure 4-10), chosen primarily for its integrated Wi-Fi module and its ability to run the rich, second version of the .NET compact framework. The programmatic access of these features was essential for the construction and transport of multimedia messages over the Wi-Fi network. Another key feature of the i-mate SP5 was that it resembled the type of cellular phone handset with which the nurses were already familiar. Most mobile devices with Wi-Fi connectivity that were available at that time resembled PDAs or pocket organisers and utilised a QWERTY keyboard (see Figure 4-11) or stylus interactions. We wanted to leverage the nurses' existing skills gained through using their own cellular phones with alphanumeric

keypads. We also simplified the i-mate SP5 home screen and main menu. Our goal was to create a less daunting experience by removing irrelevant home-screen information and only exposing the most important features.

**Figure 4-10: The i-mate SP5**



**Figure 4-11: Unsuitable alternative devices**



The MuTI Mobile application was developed for the Windows Mobile 5 platform and utilised the second version of the .NET Compact Framework. The .NET development environment provided us with a powerful set of tools for creating and customising a graphical user interface (GUI) suitable for the nurses. The MuTI Mobile interface aimed to guide the users through a series of linked forms that contained various GUI components for message creation e.g. text box, dynamic list box and multimedia thumbnail lists.

#### 4.6.2.1 Integrated multimedia features

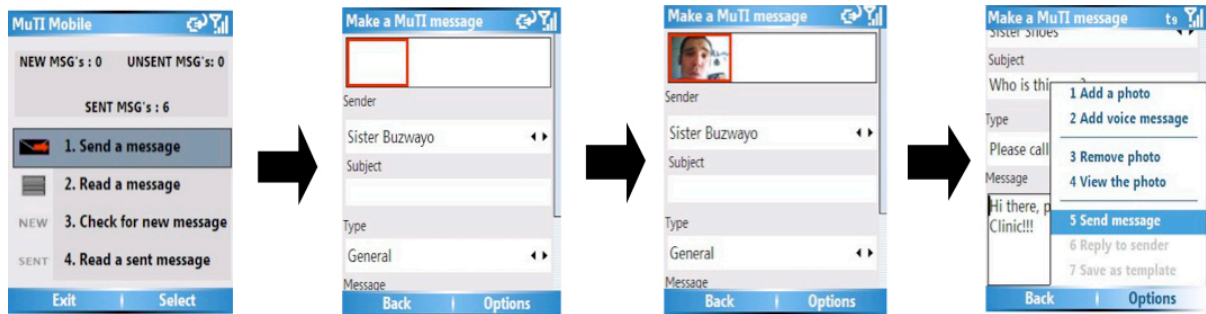
Besides migrating offline messaging features to a less intimidating cellular phone platform, the design also utilised the integrated multimedia features of the device such as the camera, microphone and speaker, removing the need for peripheral devices. The design decision was based on the observational findings from the MuTI training sessions in which we noted that the nurses spent a significant amount of time trying to capture and attach multimedia files to asynchronous messages. MuTI Mobile automated the attachment process and reduced it to four button clicks (see next section for details – ‘Attaching a photo to a message’). The .NET Compact Framework allowed the MuTI Mobile application to control when multimedia features were accessed (opened or closed), where the captured media files were stored and how they were displayed. These steps were successfully automated and effectively removed the need for file browsing when attempting to attach multimedia files.

#### 4.6.2.2 Attaching a photo to a message

If a user chose ‘Add a photo’ from the Options menu (see Figure 4-12), MuTI Mobile would automatically open the camera viewfinder. When the user pressed the ‘capture’ soft key the

photo was captured and stored on disk, and the GUI returned to the message construction screen. A thumbnail image was then inserted into the multimedia list at the top of the message. The goal was to provide the user with visual feedback regarding the success of the photograph attachment. The captured image could be reviewed or removed by selecting the appropriate option from the Options menu.

**Figure 4-12: MuTI Mobile form flow**



#### 4.6.2.3 Attaching an audio clip to a message

MuTI Mobile also allowed users to record voice messages to support (or in some cases replace) text messages. Audio recording gave the nurses the flexibility to record in English or in their local language, depending on the recipient. A descriptive icon was then placed into the multi-media list to indicate success (see Figure 4-13).

**Figure 4-13: The audio capture interface**



#### 4.6.2.4 Adding structure to the message

Switch boxes (horizontal drop down boxes) were used for common text snippets such as names or common message types.

### 4.6.3 Evaluating the high fidelity prototype

The first evaluative session presented the clinic nurses with a high fidelity prototype that had the look and feel of the final version, but without the need for network or server connectivity. The overall goal of the session was to allow the nurses to experience the MuTI Mobile application at first hand. This activity was especially important given that the previous low fidelity session had failed to capture any useful feedback.

The session began with a basic overview of the MuTI Mobile application, demonstrated how it worked, highlighted the similarities and differences between it and the existing MuTI application and built upon the information the training assistant, TV, had passed on to the nurses. Next the designer allowed the nurses to try MuTI Mobile for themselves and attempt to complete a task. One of the nurses happened to press the dedicated ‘Contact List’ button instead of the MuTI Mobile soft key, which unexpectedly brought up the phone’s contact list screen. This interrupted her and seemed to have a negative impact on her confidence. A few minutes later she expressed that she required more training and was hesitant to interact with the new solution. At that point we reverted back to a demonstration and discussion approach.

Luckily, the nurse gathered her composure and a meaningful discussion relating to cellular phones and MuTI Mobile followed. She pointed out that MuTI Mobile would be a useful tool because it worked on a highly portable piece of technology. Her sentiments were captured in her description of MuTI Mobile as ‘MuTI in your pocket’. The nurse agreed that using MuTI on a cellular phone would be easier. Towards the end of the demonstration the nurse even commented that MuTI Mobile reminded her of multimedia messaging on her Nokia phone.

She then proudly displayed an MMS (multimedia messaging service) message containing a picture of her nephew. The nurse then showed the designer several other pictures of her family via the phone’s gallery feature. The session confirmed what the nurse valued most – her family. The camera-phone allowed her to capture, receive and store photographs of her family, strengthening her connection with them she was away from home. The technology delivered a valuable service.

#### 4.6.3.1 Termination of the MuTI Mobile project

The follow-up MuTI Mobile training and evaluative activities had to cease due to a nationwide strike by health care workers and subsequent vandalism of the Lwandile clinic's solar panels in April 2007 [150]. This resulted in the battery array not being charged and no power being available for the wireless network router and MuTI laptop PC. Time and funding constraints forced the author to consolidate his research findings at this point and to pursue the remainder of his graduate research in an environment with fewer uncontrollable factors. The MuTI project manager, BT, did manage to keep the research relationship alive mainly through the efforts of NB, an ethnographer who started working with Transcape and the Canzibe and Lwandile communities. Her work explored the use of the remainder of the wireless network, in particular as a means to enable the headman's son to access the Internet, and the impact of access to online information sources on decisions made by the community leaders.

#### 4.6.3.2 Interviews with TV and Dr C

The author subsequently conducted final interviews with TV and a new doctor, Dr C, who showed interest in the MuTI Mobile project.

TV described how MuTI Mobile had addressed some of the practical problems associated with the previous MuTI system. She listed the fact MuTI Mobile did not have to be plugged in (referring to peripherals such as headphones, video and still cameras) and could be moved around between rooms at the clinic. This solved a number of problems, including that of missed calls: Previously nurses had left the headphones plugged in to the PC, so could not hear the ringing sound associated with an incoming MuTI call.

The interview with Dr C revealed a different perspective of the MuTI Mobile system. He had been using the i-mate SP5 as his regular cellular phone and had tested the MuTI Mobile system. He described MuTI Mobile as "not that bad" but suggested porting it to another phone. He expressed frustration about the i-mate SP5 handset and described it as "impossible to use". He was referring to integral phone features such as creating and sending SMS messages and the use of the 4-way navigation button. He also noted that the Wi-Fi module consumed a significant amount of power, thereby draining the battery very quickly

His feedback highlighted the fact that the overall usability of the MuTI Mobile was dependent, in part, on the usability of the phone handset itself. The i-mate SP5 was the only phone available at that time that included a Wi-Fi module compatible with the wireless

network, resembled a regular cellular phone and provided a rich API (application programming interface) that allowed access to the necessary wireless networking features. This constraint, as well the fact that the MuTI application was only compatible with the Windows Mobile operating system, meant that porting MuTI Mobile to another phone, such as the Nokia phones with which Dr C and the nurses were more familiar, was not feasible in terms of time or budget.

## 4.6.4 Learning outcomes

### 4.6.4.1 The artefact

A remarkable feature of the first evaluation session with the Lwandile nurse was that she was able to engage in a technology-related conversation with the designers after experiencing MuTI Mobile. The MMS analogy laid a common foundation for design communication and discussing potential uses for MuTI Mobile. Low-fidelity prototyping, by comparison, was unsuitable because the prototype introduced a level of abstraction and ambiguity that made effective design communication difficult. Traditionally, designers use low-fidelity techniques to explain design concepts; but, as we have seen, the nurses only understood the MuTI Mobile concept after they had experienced a higher fidelity prototype. When shown a prototype running on the i-mate, the nurse was able to leverage her existing cellular phone knowledge and experience and relate it to what she was experiencing with MuTI Mobile.

Triangulation of the data collected from the two interviews and the ethnographic data that was analysed and consolidated with the help of our key informant, AS, revealed an interesting picture. Our work with TV showed that the asynchronous messaging features of MuTI Mobile were quicker to learn, and easier and more efficient to use, than those available on the existing MuTI PC application. TV learned how to use MuTI Mobile in less than 20 minutes after a single training session at the Lwandile clinic. She was able to construct MuTI Mobile messages in significantly less time due in part to MuTI Mobile's use of the integrated multimedia features and to the 'two-click' media attachment strategy.

The interview with doctor Dr C, as discussed above, highlighted several practical problems with the i-mate SP5. Dr C also assisted us in testing MuTI Mobile and identifying bugs to be addressed in a software update (patch) that was deployed in March 2007. It became clear that the usability of the MuTI Mobile system was not a function solely of the application, but was deeply affected by the physical hardware of the phone. In the case of the integrated multi-

media features the author was able to leverage them to improve usability, but the operating system and physical features such as the 4-way navigation and contact list buttons detracted from the usability of the solution.

Ultimately, as Cockton [29,30] points out, it is not the usability or contextual fit of MuTI Mobile alone that can determine its appropriateness. The solution had to deliver value from the nurses' perspective. The ethnographic study, in particular, revealed how factors outside the workplace coloured the nurses' perspective on the technology and will help us discuss the appropriateness of the MuTI Mobile design.

The most significant finding to emerge from the ethnographic study related to the fact that the Eastern Cape Department of Health (DoH) assigned nursing posts throughout the region and could not guarantee that a nurse would be posted near her family home. The Lwandile clinic was one of the most isolated clinics in the district — one of the clinic nurses had to travel for more than four hours by bus to reach her family home. For this reason the nurses lived in the clinic housing block during the week and only returned home at weekends. To make matters worse, the entire area suffered from social instabilities (often associated with alcohol and substance abuse, mostly during the weekends) that led the nurses to feel uneasy and unsafe when living at the clinic. This uneasiness was exacerbated by their separation from their family and community support systems.

As a result, the nurses adjusted their work schedules to suit their travel arrangements and maximise time spent with their families. The nurses would leave the clinic at lunchtime on Fridays, travel home to spend Friday evenings, Saturday and Sundays with their families and then leave for the clinic again on Monday morning. As a result, the clinic only operated from Tuesday morning until lunchtime on Friday. Despite this formal breach of contract, the nurses were able to continue working a four-day week because the clinic manager only visited once every two to three weeks, and the nurses ensured that they were present on that day. They certainly did not want one of the hospital doctors to discover that the clinic was not operating on Mondays, and tried very hard to hide this fact; for example, the designers noticed that the nurses never offered Monday as an option for a meeting day.

The deployment of the MuTI communication system had a serious impact on this arrangement. One of the nurses jokingly made a comment in Xhosa (her home language) during the MuTI training sessions, roughly translated as “Now you can spy on (watch) us”.

The nurses were aware that the system might expose their work patterns and possibly cost them their jobs. Their perspectives on the MuTI technology were thus largely negative, for reasons that had nothing to do with the technology itself, and had a serious impact on their willingness to appropriate it.

This negative view of the MuTI system was in stark contrast to the nurses' perspective on the PC training sessions that preceded the MuTI application deployment. The clinic nurses had no prior PC exposure or training, but had heard about PCs and the opportunities associated with them. Their attitude towards the training sessions was overwhelmingly positive; they were motivated, enthusiastic and never skipped a session. It later emerged that one nurse had considered applying for relocation to a city hospital, an application which would have a higher chance of success if she acquired PC skills. Unfortunately the cultural model and associated sociocultural perspectives only surfaced late in the design process, after the nurses had experienced the MuTI technology for themselves.

The ethnography revealed what was truly valuable/desirable in the eyes of the nurses – their relationships and connection with their families and communities. At some level the MuTI system seemed to oppose these values or at least threaten them.

#### 4.6.4.2 The process

The design of MuTI Mobile started with a thorough contextual analysis of the clinic and hospital work environments and daily processes. The analysis successfully identified opportunities for technology to improve livelihoods either directly or indirectly: For example, the sample result pathway. Despite a positive start, the process hit two major obstacles.

First, as discussed above, the success of the solution design was subject to forces from outside the immediate context of use. Bridges.org [16] has described how socio-cultural, economic, political and legal forces can significantly impact the accessibility of an ICT.

These external forces were able to permeate into an organisational context. Organisations such as the DoH strive to extend their services into the rural areas of the Eastern Cape, but struggle to micro-manage service delivery at the rural fringes. Nurses are required to work autonomously and take control of their daily workflow and service delivery. The Lwandile nurse's work processes were further subject to social and cultural forces, in particular their isolation at Lwandile and their desire to spend time with their families. The combination of

these socio-cultural forces with the weak DoH management processes resulted in the nurses only working a three and half-day week.

If ICT systems are to be deployed at rural clinics like Lwandile, their use needs to be integrated into daily routines and supported by the regional managers and DoH. The integration process would require several supporting processes, including:

1. Deployment of technical support and service teams.
2. Rigorous training programs.
3. Stronger buy in from region managers, including the necessary encouragement and enforcement.

The MuTI and MuTI Mobile initiatives managed to satisfy the first and second requirements, but were unable to secure the third. This meant that the nurse's decision whether or not to use the ICT system depended on their personal motivation – and in their eyes the MuTI system was largely negative and lacked any real value. They believed frequent use of the system would expose their work habits, which were in breach of their contract with the DoH.

It is therefore unlikely that the nurses would ever appropriate the MuTI or MuTI Mobile technology, even with additional training and significant usability fixes and improved contextual fit.

Selecting an alternative design path, such as the sample-result pathway, may have avoided such complexities. The sample result pathway was already part of the nurses' existing way of working and was essentially a one-way information flow from the hospital to the clinic. The nurses would have been able to refer to the technology when needed, without revealing their work routines. Pursuing this option was, however, not possible due to the third-party lab operator's refusal of involvement.

The second major obstacle was that the empathic user centric process only exposed the nurses to a high-fidelity prototype late in the design process – which meant we could only gather meaningful design feedback at that stage. In fact, it was only after the nurses attended the training sessions and communicated with the Canzibe doctors that they realised the implications of the MuTI system (recall the comment “Now they can spy on (watch) us”). Developing an early appreciation for pertinent socio-cultural issues is vital within an

ICT4Dev design process. The trouble, however, is that building a high-fidelity prototype early in the design process is expensive.

Rittel and Webber [137] call these ill-defined, ambiguous obstacles, often associated with strong moral, political and professional issues, “wicked problems”. They describes these problems as a set of complex, interacting forces that evolve in a dynamic social context. The nurse’s complex perspective on the MuTI system could be considered as just such a wicked problem. It was near impossible to predict how they would interpret the MuTI technology. Their initial enthusiasm about the training sessions quickly faded, to the point where they knew they had to be available for consultation but never initiated communication.

Ultimately, the MuTI and MuTI Mobile systems provided a communication platform that could have been repurposed and used for other applications in an attempt to circumvent the wicked problem. This was not possible, largely because the technology was not accessible to other people in the community. The laptop PC, MuTI application and physical building were significant barriers to access:

1. The clinic was one of the few buildings with a solar cell array that could power the laptop.
2. Only the nurses possessed the required skills to operate the laptop PC and the MuTI software.
3. The nurses kept the keys to the clinic.

Had the MuTI system been directly accessible to other members of the community, more people could have attended the training programme, experienced the technology first hand and interpreted it in a unique way. This may have resulted in multiple perspectives being formed and the possibility of the MuTI technology being applied in unique and interesting ways. Chapter 5 explores a design approach that leverages multiple perspectives and voices as a source of design inspiration.

## **4.7 Conclusions**

This chapter described the application of an empathic UCD process to an ICT4Dev initiative in the rural Eastern Cape of South Africa. A number of preliminary conclusions can be drawn

about the suitability of this design approach.

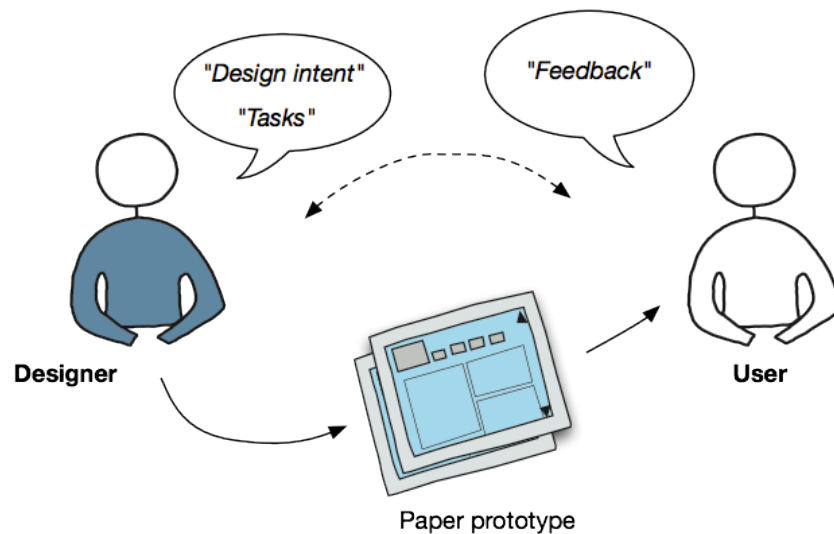
### 4.7.1 Communication challenges

Design communication emerges as a major challenge for designers operating outside their own contexts. The problem stems from the fact that 4Dev designers are almost always working in a social and cultural environment that is foreign to them. Within these design environments they face effectively insurmountable communication obstacles. Literature has so far noted that these problems exist and can hamper design activities, but has failed to emphasise how they impact the suitability and effectiveness of UCD as a design approach. The effectiveness of UCD relies heavily on effective communication during every stage of the design process:

1. *Understand users and organisational context:* Contextual design [6] encourages designers to immerse themselves within the local context and to learn about the user's daily routine and work activities. The technique requires the designer to adopt the role of an apprentice, learning through observation and asking questions. The author found that effective communication was required not only to phrase the necessary questions, but also to explain the designer's intent and purpose. Failure to do so would run the risk of the users being sceptical of the process and mistaking it for a performance evaluation.
2. *Generating user and organisational requirements:* Communication with key informants, understanding observations and extracting salient points was key. We found that effective communication at this stage was critical in allowing the designer to frame the problems identified in the contextual analysis and to identify a suitable opportunity to pursue – one that would deliver value for users and have a positive livelihoods impact on their lives or their communities.
3. *Producing a design solution and evaluating it against the requirements:* UCD assumes that evaluating a design solution within context enables the designer to learn more about both users and the context. The designer must attempt to communicate the underlying design concept, via an artefact, to elicit user feedback.

Low fidelity prototyping is a popular way to elicit feedback early in the design process. However, it relies on the designer's ability to use verbal communication to compensate for deficiencies and ambiguities relating to the prototype (see Figure 4-14).

**Figure 4-14: Eliciting user feedback through prototyping**



The communication challenges encountered in an ICT4Dev initiative mean that user centred designers are very likely to find it difficult to use low-fidelity evaluative activities as effectively as they would in their own contexts (typically a developed world organisational context). During Grisedale, Graves and Grünsteidl's [58] work in India, for example, design participants were confused by the fact that design professionals from a world-famous technology company were asking them for feedback regarding sketches on paper.

The author was able to utilise key informants and local project partners to good effect to bridge the communication barrier in most instances, but nevertheless found design-specific communication challenging. Particularly problematic were low-fidelity prototyping activities that aimed to be convergent (or in Tohidi et al.'s [154] words 'getting the design right'). By this we mean low-fidelity prototyping activities that aimed to refine the underlying design concept to improve its usability and contextual fit. We found that the level of abstraction and ambiguity of the design artefact and design activity were too high, and the communication environment too weak, to convey the necessary information.

The failure of the low-fidelity prototyping techniques meant that design assumptions regarding the design concept were allowed to persist until late in the design process. Design built on assumptions effectively increased the risks that the final artefact would not be usable, fit the context or deliver value and therefore not be locally appropriate.

## 4.7.2 Understanding local goals and motivations

An empathic UCD process is founded on the key assumption that the designer can not only communicate effectively, but can sufficiently understand (empathise with) the users and their context. This understanding is an essential part of defining the scenarios of use and the associated goals.

The challenge for 4Dev designers is that to ensure that the goals derived from the contextual data align with users' actual goals and motivations (even if these remain tacit). 4Dev designers have used tools and techniques such as contextual inquiry and/or ethnography, supported by key informants and collaborative data analysis, to achieve this purpose.

The MuTI and MuTI Mobile initiatives clearly showed that this goal alignment was extremely difficult to achieve. The environment under study at first appeared to be a structured, public and transparent work environment with clear, common goals and consensus regarding work practice. It was for this reason that an empathic UCD approach was chosen – it seemed like a good fit at the time.

With hindsight, it was perhaps naïve to assume that a method derived from developed world organisational practice would execute smoothly in a developing world context. The author effectively imposed a UCD design process that has its roots in research and practice conducted in highly structured developed world organisations. By contrast, the work environment at Lwandile was at times unstructured, fluid, unpredictable, complex and contained porous boundaries between work, family and community.

An empathic approach to UCD was not entirely suitable to such an environment because it was difficult to define a clear understanding of what the user's real goals and motivations might be.

The result of the goal misalignment was a technological solution to enable better collaboration between doctors and nurses. This satisfied the goals defined by the designer, but not the users' real goals. Daily communication and collaboration was not, in fact, in the Lwandile nurses' best interests because their work practices did not conform to those expected by the DoH. Harper and Carter [61] remind us that in organisational settings involving discrete work practices it may be inappropriate to deploy technology that brings

people together.

Harper and Carter [61] add that, in pursuit of new technologies, the required degree of sensitivity may be lost. In ICT4Dev design initiatives where the designer is often working outside his own context, language, culture and social obstacles in combination with time and budget constraints make it difficult to develop the required degree of sensitivity, especially in the early stages of the design process. If the impact of the technological intervention and the local perspectives and attitudes towards the technology are only exposed late in the design process, it may be too late or too expensive to make the required changes or to choose a different problem to solve.

## **5 Designing the SnapAndGrab technology probe**

This chapter describes the design of the SnapAndGrab public technology probe. We begin by reporting on how accessibility and affordability were prioritised to constrain the design space, while trading off on other qualities such as efficiency in use, and how this influenced the probe's design. We then describe how the probe was incorporated into a user-centric design process, paying special attention to the evaluative tools used as well as to emergent design visions, usages and applications.

### **5.1 Prioritising accessibility and affordability**

The design of the SnapAndGrab technology probe started as an exercise in heavily constraining the design space, by using the criteria of accessibility and affordability to filter out design concepts and force exploration of unconventional solutions. Most importantly, if design tradeoffs had to be made other qualities such as efficiency in use would be considered for sacrifice before accessibility and affordability were compromised.

In the MuTI and MuTI Mobile projects discussed in Chapter 4, the solutions were designed for the Lwandile nurses and Canzibe doctors, not for access and use by the wider Lwandile community. What if the community had been able to access the MuTI and MuTI Mobile systems directly?

Although the MuTI Mobile tool was implemented specifically to facilitate communication between medical staff at the clinic and the district hospital, its design allowed for other uses: community members could have used it for other forms of multi-media messaging. If the wider community had been allowed to experience the technology at first hand, they may have appropriated it for their own uses.

The termination of the MuTI and MuTI Mobile projects meant it was not possible to add additional nodes to the network and thereby test this hypothesis in the Eastern Cape. It did, however, inform the SnapAndGrab project, which once again set out to explore a technology platform for sharing multi-media – but in this case with a focus on accessibility to a wider community. The project plan required seeking out multiple perspectives on a technology probe, then developing the design according to the interpretations revealed by these perspectives.

In HCI terms, ensuring accessibility means removing any barriers that may prevent people from participating in life activities or from enjoying the benefits of services, products, and information [9]. But to remove accessibility barriers, we need first to discover what the barriers are. The MuTI and MuTI Mobile projects in the Eastern Cape had revealed both low levels of computer literacy and the growing ubiquity of cellular telephones in South Africa's poorest communities. This suggested that focusing on cellular phones instead of PCs would be a simple way to increase the accessibility of an ICT system.

The SLF [40] recommends that researchers build on existing strengths — one of which is precisely the prevalence of the cellular phone within all sectors of South African society. In 2007 there were ~39,207,440 million GSM cellular subscribers in South Africa [54], a country with a population of ~48.7 million people [152]. The latest statistics (2007) available show that 61.2% of families in the Eastern Cape now possess at least one cellular phone [155]. This means there is an opportunity to build accessible ICT systems by building on the strengths of cellular technologies: Ubiquity, robustness and existing skills and knowledge.

The growing popularity of applications such as the Mxit [113] mobile instant messaging service further supports the view that cellular telephones are already an accessible and affordable computing and communication platform for many South Africans. The Mxit application is compatible with more than 1,600 handsets, and the application's communication protocol has been trimmed down to the point where a user can send ~1,000,000 characters via GPRS (General Packet Radio Service) data channel for the same price as sending 160 characters via GSM SMS (Short Message Service). Donner's [38] work on missed calls highlighted how such simple, affordable and accessible services have been appropriated globally despite their limitations.

An initial design direction was thus decided: To create a simple, multi-media sharing platform, compatible with all multi-media enabled cellular phones, that entailed no cost to the end user. The design constraints – prioritising accessibility and affordability -- encouraged the exploration of interaction paradigms that at first appeared unusual, unconventional or even less usable. If Cockton [29,30] is to be believed, then quality in use and contextual fit are not the sole determinants of an appropriate technology. He believes that, so long as users assign sufficient value to their interactions with the technology, quality in use has only to be 'good enough' that it doesn't prevent them from completing interactions. In this case, the

technology's value would stem from its ability to give people access to rich multi-media content available on the Internet, at no cost and without relying on PC-based skills such as using a keyboard and mouse, an Internet browser or a search engine.

### 5.1.1 Design requirements

The constraints described above and the RA/RI criteria led to the definition of a basic set of requirements (the relevant RA/RI criterion or other origin of the requirement is shown in bold):

1. The solution must allow multimedia content to be accessed by an entire community (**Physical access**).
2. The solution must allow multimedia content to be posted and shared (**Locally relevant content, applications and services**).
3. The solution must focus on personal devices such as cellular phones (**Statistical data showing the growing ubiquity of cellular phones** [155]).
4. The solution must support the widest range of cellular phones possible (**Physical access**).
5. Interactions must be simple and quick (**Human capacity and training, Integration into daily routine**).
6. The cost of interactions must be zero (**Affordability of technology and technology use**).
7. The user must initiate all interactions (**Trust in the technology** – users must be empowered and in control).

These basic requirements then enabled the description of the following generalised usage scenario, in which multiple users are able to interact with a public technology. A generalised scenario, in our case, is one that is not user or context specific and displays a simple goal. The general scenario underpinning our technology probe design is presented below:

The user enters a public space with a particular information need. They notice a display screen showing various pieces of content and move towards it. Upon closer inspection, they realise that the display system includes content that may meet their needs. The display system provides two interactive services: multimedia upload and download. In an attempt to initiate an interaction with the system, the user pulls out their cellular phone and proceeds to select the content of interest. The system then returns the content via a networking service. The user is then able to consume the

newly acquired content either immediately or later, depending on the situation.

There may be concerns at this point regarding the use of a single design scenario for the purpose of designing an interactive system. It is useful, then, to recall the purpose of “public technology probing”: To build simple, flexible and adaptable pieces of technology to probe complex environments of use. The designer accepts that he/she does not know exactly who the users will be or any specifics of the context – the usage scenarios underpinning the probe’s design are therefore not complete. The details of users and their goals are emergent and will be filled out through the deployment of the probe and the extraction of information regarding how users apply it in their daily lives. These ‘complete’ scenarios will serve as design inspiration for future UCD iterations.

## **5.2 Designing a public technology probe**

Moore’s Law states that the number of transistors that can be inexpensively placed on an integrated circuit is increasing exponentially, doubling approximately every two years [106]. Developed-world industrial and product designers tend to work on the assumption that Moore’s Law holds true and that computing hardware will become smaller and more powerful over time.

When these designers envision a new technological service or application, they tend to adopt an unconstrained design approach, assuming that a supportive technology will be released into local markets in the near future. This design model holds for developed-world markets where the upper and middle market segments represent a wide portion of the local population.

Within developing world environments, however, where the majority of the population cannot afford new technologies, designers must adjust their design thinking and consider the prevalence of legacy technologies. New technologies typically enter the consumer market at prices that render them inaccessible to most in the developing world. As a result, interactive services or applications designed for these technologies are also rendered inaccessible to those users. Technology companies with a developing world focus, such as MXit [113] have instead focused their attention on legacy technologies (MXit supports over 1600 cellular handset types).

This realisation encouraged the author to constrain the design space even further by requiring the solution to be compatible with legacy cellular phones as much as possible. This would be

a first step towards achieving a widely accessible ICT solution within South Africa.

### 5.2.1 Personal device-based interactions

Our generalised scenario considered personal device-based interactions with large situated displays, which has been an active research topic for several years [5,6,97,138,139] thanks to the growing ubiquity of both technologies. Despite this growing interest, most public displays remain non-interactive and display mostly static content – possibly because it is difficult to define interactions that are practical for use within real-world public settings.

These difficulties stem from the fact that public information displays need to be accessible to several people at once. Anyone within viewable range should be able to read the information displayed and no single individual should be able to take control of the display. If that is the case, how is it possible to present a variety of simultaneous interactive experiences? Greenberg [57] suggests that the controls (buttons and screen area) available on cellular phones are perfect for creating a personal tool (analogous to a remote control [49]) for selecting content from a larger display system. The simplest way to implement a personal controller is to number each piece of display content and then allow users to select content by pressing the appropriate numbers on their phones.

How, in that case, should user selections be sent to the display system? One possibility is to use SMS (Short Message Service) messages: SMS is available on almost every cellular handset and most users are familiar with it. There is one insuperable obstacle, however: Sending SMS messages incurs costs, for users and network operators alike. This makes SMS an inappropriate solution according to the RA/RI criteria.

The next possibility is to use Personal Area Networking (PAN) features, such as Bluetooth and infrared ports, which are found on many cellular phones. PAN features transfer data directly between two devices (peer-to-peer), without using any cellular network services or incurring any costs.. At the time of the research, some handsets included a feature that allowed users to create a text message inside the SMS interface, and then send it using Bluetooth. However, this feature was only available on a very limited number of handsets – choosing this option would again limit the accessibility of the system.

The question was then how best to enable PAN-based interactions between a cellular handset

and a situated display.

### 5.2.2 Interaction techniques with situated displays

Rohs, Sheridan and Ballagas [6,138,139] explored two interactive techniques for allowing camera phones to directly manipulate objects on a display system. The first used visual tag sensing and absolute targeting to allow a user to select an object on the display. Users would align the crosshairs shown on their cellular phone screens over the tag associated with the desired display object, then press and release the phone's joystick button to take a photo. The information encoded in the visual tags would then be decoded and sent to the display as information about user selections.

The second technique used optical flow calculations to determine the movement of the camera phone relative to the display. Optical flow calculations are performed by rapidly sampling successive images captured by the camera, then using image processing to determine the relative motion of the phone. The resulting data is then sent to the display system to control an object selection cursor.

Hardy and Rukzio [59] present a third means of interaction, Near Field Communication (NFC). Their system used a cellular phone with a built-in RFID reader to directly select a display object projected over a physical RFID tag. When the user's phone moved within range of or 'touched' the tag, the associated object selection information was read by the phone, processed by a piece of client software and the result transmitted back to the display system.

### 5.2.3 The need for client software

Rohs, Sheridan and Ballagas's [6,138,139] camera-based interaction and Hardy and Rukzio's [59] techniques appeared promising because they used PAN communications features available on the handset (in this case of Rohs, Sheridan and Ballagas [6,138,139] the Bluetooth service and Hardy and Rukzio [59] an NFC service). It was not clear, however, whether the resultant design would meet our accessibility requirements: the Rohs, Sheridan & Ballagas and Hardy and Rukzio [6,59,138,139] prototype systems all relied on client software that could only be deployed and run on a small subset of cellular phones.

Rohs, Sheridan and Ballagas's solution required handsets running the Nokia Series 60 platform and Hardy's solution required bespoke NFC hardware that is currently available on

only two Nokia handsets. Both teams were investigating the feasibility of the interaction paradigm within a laboratory setting and did not intend to produce a publicly deployable system. If they had, several accessibility concerns would have been raised, in particular the system's reliance on custom software and bespoke hardware.

This problem is not unique and still plagues the third party mobile service industry. Mobile services such as Shotcode [146], Yeigo [164] and Fring [51], for example, require users to download the appropriate version of their software according to their cellular phone's make and model. Whilst this seems simple enough, mobile service providers often only provide support for a subset of phones, due to the time and effort needed to develop alternative versions of their software. For example, neither Shotcode and Fring support the popular Samsung D-600 phone (only two years old at the time of writing); thus D-600 users are prevented from accessing these mobile services.

The handset industry's solution has been to provide the Java 2 Mobile runtime environment (J2ME) on top of the phone's operating system. Using J2ME frees application developers from hardware-related issues, enabling application calls via a standard set of libraries. Applications are thus not compiled for particular operating systems, but rather to run within a particular J2ME environment, which is (in theory) available across many handsets. In practice, it is still up to each individual manufacturer to implement the appropriate libraries within the J2ME environment – and many do not provide libraries for all the multimedia features of the handset. This is particularly true for entry-level handsets. Consider the Samsung D600 again as an example: The J2ME environment on this handset only provides access to data networking services and basic multimedia features such as the microphone and speaker. It does not provide the J2ME libraries for accessing the Bluetooth networking features, thereby rendering a J2ME solution unviable.

Is it possible to create an interactive camera-phone experience that does not require custom software running on the client handset? From the designer's perspective, custom software has two major benefits:

1. Designers have more control over the user experience.
2. Custom applications provide a rich environment for accessing the multimedia features of the device (at least in the case of applications that are compiled specifically for the

phone's operating system).

Despite these advantages, custom applications could not meet our accessibility criteria. The work of Rohs, Sheridan and Ballagas [6,138,139] did, however, encourage us to explore the use of visual codes as a means of interacting with a display system. The challenge at this point was to get around the need for client software to be installed on the user's device.

To address the challenge we explored the use of native Bluetooth communication services. By 'native' we mean the Bluetooth functionality and services exposed by the operating system and not via a 3<sup>rd</sup> party application, e.g. the OBEX (Object Exchange) services that are part of the Bluetooth specification. Bluetooth-enabled devices provide users with access to a standard set of OBEX services for moving a standard set of multi-media objects (photos, videos, audio, calendar objects (vCal) and business card objects (vCard)). For example, once a photo has been captured using the handset's native camera, the user is presented with the option to send the photo via a variety of mechanisms, of which Bluetooth would normally be one.

## 5.2.4 Utilising native features and services

### 5.2.4.1 Bluetooth

Having decided to explore native features and services available on devices, the author chose Bluetooth because it offered a free data communication channel. Earlier we rejected the use of sending SMSes (text messages) via Bluetooth because the OBEX service to support the SMS transfer is not part of a standard OBEX implementation and only available on a subset of Bluetooth devices. Rohs, Sheridan and Ballagas' [6,138,139] and Toyé et al.'s [155] work highlighted that it is possible to use an image (photo) to interact with a display system and select an item on the screen (in their case the item was a visual code). This was an attractive design pathway because a photo could be captured and sent to the display system using the device's native camera and Bluetooth functionality, which was part of the standard OBEX implementation. There were, however, more constraints that emerged.

Device pairing quickly emerged as the first challenge. The Bluetooth security model requires participating devices to identify themselves before data is transferred. The pairing process exchanges a common PIN code to set up a trust relationship between two devices. One of the requirements for the SnapAndGrab system was that the interaction process should be quick and simple: The traditional pairing model added unnecessary steps.

One solution was to use BlueCasting, in which a server sends information to every discoverable Bluetooth device that comes within range. Users are then prompted to accept or reject the incoming message. However, BlueCasting often irritates users who neither initiate the communication, nor have choice over what they receive. For example, mobile marketing agency Filter UK used BlueCasting in 2005 to promote the release of an album [13], attempting to broadcast media clips to devices within range of large display screens in a train station. Over 87,000 devices were discovered, but only 15% accepted the transfer -- suggesting that 74,000 people received unwanted Bluetooth messages. In addition, the type of media clip received was determined by the server's promotional policies: the user had no choice in the matter. BlueCasting was thus not considered for SnapAndGrab as it violated one of our original requirements: "The user must initiate all interactions."

With the option of custom software already ruled out, we next considered Cheverst et al.'s [23] Hermes photo display. This system, deployed in a semi-public office environment, allowed users to upload photographs to a display, and download from it, using their cellular phones. Selection of photos was achieved via a touch-enabled display panel. However, the system had no way to determine the Bluetooth addresses of users' phones and thus no way to return the photos. The Hermes designers solved this problem by prompting users with a list of every Bluetooth device in range and asking them to select their own device. Although this solution offered significant benefits over the Bluecasting approach, and similarly solved the pairing problem by allowing users to accept or reject messages, it still required users to physically interact with the display and to select their devices from a list of possible options.

This approach was judged unsuitable for a multi-user, public display system for several reasons including inability to support simultaneous interactions, the high cost of touch-enabled displays and the additional complexity of requiring users to set their phones' unique Bluetooth identifiers and to choose their device from a list. Device selection becomes tedious in areas with high Bluetooth activity. The author sought a simpler solution.

#### 5.2.4.2 Embedding the Bluetooth address

Scott [144] and Ballagas, Sheridan and Rohs [6] solved this problem by embedding the return address of the display server into a visual code (similar to a bar code) presented on the display. A custom piece of software running on the user's device would capture the visual code as a photo, process the code and extract the display server's Bluetooth address.

This approach avoids device scans (also known as the process of device discovery), making interactions more efficient and more suitable for public settings – but, once again, the documented solution relied on custom software installed on the client device.

After some experimentation the author discovered that Bluetooth’s native OBEX service automatically embeds the return address of user devices within the OBEX message, thus making it available to the display system. The display system is then able to package rich multi-media content into a series of OBEX messages and return them to the user’s device using the extracted return address. Users can choose to accept or reject the incoming messages, avoiding the problem of pairing. This finding laid the foundation for the SnapAndGrab architecture.

### **5.3 The details of the SnapAndGrab design**

The SnapAndGrab (SnG) display system (see Figure 5-1) presents users with an array of images, each bearing a short text annotation. The display images serve three functions: To attract attention to the system, to provide a visual index of the available content and to serve as machine-readable visual code in the content selection process.

#### **5.3.1 Downloading content**

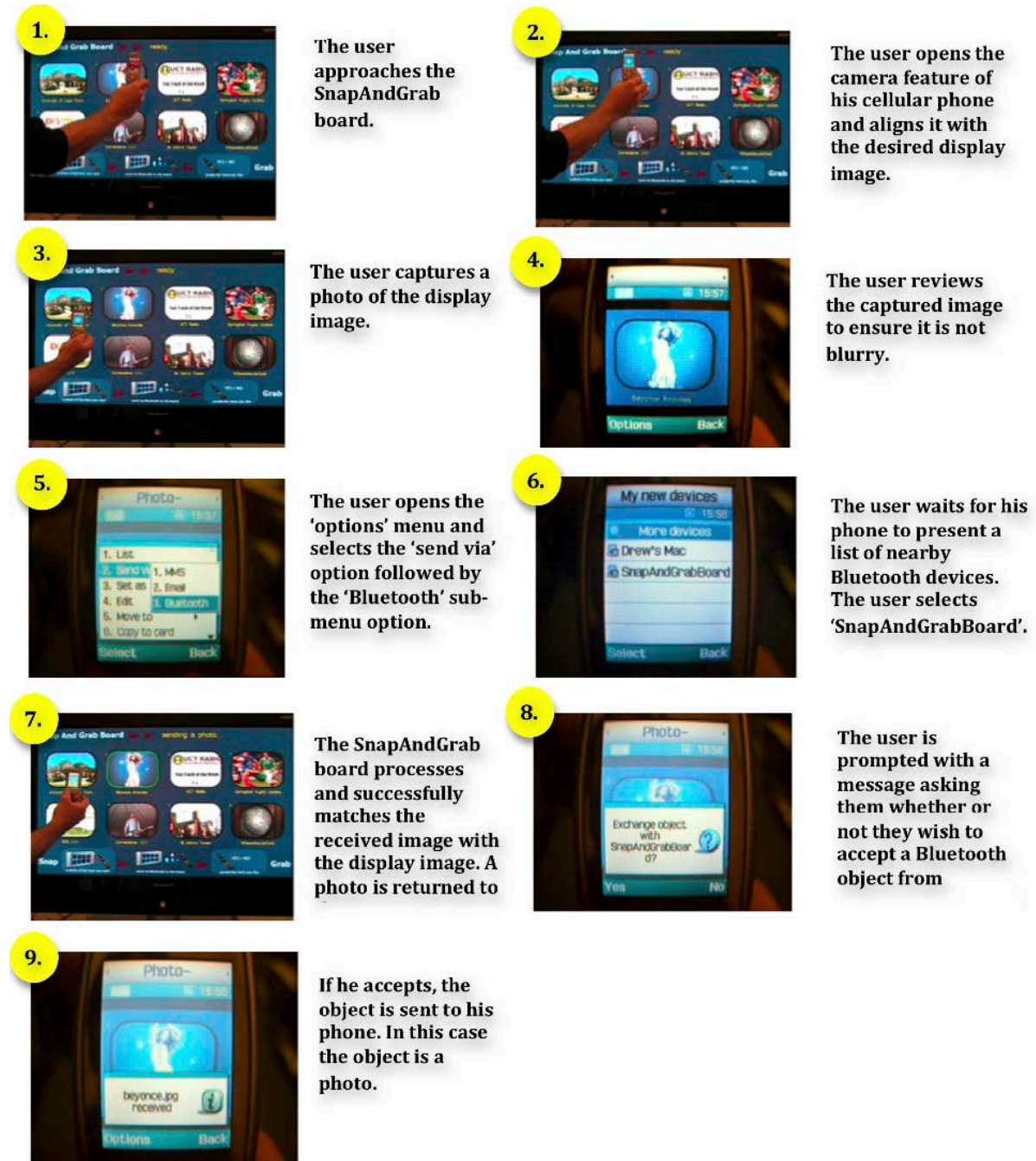
The content download process typically begins with a passerby noticing and taking interest in a display image. If the person (now a user) want to access the associated content, they can use their phone’s built-in camera to take a photograph of the image, then send the photograph to SnG via the native Bluetooth OBEX service on their phone. In a typical scenario the user would execute a ‘send via Bluetooth’ type of command, selecting the SnG Bluetooth device from a list of active Bluetooth devices within range.

Once the photograph containing the visual tag is received, a feature-matching algorithm running on the display system determines if a current SnG image matches the submitted photograph. If a match is detected, the multimedia items associated with the SnG image are sent back to the user's phone. Feature-matching algorithms such as those proposed by Lowe [91] have proven to be successful for this purpose.

To do this, the SnG system needs to know the address of a client device before it can return any content. SnG achieves this by extracting the Bluetooth MAC address (return address) of the client’s phone from the OBEX request message. The SnG server then has all the

information it needs to determine the content of interest and return it to the user's phone.

Figure 5-1: The SnapAndGrab system



### 5.3.2 Media Packages

A media package is a set of related multimedia objects that the system groups together via a Bluetooth address (for user-generated packages) or title (for packages created by an editorial

team). The content may include various multimedia objects designed for mobile device platform. Examples include Web pages (HTML files), mobile format videos (GP3, MP4 etc.), audio files (MP3), contact details (VCard), calendar entries (VCal), image files (jpeg) or text files (PDF and txt).

At a programmatic level, a media package is represented by an XML file that indicates to the SnG server application which media items are logically associated with that particular media package. Code fragment 4-1 shows an example of an XML media package file titled “Water Out of Thin Air”. The package contained a total of three media items (see XML element <itemCount>), namely a video named ‘splash.3gp’, a text file named ‘WaterOutOfThinAir.txt’ and a contact card, ‘Ashley.vcf’. This XML file indicates which files should be sent back to the client device, and in what order.

```
<?xml version="1.0" encoding="utf-8"?>

<snapandgrab>

  <object>

    <id>10</id>

    <title>Water Out of Thin Air</title>

    <textbody />

    <itemCount>3</itemCount>

    <media>

      <item>splash.3gp</item>

      <item>WaterOutOfThinAir.txt</item>

      <item>Ashley.vcf</item>

    </media>

  </object>

</snapandgrab>
```

**Code fragment 4-1:** A media package representing a master’s thesis titled “Water Out of Thin Air”

### 5.3.3 Submitting content

Recall that one of the SnG design requirements was that users should be able to create and submit their own content. To achieve this, the author created two content submission interfaces:

1. An editorial interface, aimed at content providers who wish to create media packages of an editorial nature. For the purpose of this research the author played the role of editorial content provider and SnG content administrator, but we envisage a future in which third party content providers could buy display space and time slots on various SnG installations. Editorial media packages could be submitted via a Web interface and reviewed by a SnG content administrator before being published onto SnG.
2. The second submission interface allows members of the community to create their own media packages. Users initiate the process by sending a electronic business card (vCard), via native Bluetooth OBEX service, to SnG and then sending a photo to serve as the cover image and visual code for their package. Any subsequent multi-media sent to SnG (barring a photo that matches the visual code of another media package) is appended to their media package and made available for download by other users.

The inclusion of a user generated content (UGC) submission interface was an important addition to the overall design of SnG. The RA/RI criterion [16] ‘Locally relevant content, application and services’ encouraged us to include a UGC interface; the expectation was that as UGC evolved, the system would become more relevant and valuable to end users and the wider community.

## 5.4 A detailed usage scenario

The generalised scenario presented in Section 5.1 can now be elaborated to include the details of the SnapAndGrab system and an envisioned application in a developing world setting.

### 5.4.1 Siphon the builder

Siphon is a bricklayer from Guguletu township in Cape Town, South Africa. His daily income depends on the availability of construction work within the central business district and surrounding areas. To find work, Siphon checks the SnapAndGrab job board at his local taxi rank. He would typically download all the media packages related to building and construction while waiting for a taxi. Today, five media packages are available for download,

one of them posted by John Botha, a construction manager for GoodBuilder Inc.

The media packages includes a Web page with details of the job, a vCal object that enters the date and duration of the build into Siphos calendar and a vCard object that loads John's contact details into his address book. With this information Siphos is able to stay informed about available jobs without relying on word of mouth tip-offs.

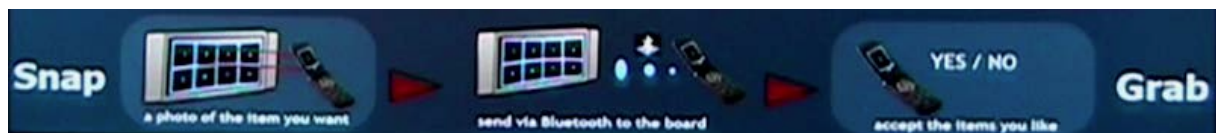
Siphos is also able to create a personal SnG media package advertising his own skills and experience. The media package would typically contain a cover image (required), personal vCard (required) and any other multimedia Siphos might wish to add, such as photos of his past projects or video references from past employers. The result is an electronic résumé that is now accessible to local SnG users and wider Web users, in this case Mr Botha (future feature).

## 5.5 Laboratory Evaluation

A short lab-based pilot study was conducted on June 12-14 2007 to explore user reactions to the SnapAndGrab concept. The experiment assessed whether new users were able to access and use the core features of SnG without any prior training. We sought to answer the following questions:

1. Could the users complete an interaction based on the visual instruction set shown on the display? (See Figure 5-2)
2. Did the users know where and how to find and access the returned multimedia on their handsets?
3. Did they find the interaction too time consuming?

**Figure 5-2: Visual instructions on the SnapAndGrab display**



### 5.5.1 Experimental subjects

The author recruited eight University of Cape Town (UCT) students, all between 18 and 24, who owned Bluetooth-enabled camera phones. According to Nielsen's [118] research, a usability study with eight subjects can theoretically uncover ~90% of the underlying usability

problems – a value deemed acceptable by the author for a pilot study. All eight students had prior PC and Internet experience and had completed UCT’s computer training programme in their first year of study.

### 5.5.2 Experimental plan

The laboratory experiment aimed to capture data showing whether the users (subjects) were able to complete a basic interaction with SnapAndGrab (SnG) without prior training; that is, based solely on their interpretation of the visual instructions shown on the SnG screen. An SnG interaction relied on the user being able to effectively use the Bluetooth and camera features of their cellular phone. It was therefore necessary to gain an understanding of each user’s Bluetooth and camera-phone experience levels to assist the analysis of the task-based data gathered in the experiment.

The subjects completed a pre-experiment questionnaire (see Appendix A) to gauge these experience levels. The pre-questionnaire included a consent form, gathered basic demographic information (age, occupation, gender and home language) and probed the following topics:

1. Had the subject ever used their mobile phone’s camera and Bluetooth features before the study?
2. How often had they used their camera?
3. For what purposes had they used their camera?
4. Had they ever shared pictures or video via Bluetooth?
5. Had they ever been sent a file via Bluetooth?
6. Did they know where to find the files after receiving them?

Each subject was then asked to complete a simple task, which required them to download three media packages from the SnG system. The users were not briefed or trained regarding the use of SnG. Instead, they had to rely on a simple three-step instruction displayed along the bottom of the screen (see Figure 5-2). The subjects were given a maximum of fifteen minutes to complete the task. If the subjects were unsuccessful, the facilitator (the author) would provide the necessary clarification and assistance before asking them to attempt the task again until success was achieved.

The subjects were then required to complete a post experiment questionnaire (see Appendix

A).

The post-questionnaire probed the following topics:

1. Did the user understand the SnG concept and have an idea how they might use it in real life?
2. Was there anything about SnG the user would change?
3. Did they know where to find the files that SnG sent to them?
4. Did the users feel that a SnG transaction took too long for what it was worth?

The resultant data was analysed to determine whether:

1. The users were able to successfully complete a SnG interaction.
2. An SnG interaction was efficient enough, from the users' perspective, to be of practical use.
3. Users were able to find and consume the content they downloaded from SnG.

### 5.5.3 Results

See Appendix A for pre and post questionnaires.

**Table 5-1: Lab test: Pre-questionnaire results**

Numerical scale used (1 = rarely...5 = a lot)

Questions	Subjects								
	1	2	3	4	5	6	7	8	Avg.
Gender	F	F	M	F	M	-*	M	F	-
Age	18	22	20	19	18	19	21	24	20,3
Home language	Zulu	Sesotho	English	Zulu	English	Zulu	English	Sesotho	-
Has used camera feature	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	-
Has taken pictures at an event	3	5	3	4	5	5	2	5	3,67
Has taken pictures of friends and family	4	3	4	4	5	5	4	5	4,11
Has taken pictures of interesting or amusing things	2	4	5	3	5	5	3	5	4,11

Questions	Subjects								
	1	2	3	4	5	6	7	8	Avg.
Has recorded videos of friends or family	2	1	1	3	5	3	2	4	2,44
Has recorded videos of an event	3	5	1	3	5	1	1	4	2,67
Has recorded videos of interesting or amusing things	3	5	3	3	5	3	1	4	3,56
Has used Bluetooth feature	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	-
Has shared pictures or video	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	-
How? MMS or Bluetooth?	Both	-	MMS	Bluetooth	Bluetooth	MMS	Bluetooth	Both	-
Types of files sent by someone else	Photo, video	Photo	Photo, video, audio	Photo, audio	Photo, video, audio, contact details	Photo, video, audio, contact details, themes	Photo, video, audio	Photo, video, audio, games	-
Did you know where to find the files after receiving them?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	-

\* The subject did not wish to disclose their gender on the questionnaire

User performance during the test was assessed on the following scale :

1. The user managed to use SnG without the facilitator's (author's) help.
2. The facilitator provided minimal assistance to the user.
3. The user was unable to use the board despite the facilitator's help.
4. The user's phone was incompatible with SnG.

**Table 5-2: Laboratory test results**

	Subjects								
	1	2	3	4	5	6	7	8	Avg.
Scale value	2	2	2	4	2	2	2	1	2.33

Users completed another questionnaire after the study, with the following results:

**Table 5-3: Post questionnaire results**

Question	Subjects							
	1	2	3	4	5	6	7	8
Did you feel that the total time taken to complete an interaction was too long?	No	No	No	-	No	No	No	No
Did you know where to find all the files that were sent by SnG?	No	No	No	-	Yes	Yes	Yes	No
Which file types were you unable to find?	All	Text	Found all eventually	-	-	-	VCal took a while	VCal
Could you imagine using SnG in an everyday public setting?	Yes	Yes	Yes	Yes*	Yes	Yes	Yes	Yes

\* Result based on a demonstration of SnG by the author.

Users were also asked for suggestions and to say what their favourite SnapAndGrab features were, with the following results:

**Table 5-4: User suggestions for SnapAndGrab**

Subject	
1	Put it in secure places in big malls and ensure that data sent and received doesn't contain any viruses that would damage phones.
2	I would not change it.
3	Perhaps mention the space requirements below the files and mention where the files get saved
4	Make it compatible with a wider range of cell phones Allow auto updates
5	Add more information. Things such as urgent announcements or breaking news.
6	It would help if it had more instructions about Bluetooth settings.
7	Allow for multiple pictures to be taken at once.
8	Include a dictionary or at least definitions that can be sent back to me if I send a word through.

**Table 5-5: Users' favourite features of SnapAndGrab**

Subject	
1	Get updates about Beyonce's shows and other information. Promotions on campuses, targeting students who use phones regularly.
2	The ability to provide more than one item that comes with a picture.
3	The option to choose the content you download, and then save it and take it with you. Once you have the content, you can share and spread it.

4	The speed and different media packages'. <i>(This user's phone was not compatible with SnG; her comments were based on a demo by the facilitator.)</i>
5	The high definition picture quality, which makes it even brighter than usual billboards. The simplicity and speed.
6	It's paperless but just as effective as the information brochures that people end up throwing away.
7	Besides Bluetooth being free, it was very fast.
8	Fast, don't have to log in to get it. Don't wait long for it to be sent back.

#### 5.5.4 Findings

The data revealed that SnG was not ideally suited for deployment as a walk-up-and-use public information system for new users.

1. Only one of the eight users was able to work out how to use SnG based on the visual instructions alone.
2. Five of the eight users were able to complete an interaction with minimal assistance.
3. One of the eight users possessed an incompatible phone.
4. One user was unable to find the returned multi-media on their phone.

Analysis of the pre-questionnaire data ruled out the subject's handset as a usability barrier and a cause of the subjects being unable to complete the task. All of the subjects used their camera phone to take photos on a regular basis (the average value for the photo activities was 3.96 out of 5). All had used Bluetooth to share photos and videos on a previous occasion. We concluded that the subjects were all experienced camera and Bluetooth users.

The author did, however, notice that subjects assumed that the absence of a keyboard and mouse meant that they should interact with the display via a physical touch. SnG's unique style of interaction -- taking a photo of the screen and sending the photo to SnG -- was not immediately obvious to new users despite the visual instructions. The data showed that once the facilitator (the author) entered the room and explained how SnG worked, five of the six users, who initially failed to complete an interaction, were able to do so without any further assistance.

Further analysis of the data showed that SnG's reliance on OBEX services and the user's familiarity with the storage of OBEX files did not pose a usability problem for five of the eight users. Four of those users found it difficult to locate less common OBEX file types such

as text and calendar entries. This finding is consistent with the data supplied in the pre-questionnaire: Before the study, users had only been sent photos, videos, audio or game files via Bluetooth. Calendar entries and text files were not mentioned, indicating that the users would not be familiar with these file types.

None of the users felt that the interaction took too long for the value of the media returned.

The post questionnaire feedback (see Tables 5-4 and 5-5) revealed that the subjects were satisfied (often excited) with their experience of SnG.

We concluded that users who were experienced at using the Bluetooth and camera features of their phone were able to learn how to use SnG effectively with minimal training. SnG's unique style of interaction was a potential usability, and therefore access barrier; but its learnability, efficiency in use and provision of a satisfactory experience compensated for this. The study did, however, show that the provision of local training and support would be essential during future field studies, particularly as SnG was intended to be deployed within resource-constrained communities in which technology skills and knowledge were not guaranteed.

## **5.6 Incorporating SnapAndGrab into a user centric design process**

Satisfied with the results of the laboratory study, the author proceeded to plan a longitudinal field study in which SnG would be used to probe complex environments of use. The findings would be used to address emergent technology needs and to inspire new interactive systems for people in similar environments, whilst simultaneously determining whether SnG was locally appropriate for the target community.

### **5.6.1 First UCD cycle**

The first UCD cycle focussed primarily on establishing the design environment. This included choosing a project partner, conducting a rapid contextual inquiry to establish whether SnG compatible handsets were ubiquitous devices in the target community and conducting the first of two training workshops with the target user group.

#### **5.6.1.1 Understanding and specifying the context of use**

In Chapter 3 we detailed how we partnered with Learn to Earn, an NGO based in the Khayelitsha township outside Cape Town, South Africa. Recall that Learn to Earn was chosen

as a project partner for several reasons: Its focus on people, its holistic view on livelihoods development, the way it builds on creative strengths of the community, the linking of micro-level graduates with macro-level businesses opportunities, support for dealing with a dynamic economic environment and the fact that Learn To Earn's projects are sustainable and not dependent on external support and funding.

Within the Learn to Earn community, the Zakhele team was identified as the target user group. The Zakhele team members, all women and most over the age of 50, did not have access to rich multi-media content available on the Internet. They did not possess the necessary PC skills and knowledge and multi-media was too expensive to download via the GSM cellular network (a single audio track could cost up to R16.99 (~\$2.40) to download). We saw SnapAndGrab as an alternative mechanism of providing such access and believed that it could have a positive livelihoods impact.

The first cycle of the UCD process focussed on preparing the design environment for probe deployment. We conducted a rapid contextual inquiry at Learn to Earn, not to enable us to specify what the technology should do or what service it should provide, but rather what the target users required to enable access to the probe.

One aim of the enquiry was to discover whether the available handsets at Learn to Earn were Bluetooth enabled camera phones. The data showed that handsets ranged from models released in the late 1990s to more modern handsets currently available from retailers. Most of the Zakhele team, however, did not possess a compatible handset. This lack of compatible handsets, and an associated lack of Bluetooth and camera-related skills and knowledge, posed an accessibility barrier. The author thus arranged for 14 Zakhele volunteers to receive a new Samsung E-250 cellular phone (chosen for its relatively low price and compatibility with SnG), which they would be able to keep after the completion of the study. We also appointed NV, the key informant, to provide local training and support in the Zakhele volunteers' home language of Xhosa.

#### 5.6.1.2 Producing a design solution

The findings of the rapid contextual enquiry were then used to design a training programme to equip the Zakhele volunteers with the necessary skills and knowledge to be able to complete an SnG interaction.

NV conducted four group activities at Learn to Earn to teach the Zakhele volunteers the necessary skills for interacting with SnG, namely taking a photograph and sending it via Bluetooth. The aim of these learning activities was to minimise the effects of the handset when evaluating the overall usability of the SnG system. If users were familiar and comfortable with their phones, specifically the Bluetooth and camera features, the handsets themselves would not represent an accessibility barrier.

A total of five group sessions was held:

1. **Introduction:** The Learn to Earn manager introduced the author to the Zakhele volunteers and explained that we wanted to learn about cellular phone usage in Khayelitsha. The author was not identified as the designer of the SnapAndGrab system, either then or later in the process. The goal of this omission, based on the MuTI experience, was to distance the designer from the technology in the users' minds, thus avoiding bias introduced by users' desire to please or a perception of the author as an authority figure.
2. **Get to know your phone:** NV ran two training sessions to ensure that the 14 Zakhele volunteers were able to use the core features of their E-250 phones, to develop their phone skills and to prepare them for future interaction with the SnG system. They were then given a week to practice using their new phones, during which they were encouraged to ask NV for assistance should they be struggling. The use of a common phone model also meant that skills could be transferred through peer learning.
3. **Taking photos:** The Zakhele volunteers were next taught how to take photos using their phone cameras. NV led the teaching activity by demonstrating and explaining with the E-250; the volunteers were then encouraged to practice taking photos and to bring a favourite to the next group meeting. Each user was given a chance to share the story behind her photo, as a means of encouraging participation and discussion within the group.
4. **Sharing photos via Bluetooth:** Next, NV taught the users how to switch on the Bluetooth feature of their handset, personalise their Bluetooth name and send a photo to a laptop PC for display as part of an evolving mosaic presentation.

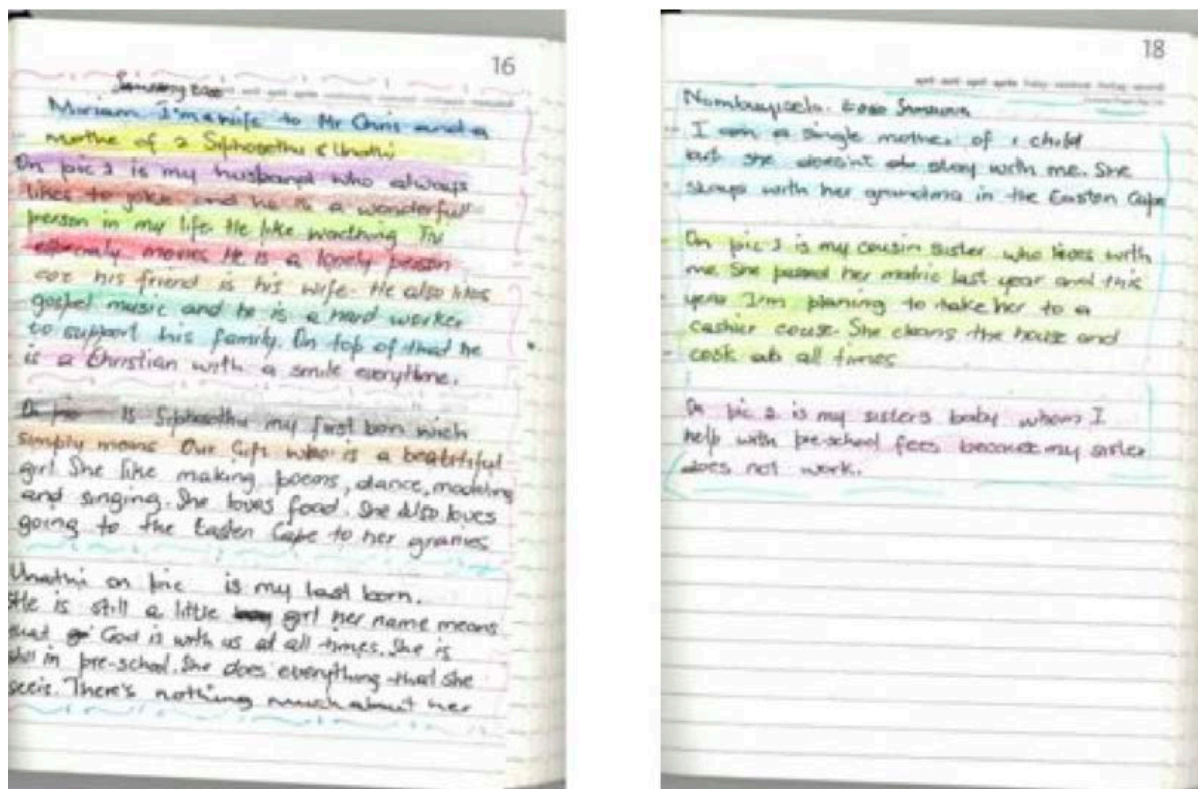
#### 5.6.1.3 Evaluation of design against requirements

The users appropriated the voice and text messaging features of their E-250s quite easily, but

struggled with the Bluetooth functionality and relied on NV for assistance. At the same time, we observed that several users independently discovered and appropriated features such as the built-in FM radio. Since this feature was no less complicated to use than the Bluetooth features on the E-250, we were confident that once our users found a reason to use their phone's Bluetooth functionality, they would have no difficulty in mastering it.

Our key informant, NV, was issued with a paperback journal and assortment of colourful pens and asked to keep a running diary of the SnG story. In particular, she was asked to document how the users felt about SnG, what content they found most interesting and the application and future usage ideas they had for the probe (see Figure 5-3).

**Figure 5-3: Extract from NV's field diary**



NV captured two comments made by the Zakhele volunteers after the training session in her diary, highlighting the training as being enjoyable and empowering:

- “We were so happy about the experience of Bluetoothing from one phone to the other, especially when transferring to the computer, because the computer can play around with all the images. It made us see the importance of having a cellphone as well as a computer. Computers and cellphones work hand in hand.”

- “I thought that cellphones are for receiving and making calls, but after learning about the Bluetooth I’m sure I can also do a lot of things with my cellphone.”

#### 5.6.1.4 Learning outcomes

##### The artefact and process

This first UCD cycle was focussed on understanding the physical context at Learn to Earn and developing local capacity and skills. The training sessions exposed the target user group to the camera and Bluetooth functionality of their handsets and provided encouraging signs that the Zakhele volunteers would be able to interact with the SnG system.

One important finding from the process was that the Zakhele volunteers all participated and engaged actively in the training sessions. The author believes there were three reasons for this:

1. The practical, hands on nature of the sessions.
2. The fact that users were able to express themselves in their home language and that the sessions were led by community members whom they knew and trusted.
3. Users were given the time and assistance necessary to become familiar with the basic functionality of their phones before attending the two more advanced Bluetooth and camera training sessions.

The volunteers seemed to understand the purpose of the design activities and acquired new practical skills and knowledge – a positive step towards fostering a solid foundation for design communication.

#### 5.7.2 Second UCD cycle

The second UCD cycle included the deployment of the SnG technology probe and an initial progress evaluation with our key informant, NV. The SnG probe was deployed in the Learn to Earn Business Resource Centre (BRC) for 4 weeks (23 days in total due to the fact that Learn to Earn was closed on Saturdays and Sundays). We believed that this would provide enough time for the Zakhele volunteers to learn how to use SnG and explore its possibilities, as well as for unexpected usage practices, patterns and applications to emerge.

##### 5.7.2.1 Understanding and specifying the context of use

The deployment of the E-250 handsets had a significant impact on the Zakhele volunteers.

Not only did they use the phones for making voice calls and sending text messages, several started using the headphones to listen to the built-in radio and one even started listening to MP3s (when questioned, she said her children had put the music onto the phone for her). The Zakhele manager, AL, noted that the volunteers were more productive when they were listening to music via headphones: they spent less time talking to each other and more time working.

Our key informant NV was very eager to experience the SnG technology for herself, as up to that point she had only heard about it. When the SnG display was installed, but not yet operational, she wrote a note capturing the curiosity, excitement and anticipation that had built up within the user group:

“They all wanted to know what was going on with the screen.”

“Some would say I must switch on the TV but then I told them it was a computer. They were so happy that they were going to use a computer with their phones.”

The SnG technology was thus able to generate a high level of interest and ‘buzz’ [134] within the Learn to Earn community.

#### 5.7.2.2 Specifying the user and organisational requirements

The most important, yet obvious access requirement was for the SnG system to be deployed and activated within the physical context of use. SnG deployment consisted of a 37” Samsung LCD connected to an Apple Mac Mini computer running Windows XP. The Mac Mini was selected for its compact form (15cm x 15cm x 8cm) and built-in Bluetooth radio. It could be discreetly packed away below the SnG display, making it look less like a potentially intimidating computer system. The SnG display was mounted in the co-operative tea area, next to the fridge and kettle, with the intention of encouraging users to interact with it during tea breaks (See Figure 5-4).

**Figure 5-4: The SnapAndGrab display in the Zakhele tea area**







### 5.7.2.3 Produce a design solution

Once the SnG probe was installed at Learn to Earn we demonstrated to NV how to download content from the display onto her E-250. She mastered the skill in less than five minutes, giving us confidence that she would be able to easily transfer the skill to the Zakhele volunteers. Critically, we carefully avoided offering any explanations of the purpose of SnG, or instructions about how and when it should be used. We wanted to create space for exploration and discovery, the formation of unique perspectives and – we hoped – local application.

The technology probe was scheduled to remain in place for four weeks before the polyphonic assessment (see Section 3.3.3 above) would take place. The SnG deployment was initially seeded with some generic content using ‘Cape Town’ as a theme. At this early stage the SnG media packages only contained a single media object, in most cases simply returning the cover image to the user – designed to be used for training purposes and to allow the users to experience the basic utility of SnG. The seeding content is shown below in Table 5-6.

**Table 5-6: Seeding content for the SnG probe**

Title	Associated content	Cover Image
Healthy Food	The display photograph was returned to the user's phone.	
Arnold's Restaurant	The display photograph was returned to the user's phone.	
University of Cape Town	The display photograph was returned to the user's phone.	
Cape Point	The display photograph was returned to the user's phone.	

#### 5.7.2.4 Evaluating design against the requirements

The seeding media packages held little value in the users' eyes, but were sufficient for use during a second set of training sessions run by NV. After two weeks NV was asked to arrange a group discussion to capture the community's collective perspective on the SnG technology. Interviewed afterwards, she described the users as being very curious about the purpose of the screen and very interested in finding out more about it. The same was true for visitors and tourists who entered the sewing centre. Despite this initial curiosity, SnG lost some of its appeal when users were not interacting with it directly i.e. whilst working. The general feeling was that it should do some more interesting things, like play music or show videos. NV was also asked to probe the volunteers' visions for the technology. If locally shaped vision statements could be extracted, it meant that the volunteers had begun to progress from basic access to assessing the probe's worth and exploring possible applications within their lives.

NV described three possible media package concepts that emerged from Zakhele volunteers:

1. **Music:** Music is an important part of daily life at Learn to Earn, with most of the Zakhele

workers listening to the radio or music while working in the sewing centre. Several of them had loaded music onto their handsets.

2. **Social information:** The Khayelitsha community is plagued by social instabilities including violent crime, gangsterism, theft and child abductions. One suggestion was to use SnG to display pictures of criminals and missing children.
3. **Advertising:** The woodworking students at Learn To Earn felt SnG would be useful if it could provide them with information about sourcing the wood and equipment they needed for their projects.

### 5.7.2.5 Learning outcomes

#### The artefact

Feedback received from the users via NV highlighted the need to integrate SnG with Web-based content services such as RSS (Really Simple Syndication) feeds and other Web content portals in an attempt to keep SnG content fresh. We proceeded to experiment with a version of SnG in which one of the screen items and its associated media packages were generated dynamically from an RSS feed. A fully dynamic version of SnG was tested in the laboratory but could not be deployed at Learn to Earn as there was no Internet connectivity in the sewing centre. If connectivity had been available, content providers would in theory have been able to publish media packages to one or more SnG installations via an RSS feed, with minimal effort and using off-the-shelf tools.

#### The process

One of the goals of the technology probing approach was to strengthen the participatory design environment by allowing the users to experience a technology interaction early in the design process. The SnG probe was successful in allowing Zakhele's volunteers to experience an interaction within the first week after deployment. The volunteers were then able to envision modifications to the future behaviour of and content available on SnG. NV played a key role in extracting these design visions by allowing the volunteers to express their thoughts and ideas in their own language, thereby creating a solid platform for design communication between NV and the users. NV was then able to convey the design feedback to the author (the designer). This effectively closed the design communication loop between user and designer.

To summarise, the SnG technology probe helped foster a stronger design environment. Design communication was strengthened through the provision of relevant information to the

volunteers during NV's training sessions, through the absence of pressure to use the system and by providing users with a forum to express their thoughts and opinions (design feedback) in their own language.

### 5.7.3 Third user centric design cycle

The third UCD cycle included two updates of the SnG content and the in situ evaluation of the SnG technology probe.

#### 5.7.3.1 Understanding and specifying the context of use

NV's diary documented the following comments during this period:

- "I worked so well with it!"
- "I never found any complications with it."
- "I was so happy that I could even help a lot of people by showing them how to use it."

In addition to the Zakhele workers, students from Learn To Earn's office administration course also tried out SnG. According to NV's notes they believed that SnG could provide:

- "Information about bursaries and courses at schools or Learn to Earn."
- "History or June 16th content."
- "Important things to help young people."

These entries provide evidence that SnG had achieved the initial goal of creating a buzz within the community, and showed signs of being an accessible multi-media platform for the wider Learn to Earn community. NV's comments showed an initial sign of SnG having an empowering effect on her.

#### 5.7.3.2 Specifying user and organisational requirements





The author decided to schedule weekly content update, which took place on three successive Wednesdays (May 28, June 4 and June 11 2008). NV was also asked to encourage users to post their own content. The author seeded this activity by teaching NV how to create and add content to her own SnG media package via the user generated content interface.

#### 5.7.3.3 Produce a design solution

NV's comments helped the author adapt the seeding editorial content according to the

interests and desires of the Zakhele team (see Table 5-7), in the hope that updated content would hold additional value in their eyes and motivate them to initiate further interactions with SnG. The new content was significantly richer than the original content, leveraging the full multimedia potential of the Samsung handsets. For example, packages on Robben Island and Nelson Mandela included slideshow presentations accompanied by music. NV also recorded a daily Bible reading in Xhosa.

**Table 5-7: Updated SnG content**

Title	Associated content	Cover Image
Nelson Mandela	A musical slideshow commemorating Nelson Mandela’s birthday was returned to the user as a 3GP video.	
Gospel Music	A music video capturing the work of local gospel artist Rebecca Malope was returned to the user as a 3GP video.	
Daily Bible Reading	A daily Bible reading, recorded in Xhosa, was returned to the user as an MP3.	
Robben Island	A musical slideshow depicting historical images of Robben Island was returned to the user as a 3GP movie.	

**5.7.3.4 Evaluation**

Following the deployment period, a detailed evaluation was held to establish where users stood on Heeks’ Information Chain [63]. The evaluation framework consisted of three components: A two-day polyphonic assessment, analysis of NV’s diary and an analysis of the log file analysis.

Applying the evaluative framework

Three data sources, namely the two commentator narratives (the output of the polyphonic assessment), NV’s diary and the system log files, were triangulated and analysed with the aid

of the evaluative framework described in Section 3.3.3.

The framework, built on Heeks' Information Chain [63], was applied to the data to determine whether the Zakhele volunteers were able to access, assess and apply SnG within their daily lives. The findings were used to inspire extensions to SnG or even completely new interactive systems, whilst simultaneously assessing whether the SnG technology probe, as it stood, was locally appropriate. For our purposes, we return to Dix [42] and Salovaara's [140] description of an appropriate technology – one for which the user shows vision, understanding and application of a designed artefact. An appropriate technology is thus one that the user can envision a use for and then successfully apply.

We start by evaluating the accessibility of the SnG system as Heeks [63] believes access is a precursor to the understanding and the application of an ICT. Thereafter we will continue to describe how the Zakhele group applied SnG within their daily lives.

#### The accessibility of the SnapAndGrab system

The accessibility of the SnapAndGrab system was evaluated at a broad level by applying the RA/RI impact criteria [16] as a lens to our three data sources: the polyphonic assessment, NV's diary and the system log files and then discussing the issues that come into focus. The RA/RI criteria are listed again below for reference:

1. Physical access to technology.
2. Appropriateness of technology.
3. Affordability of technology and technology use.
4. Human capacity and training.
5. Locally relevant content, application and services.
6. Integration into daily routine.
7. Sociocultural factors.
8. Trust in the technology.
9. Local economic environment.
10. The macro-economic environment.
11. The relevant legal and regulatory framework.
12. Public support and political will.

From an UCD perspective, we were interested in two particular qualities that affect the access

and use of a technological artefact: usability and contextual fit. The Bridges.org [16] framework addresses issues relating to these two qualities in criterion two, “*Appropriateness of the technology*” and four, “*Integration into daily routine*”. The evaluation of these two qualities was used to determine if SnG was accessible at the most basic level: the immediate interaction space [29, 30]. The remainder of the RA/RI criteria were used to determine whether there were any other barriers to access beyond the immediate interaction space.

The usability of SnG was evaluated according to the properties outlined by Nielsen [117]:

1. *Learnability* – The system should be easy to use and the user should be able to rapidly start getting some work done.
2. *Efficiency* – The system should be efficient to use so that once they have learned how to use the system they can reach a high level of productivity.
3. *Memorability* – The system should be easy to remember so that a returning user does not have to learn how to use the system all over again.
4. *Errors* – The system should have a low error rate, users should make few errors whilst using the system. If they do make errors they should be able to recover.
5. *Satisfaction* – The system should be pleasant to use.

Contextual fit was evaluated according to the degree to which SnG use integrated into the Zakhele groups daily routines.

The above-mentioned evaluative lens was applied to the triangulated data set (polyphonic assessment, NV’s diary and the system log files). The most relevant being the polyphonic assessment data and in it the cultural commentators’ description of each individual user’s attempt to complete a basic task - download content from SnG.

### **Usability 1: Learnability**

Analysis of LS and MX’s polyphonic assessment narratives revealed that several of the Zakhele volunteers had not yet learned how to use SnG effectively. Of the ten users interviewed on the assessment days, only one was able to successfully demonstrate how to download content from SnG. Another user confidently and correctly described how to complete the task of downloading content from SnG. Others had learned how to activate their Bluetooth and take a photo of the desired SnG content but forgot about the final step:

Bluetoothing the photo to the SnG system.

Although these results at first appear disappointing, the learnability of SnG should be considered within the broader context of the field study:

1. Five of the remaining users described receiving assistance from NV, who had thus enabled access to SnG as a technology intermediary.
2. The laboratory study showed that experienced camera and Bluetooth users were able to learn how to use SnG after a single demonstration. Evidence from the cultural commentators' narratives showed that several Zakhele group members were still learning how to use the camera and Bluetooth features of their handsets and thus were unable to complete a SnG interaction. The learnability of, and therefore access to, the SnG system was largely dependent on the development of the necessary camera and Bluetooth skills. NV and the two commentators were all experienced camera and Bluetooth users and easily learned how to use SnG. NV was trained by the author in less than 5 minutes and LS and MX both learned how to use SnG from their discussions with Zakhele volunteers and the visual instructions on the SnG screen. The laboratory study showed that users who are familiar with their phone's native camera and Bluetooth features are able to learn how to use SnG quickly and easily.
3. The commentators described cases in which users became nervous in their presence; they believed this hindered users' ability to complete the task.
4. Lastly, participation in the SnG project and use of SnG system was completely voluntary. There was no timeframe dictating when training schedules or practice sessions should take place and these were therefore subject to external forces such as workload pressure. The result was that some of the users had not set aside time to learn how to use SnG effectively before the commentator's visit. This is supported by two excerpts from LS's narrative: "She has not used SnG much but in time she will use it a lot more" and "She says she is often too busy (with her work) to download stuff (from SnG)". We believe that with additional time all the Zakhele volunteers would have been able to use SnG effectively, if they had the desire to do so.

### **Usability 2: Efficiency**

No users said SnG was too slow in use or that it took too long to deliver their media. One user commented to the commentators that she was too busy to interact with SnG; another said

most of the Zakhele members only had time to use SnG during their lunch break. One interpretation of these statements is that SnG interactions were not efficient enough to be accommodated into the daily work routine. Against this should be considered the fact that most of the users were still learning how to use their handsets and the system.

In addition, one of the more confident Zakhele volunteers described SnG as a more efficient way of getting new multi-media content: “She doesn’t have to wait for others to get new media, she can go straight to the source (SnG)” – Commentator LS.

### **Usability 3: Memorability**

It was not possible to evaluate the memorability of SnG interactions since most users were still learning how to use the technology. It should be noted, however, that NV facilitated the memorability of SnG as well as its learnability.

### **Usability 4: Errors**

The SnG log files revealed an overall error rate of 14% when using SnG: in 11 out of every 75 interactions users made a mistake and submitted content that SnG could not understand. Analysis of the submissions revealed common error types:

1. The user did not capture the entire image or the camera was misaligned.
2. The submitted photo was blurry because the user held the camera too close to the screen.
3. The user attempted to capture multiple SnG items.
4. The user forgot to submit a vCard before submitting user-generated content.

At a broader level, one of the Zakhele volunteers had a slight fear that SnG would be misused. She pointed out they could not remove content that was put up on SnG and that this would be a problem if someone put up a photo that was embarrassing or private. This was a valid concern. The current SnG system would require the system administrator to remove the problematic content, which was not the most efficient approach.

The highly constrained interaction style meant that enabling a user-initiated delete function was challenging. Recall that in designing the SnG technology probe we prioritised access and affordability, even to the detriment of other qualities such as usability. This is an example of where a usability quality was traded off. A possible solution to the problem would be to

provide a Web interface to the SnG content repository and to allow a member of the Learn to Earn management to be able to remove any undesirable content.

### **Usability 5: Satisfaction**

There was clear evidence that using SnG was a satisfactory experience for most of the Zakhele volunteers. One said she “likes the technology and uses it every chance she gets”. An excerpt from another’s comments revealed that through using SnG she became more comfortable with modern technologies and empowered her to, in her words, “try things out.” A third user described her SnG experiences as being “fun to learn how to use the technology (SnG) together and grow right in front of our eyes”.

Two members of the Zakhele team were, however, not as enthusiastic as the rest of the group. One, NM2, described SnG as “difficult to use” and commentator MX noted that she was not that interested in SnG. A second user shared this lack of interest: She had just learned how to use Bluetooth and was still planning to learn how to use SnG. The reasons for this lack of interest were, however, unclear.

NM2’s explanation was that she was unable to use SnG effectively and found it difficult to use. This may be true but a second explanation may be found in the fact that she was only 21 years old, significantly younger than the rest of the Zakhele group, most of whom were in their 50s and 60s. Her interests, particularly in the content, may have been vastly different from the rest of the team. It is possible that, like the students in the laboratory study, she was using other channels to access and consume media that was more to her taste.

### **Usage trends: Analysis of the system log files**

The log file showed a total of 75 interactions over the course of 23 days, initiated by 20 unique devices (including those of the two commentators, NV and the author). Further analysis of MAC addresses revealed that 11 of the 14 Zakhele volunteers had accessed SnG or at least attempted to do so; 3 had not, despite the ‘buzz’ [134] generated in the community. (This finding confirms that SnG usage was truly voluntary and that the Zakhele volunteers did not feel obliged to engage with the probe).

The log files also showed evidence of 6 users from outside the core Zakhele group, which

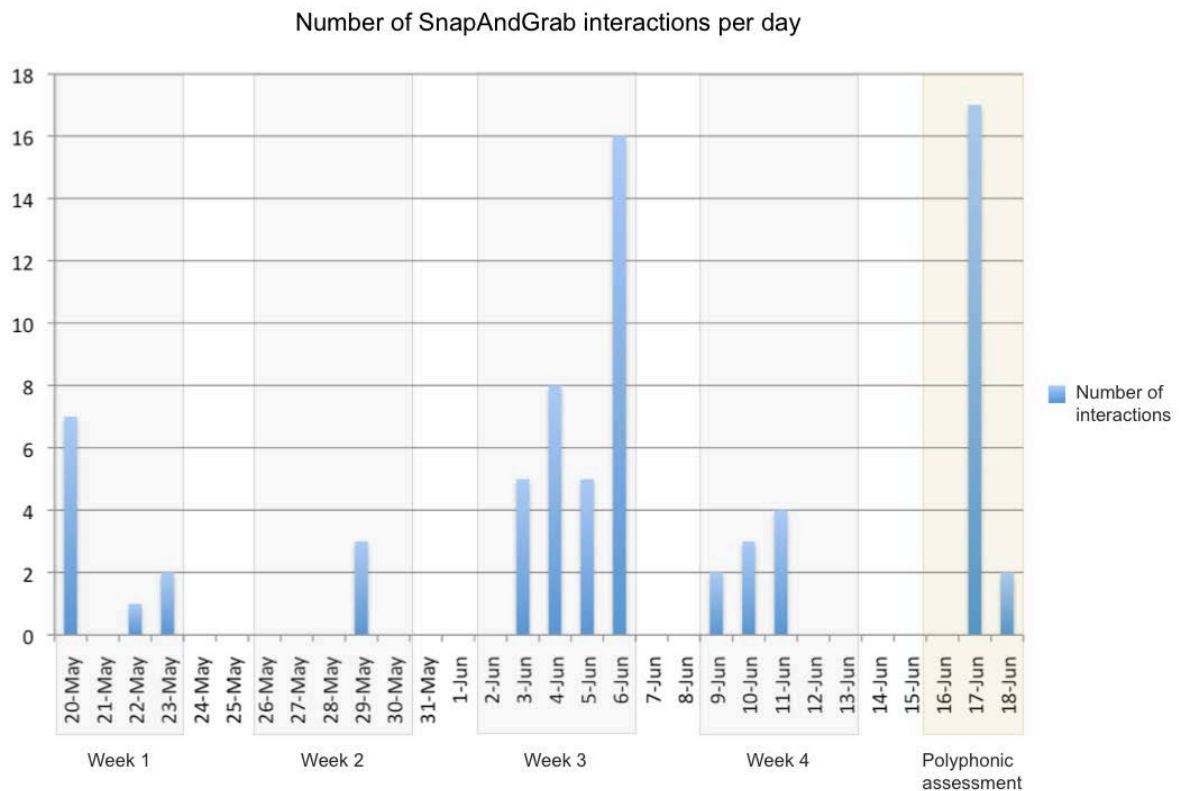
suggested that knowledge and skills relating to SnG were permeating beyond the core group.

The log files showed a general increase in system usage over the duration of the probe's deployment. There were 18 recorded interactions from May 20 – June 3 2008, and from June 4-11. The trend can be explained by the fact that the Zakhele volunteers were increasing their knowledge of how to use SnG and the fact that the new, more relevant content was being uploaded.

**Table 5-8: Daily interaction with SnapAndGrab**

Date (2008)	No. of interactions
Tuesday 20 May	7
Thursday 22 May	1
Friday 23 May	2
Thursday 29 May	3
Tuesday 3 June	5
Wednesday 4 June	8
Thursday 5 June	5
Friday 6 June	16
Monday 9 June	2
Tuesday 10 June	3
Wednesday 11 June	4
Tuesday 17 June	17
Wednesday 18 June	2
Total	75

**Figure 5-5: Daily interactions with SnapAndGrab**



Analysis of Figure 5-5 shows all user interactions with SnG over the four week deployment period from May 20 to June 18 2008. There was no activity on Saturdays and Sundays when Learn to Earn was closed for business.

Figure 5-5 shows usage spikes June 4, 6, 11 and 17. The two spikes on June 4 and 11 occurred on days when the author updated the SnG content. A popular music video by gospel artist Rebecca Malope was added on June 4, generating excitement and sustained use over the next three days. An entry in NV’s diary notes: “He brought us Rebecca Malope’s video. Yho, yho, yho it was like he brought a car for them.”

The spike on the June 17 coincided with the polyphonic assessment of the probe.

Figure 5-5 shows a clear correlation between SnG usage and the deployment of new, locally relevant content. The seeding content generated very little activity in the second week of deployment; by contrast, the addition of music videos in week three caused a marked increase in usage. This finding is consistent with Bridges.org’s [16] belief that an ICT must provide a community with locally relevant content, applications and services to encourage use.

### **Contextual fit: Integration into daily routine**

LS and MX (the commentators) described a situation in which they became frustrated because they wanted to browse and download all the content available on SnG, rather than waiting for SnG to rotate the content automatically. This finding highlighted a possible contextual misfit. Upon close analysis of the commentators' narratives we noticed that none of the Zakhele group mentioned this as a problem. To explain this discrepancy, it is worth noting that the commentators' goals were different from those of the Zakhele group members. The commentators were only at Learn to Earn for two days, with most of their time allocated to interviewing the group members. They therefore wanted to maximise their first interaction with SnG by seeing everything that was on offer. The Zakhele group, on the other hand, worked at Learn to Earn every day. The content available on SnG would be rotated several times during the day, providing them with ample opportunity to download the content. SnG's interaction design supported passive rather than active browsing, which suited the needs and the context of the Zakhele group but not the active browsing needs of the commentators.

### **Access: Trust in technology**

One of the Zakhele volunteers, LM, raised an issue that she had with SnG. She believed that SnG was responsible for the loss of R75 (~\$8) worth of airtime credits after making a call on her cellular phone. To put this into perspective, R75 is approximately one day's wage for a Zakhele group member. LM thought SnG was charging her for the content she downloaded.

This was not possible as SnG interactions utilised the free Bluetooth channel, not the GSM (General Standard for Mobile) or GPRS (General Packet Radio Services) channels that would cause the user to incur a cost after each interaction. However, LM's suspicion is understandable given the context of the mobile content industry in South Africa, where content is notoriously expensive. A MP3 track can cost up to R16,99 (~\$2.45) [47] and a subscription to a content service up to R30 (~\$4.32) per week [109].

This finding supports Bridges.org's [16] criterion that users should trust the technology. Misconceptions, particularly relating to the cost of an interaction, will prevent technology uptake. SnG may have attracted more users if it had been specified that they would not be charged for using it and that the content was also free.

### **Access: Affordability of the technology**

Despite LM's suspicion of SnG, she continued to use it. In fact, she described how it strengthened her relationship with her husband at home. Commentator MX described how LM could not stop talking about how much she liked SnG. LM's story revealed that for some members of the Zakhele group, SnG held significant value.

In a few cases documented by the commentators (LS and MX), the relative value of a SnG interaction was not enough to prompt use. NM1 revealed that some of the Zakhele volunteers sacrificed their lunch breaks so that they could complete more garments. This was the reason she had not attempted to download more items since the day she had been taught how to use SnG. Another Zakhele volunteer, NM2, claimed she was too busy with her work to use SnG.

The Zakhele manager confirmed that the group members were paid according to the number of garments they completed. The affordability of SnG interactions was thus not just a matter of direct financial cost but also of opportunity cost -- some group members felt their time was better spent completing another garment. For some women the value of additional income outweighed the value of the SnG content.

### **The application of the SnapAndGrab probe**

Next, we will shift the focus our analytical lens from access to application. We are now concerned with unexpected uses and emergent social practices and patterns. Recall that the ultimate purpose of the SnG probe was to probe complex environments of use, in this case Learn to Earn. The findings will then be used as inspiration for new interactive systems to support people in similar environments, and to address emergent needs of the Zakhele group and the wider Learn to Earn community.

### **Application 1: The emergence of social media consumption**

Applying the evaluative framework to the two commentator's narratives revealed an interesting application of the SnG technology and an emergent social practice.

Zakhele volunteer SD expressed a sense of elation and excitement when discussing SnG: "I have three children, one in Grade 9, one in Grade 6 and one in Grade R. This technology has helped me interact with my children more as I show them some of the things I take from it. There are many educational videos in the technology... it has helped me to strengthen my

relationship with God as there is a Gospel video in there and Bible readings” (MX’s narrative). LS’s narrative indicated that the educational content SD was referring to included the Nelson Mandela and Robben Island media packages. The Bible reading was a passage of scripture that NV recorded with the help of the author.

The content SD downloaded from SnG clearly held significant value for her, so much so that she kept it on her phone and would show it to her children when she arrived home. Harper et al. [62] have documented a similar phenomenon in their research regarding multi-media consumption and sharing with Bluetooth-enabled cellular phones. Their interview subjects described several situations in which multi-media was consumed socially for enjoyment. More specifically, subjects reported that they used their multi-media content to impress those they were with. SD was consuming the content she downloaded from the SnG system in a similar way, socially with her children. She described how this activity helped her to ‘interact with her children’ (MX) or ‘share the magic that is technology with her children’ (LS). Her comments point to a strengthening of a relationship, through conversations with her children around the SnG content and possibly respect for their mother’s newly acquired skills.

Zakhele volunteer LM expressed a similar account: She believed that the content she downloaded from SnG helped strengthen her relationship with her husband. She would typically download content from SnG during the day and then consume the video content with him in the evening. Once again, content consumption was a shared activity.

This emergent social practice holds an interesting implication for the design of the SnG system. In a scenario where a user transports content from Learn to Earn to their home, the SnG display system can be considered as the content source, the users and their mobile devices as the content transport mechanism and their home as the place for content presentation and social consumption.

Mobile phones like the Samsung E250 have small screens, and are not an ideal multi-media presentation or sharing platform. A future SnG system development might include a larger complementary device situated in the user’s home that allows a variety of multi-media to be viewed – a Bluetooth enabled multi-media player, possibly an 8-10” low powered display unit with either internal or external audio speakers.

In the resultant scenario, SD wants to download some new content from the SnG system for

viewing that evening. The other Zakhele volunteers have been talking about the new music and educational videos that are available on SnG and so she is keen to download them and take them home to her family. She does so before catching the bus home at 5pm. That evening, SD uploads the new content to her SnG media player and plays the music videos in the background over dinner. Later that evening she watches the educational videos with her children.

There are two important points to note here. Firstly, the SnG usage scenario now includes a goal derived from the feedback given by the users. The value proposition is also grounded in the way SnG was applied in situ by the users. The result is a much richer scenario grounded in reality of daily life.

Secondly, we notice two emergent media consumption patterns. The first, during work hours, saw the Zakhele volunteers consume the music they downloaded whilst continuing with their work by using the headphones that came with their Samsung E-250s. The Zakhele manager, AL, described how the team's productivity increased after they received the phones (media player) and the SnG system (media source). He described how the ladies spent less time chatting and more time focussing on their sewing work.

The second pattern, as described above, saw Zakhele volunteers delay social consumption until they arrived.

There is a livelihoods benefit to these behaviours: It was financially beneficial for the Zakhele volunteers to be less social during work hours. Listening to music via headphones makes it easier to focus on the task at hand, increasing productivity and earnings. Delaying social consumption until after work was also beneficial because the Zakhele volunteers were able to consume the media with their families, thus strengthening meaningful relationships.






### **Application 2: The emergence of media sharing**

Analysis of the system log files and UGC submitted by the Learn to Earn community revealed another emergent social practice: media sharing.

Community members at Learn to Earn began uploading music in MP3 format and photos in JPEG format to the SnG system. The system log files showed evidence of five UGC media packages with MP3 files attached (see Table 5-9). This behaviour resembled the multi-media

sharing practices described by Harper et al. [62]; but in the case of SnG, the multi-media was not shared directly between individuals, but rather by using SnG as a intermediate platform for sharing with the entire community. This practice is similar to the way Harper’s subjects shared multi-media that they considered valuable and that they felt would capture local interest [62]. It differed, however, in that the act of sharing was mostly philanthropic (generously sharing one’s multi-media with the wider community) or to elevate social status (by associating one’s real name and picture with the media package) rather than the act of trading of multi-media that Harper et al. describes as ‘trafficking’ [62:5].

**Table 5-9: User-generated content added to SnapAndGrab**

User-Generated Content		
Title	Associated content	Cover Image
Dlomo	1 x Contact Card 1 x Photo 1 x MP3	
Nonesi	1 x Contact Card 1 x Photo 1 x MP3	
Mama	1 x Contact Card 1 x MP3 1 x Photo	
Nonkhona	1 x Contact Card 2 x Photo 1 x MP3	
Nomhld [sic]	1 x Contact Card 1 x Photo	

In a particularly interesting example of photo sharing, the author was approached by a Learn to Earn community member (not one of the Zakhele volunteers), while updating the SnG editorial content. The community member indicated that there was a photo on the SnG board that he wanted to print and asked the author to copy it onto a USB memory stick for him. He

explained that the photo was of a popular, highly respected community member who had recently passed away – the photo had been uploaded as a memorial and made available for the community to download.

In these examples SnG was applied in two ways. First, community members were sharing multi-media content that they felt was valuable and would be enjoyed by the rest of the community. The data sets clearly showed, for example, that Gospel music was particularly popular -- in fact, all the music shared via SnG fell into the genre of South African Gospel. Below are excerpts from the three data sources:

*Polyphonic assessment:*

“She (NY) has almost downloaded everything and cannot wait for the new items to be loaded onto the screen. She wishes that the new items would be Gospel music and Gospel videos.” – NY (Zakhele volunteer)

“I send pictures back and forth; I love the content but wish there would be more Gospel items on the screen” – NN (Zakhele volunteer)

*NV's diary:*

“This boy (the author) should bring us more music!” – Zakhele volunteer’s comment

“He brought us Rebecca Malope’s (South Africa Gospel artist) video. Yho, yho, yho it was like he brought a car for them.” – NV’s comment

*Log files:*

The SnG log files showed that the Rebecca Malope media package was downloaded 10 times over the course of the 23-day field deployment.

In a second application of SnG, photos were uploaded to SnG for display purposes – the memorial photograph is one example of this. The log files provided additional evidence that the technology was being applied as a shared photo display unit (see Table 5-9).

**Application 3: Local assumptions regarding SnG**

The SnG probe uncovered an interesting finding regarding the suitability of SnG as a shared

system for the entire Learn to Earn community. Cultural commentator LS interviewed a group of students who were studying Graphic Design at Learn to Earn. They were under the impression that SnG was only available for use by the Zakhele group. This mistaken impression highlights the existence of cultural and organisational assumptions that affected the accessibility of SnG.

In the physical layout of the Learn to Earn buildings, equipment was tightly mapped to groups of people and physical locations e.g. the Apple Mac computers were kept in the graphic design studio and used by the graphic design students. The students may have assumed that SnG was strictly for use by the Zakhele team because it was located in their sewing centre.

It is possible that moving the SnG display to the Learn to Earn entrance foyer, a far more public area than the sewing room, would address these ownership or territorial assumptions. However, this would have an impact on the social practices that emerged within the Zakhele group. Sharing photos publically is a vastly different proposition to sharing photos with your colleagues in a shared work space; it is likely that relocating SnG would have a significant impact on the types of media uploaded and the emergent social practices.

In a similar example, Zakhele volunteer FN commented that she wished that SnG was “available for children and men”.

A comment by Zakhele volunteer NN highlighted another underlying assumption or misconception: “SnG does not work with other phones, only the phones that the ladies were given”. The Zakhele group did not even know that other people could use SnG.

This finding leads us to agree with Bridges.org’s [16] belief that access is a multi-faceted quality. We could add that local assumptions and beliefs about the prerequisites for using a technology will affect its accessibility, uptake and use. In a technology-poor environment, people may assume that because technology is a scarce resource it is somehow rationed or that access is limited. To address this problem, it should be made explicit that users are allowed to encourage friends and colleagues to try the technology – permission needs to be granted. In the case of the Zakhele team, permission was granted through the process of training, but it was not made explicit that others could and should interact with the technology.

#### **Application 4: Social cohesion within the Zakhele group**

The polyphonic assessment provided evidence that SnG strengthened social cohesion within the group of Zakhele volunteers. NN described how, before SnG, team members typically interacted mostly with colleagues in their immediate work vicinity (near their desk). With Bluetooth enabled phones and the SnG display they are able to “share in each others lives regardless of their seating arrangement” (NN).

NM1, described SnG a “a source of entertainment for all of us, we laugh together.” NV, our key informant, described how one piece of content (the user generated media package titled ‘Mama’ – see Table 5-9) was found to be particularly funny due to the cover photograph of one of the Zakhele volunteers; the group members were amused by the contrast between her colourful dress and her rather dour facial expression.

Cultural commentator MX’s discussion with BH, a member of the Zakhele team who did not receive a phone and who did not possess a compatible phone of her own, revealed a similar picture. She described how the Zakhele volunteers who did receive phones “spoke about Bluetooth all the time.”

#### **Application 5: Empowerment of the Zakhele volunteers**

The polyphonic assessment also provided significant evidence that the Zakhele group was empowered through the SnG project. Several of the Zakhele volunteers said exposure to new technologies such as Bluetooth, digital photography and the unique SnG system had given them confidence to engage with and discuss modern technologies:

“We are now able to share things with each other that we never thought we would be able to.” – NN

“I’m not afraid to try things out now.” – NM1

NM1 described how she used to run away from cellphones when they rang but has changed her perspective since receiving her Samsung E-250 and using SnG. She said that she was “very happy that she gave the new experience a try as it opened her up to a new world of possibilities”.

#### **5.7.3.5 Learning outcomes**

## The artefact

Our analysis of the triangulated data sources (commentator narratives, NV's diary and the system log files) showed that the usability and contextual fit of SnapAndGrab (SnG) technology probe was 'good enough' [29, 30] not to degrade the delivery of value for the Zakhele volunteers.

Our usability analysis revealed that: SnG was learnable with the assistance of NV, the error rate was low, SnG was described as an efficient way of getting content and the Zakhele volunteers were, on the whole, satisfied with the SnG experience and the opportunities it afforded.

In terms of contextual fit, SnG integrated well into the Zakhele volunteers' daily routine. Several of the volunteers were able to download media (with NV's assistance) while at Learn to Earn and consume it, at a more appropriate time, while at home with their families. SnG's passive style of browsing was well suited to the Zakhele volunteers' work patterns.

For one of the Zakhele women, however, a macro level accessibility factor relating to the affordability of SnG use did prevent the delivery of value. Affordability in this case was not related to financial cost (SnG use was free) but rather to the opportunity cost of using her lunch break to interact with SnG rather than finishing more garments.

We therefore conclude that SnG was accessible at a micro level (it was usable and fit the context of use) but that the macro level accessibility factor of affordability was able to degrade the delivery of value. This finding again reinforces Bridges.org's [16] contention that a 4Dev designer must consider accessibility factors beyond usability and contextual fit.

The deployment of the technology probe highlighted an additional accessibility criteria not covered by Bridges.org's RA/RI criteria, namely the impact of local assumptions on the accessibility of an ICT. Assumptions and beliefs about technology ownership and right of access had the ability to significantly reduce the accessibility of an ICT system.

In terms of value delivery, our analysis showed evidence that the Zakhele volunteers applied SnG in two meaningful ways: They consumed SnG media socially within their homes and used SnG as a space for sharing digital multi-media. Both were meaningful from a livelihoods perspective, in the case of home consumption of content with families because it strengthened

relationships. There was also evidence of emergent SnG practices having significant value. Here we recall the user who uploaded a photo of a recently deceased member of the community as a memorial. Several of the Zakhele volunteers described the experience of learning how to use SnG as empowering and said it improved their confidence with new technologies in general.

In terms of Heeks' Information Chain [35] SnG was accessible to most of the Zakhele volunteers and there was significant evidence to show that several were able to find an application for SnG within their daily lives. SnG can therefore be considered a viable, affordable mechanism for delivering rich multi-media content to users without PC knowledge and skills. In addition, we can conclude that SnG had a largely positive livelihoods impact on the Zakhele volunteers.

We are, however, mindful of the fact that access was, at that early stage, was still facilitated by our key informant, NV, and that the positive livelihoods impact relied on the user possessing an SnG compatible handset. There was sufficient evidence to show that the Zakhele team's reliance on NV wouldn't last indefinitely. At least one team member, MB, was able to demonstrate how to use SnG effectively and expressed a desire to assist the other team members.

A follow-up study at Learn to Earn in 2010 by another researcher from the author's university indicated that the prevalence of SnG compatible handsets had increased. This supported our earlier belief that compatible handsets would become ubiquitous devices within the Learn to Earn community.

### The process

We found that the public technology probing approach to UCD, combined with our evaluative framework, was successful at extracting design inspiration and a deeper understanding of the social attitudes towards and perspectives on the technology probe. Our analysis of the triangulated data sources revealed the following:

1. *Emergence of social media consumption* – This social practice inspired an extension to the SnG system. We identified a need for users to be able to upload their SnG content from their phone onto a separate multi-media display device that was located in their home to better support social media consumption.

2. *Emergence of media sharing* – This social practice highlighted the need for a better content moderation mechanism to be added to SnG.
3. *Identification of social cohesion and exclusion* – The Zakhele volunteers bonded around the SnG technology, sharing their experiences and helping each other learn. The converse was true for the Zakhele team members who did not possess compatible phones.
4. *Local assumptions about SnG* – Several assumptions and misconceptions regarding the ownership of and right to access SnG were evident within the Learn to Earn community. Several community members believed SnG was strictly for use by the Zakhele team members despite it being accessible to anyone with a compatible handset.
5. *Empowerment of the Zakhele volunteers* – Several of the Zakhele volunteers described how the experience of learning how to use SnG empowered them to be more confident with new technologies.

We can conclude that the use of technology probing in combination with a rich, multi-voice evaluative framework such as the one described in Chapter 3 enables a designer to extract valuable design feedback and inspiration from the users, early in the UCD process.

## **5.8 Conclusions**

This chapter described the application of a technology probing UCD approach to an ICT4Dev initiative in Khayelitsha in Cape Town, South Africa. We now present a set of sub-conclusions that we believe will help us answer our guiding research questions:

1. Which UCD methods best enable designers to work successfully outside their own context?
2. What challenges and pitfalls arise?
3. Can we develop and improve the UCD methodology to better support designers when working on ICT4Dev initiatives?

### **5.8.1 Technology probing strengthened design communication**

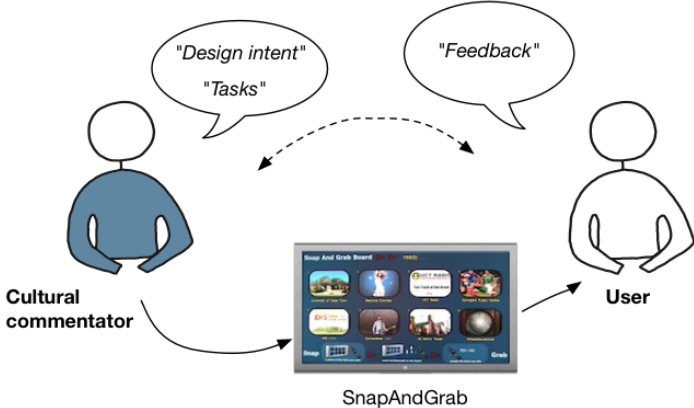
From a design communication perspective the use of a technology probe created a strong platform for design communication. There was clear evidence within the commentators' narratives and NV's diary of users providing feedback on issues ranging from the usability of

SnG to its application and use within their daily lives. The value of this is clearly evident if we compare it to the results of the MuTI Mobile low-fidelity prototyping sessions.

The low-fidelity prototyping techniques were abstract, which led to ambiguity and misunderstandings regarding the design intent and the underlying design concept being evaluated. The design communication that ensued did not help the designer improve the usability or contextual fit of the underlying design concept. By contrast, in the technology probing case NV’s diary captured user feedback as early as the second UCD cycle and the polyphonic assessment was conducted only four weeks after the deployment of the SnG technology probe.

The design communication environment was significantly different to that of MuTI Mobile. The tangibility of SnG meant that users were able to experience its utility first hand. The design communication that transpired was based on their interpretation of actual experiences of SnG. The user experiences were accessed primarily through the use of two cultural commentators whose home language and culture was the same as the users. If we return to the design communication diagram introduced in Chapter 4 (see Figure 5-6), we see that the cultural commentators played an important role as proxy for the designer during the polyphonic assessments. They were able to convey their intent, the tasks to be performed and gather design feedback based on users’ experience of SnG very effectively.

**Figure 5-6: The role of the cultural commentator in design communication**



The result is that the designer was able to access valuable feedback from users regarding the usability, contextual fit and the value of SnG early in the design process – despite language and cultural barriers.

Finally, it is worth returning to the project time line to clarify our claim of SnG being an early stage prototyping tool. The SnG technology probe was designed and built by the author in twelve weeks (October 2006 – January 2007) and tested in the laboratory for approximately four weeks in total. The delay between probe development, laboratory testing and field deployment was a result of overlapping time lines with the MuTI Mobile project, the planning the SnapAndGrab field study and research obligations to funding agencies.

### 5.8.2 Technology probing encouraged user participation

The use of a longitudinal, self-logging technological probe provided a second advantage – it created a spacious, less pressurised design environment. Users were provided with the necessary resources to access SnG (a compatible handset and training from NV) but were never forced to engage with the probe – the log file showed evidence that three users never engaged with SnG at all.

The spaciousness of the design environment was in stark contrast to the low-fidelity prototyping environments used during the MuTI Mobile design process. There the designer engaged directly with the users in a design session in an attempt to gather feedback. The MuTI Mobile workshops showed that even if a tool from Participatory Design (PD) was used, there was no guarantee that a suitable design environment could be fostered. Language, knowledge and power related barriers made it difficult for the Lwandile nurses to actively participate.

Medhi et al. [101]’s work, however, emphasises how important it is to foster a relaxed, unintimidating design environment to encourage user participation.

We found that the use of longitudinal, self-logging technology probes in combination with our key informant, NV and cultural commentators LS and MX was a way to create a spacious, less intimidating design environment that encouraged user participation. Analysing the SnG design environment using Kensing’s [80, 81] basic requirements for participation supports our claim that the SnG design environment encouraged active user participation:

1. Target users had access to **relevant information**. Our key informant NV and the cultural commentators LS and MX ensured that the users were informed as to the purpose of the project and relevant design activities in their home language.
2. The target users had the possibility of taking an **independent position**, expressing

their own opinions and views. Analysis of the cultural commentator's narratives provided sufficient evidence to show that the volunteers were indeed able to express their opinion and views without fear or intimidation. Here we recall LM's initial suspicion of SnG and the fact that she believed it had taken a significant amount of her talking credits, CM's fear that SnG might be abused or NM2's comment that SnG was difficult to use. There was also no prescribed use for SnG – users were able to use SnG when and for whatever purpose they felt was appropriate.

3. Users participated in **decision-making**: Feedback from the users had a direct impact on the content shown on the SnG. They were able to relay their needs to the author, via NV or create their own media packages. The feedback gathered through the polyphonic assessment also served as inspiration for future UCD iterations.

### 5.8.3 Technology probing supports emergent user goals

A definitive feature of technology probing is the fact that the user goals and motivations are emergent. This signifies a switch in design thinking. Rather than having designers immerse themselves in the user's context with the purpose of understanding their daily work and social practices (as with an empathic UCD process), technology probing sees the designer deploy a probe and then focuses on discovering how the it gets used in situ, or at least what users' in situ interpretation of the probe is.

The designer then uses the findings to describe more detailed usage scenarios based on users' first hand experience of the technology. User goals are now based on their interpretation and application of the technology probe – there is a tighter fit between users' real goals and those defined by the designer.

The SnG technology probe, combined with our evaluative framework, revealed several emergent social practices, patterns and perspectives relating to SnG, including:

1. Emergence of social media consumption
2. Emergence of media sharing
3. Identification of social cohesion and exclusion
4. Local assumptions about SnG
5. Empowerment of the Zakhele volunteers

We believe by incorporating these user centric, emergent technology practices and socially

shaped perspectives of the technology into future design cycles, the designer stands a better chance of producing an ICT system that is locally appropriate and will have a positive livelihoods impact on the target users and their community.

## 6 Conclusions

### 6.1 Summary of findings

At the beginning of this thesis we set out to explore two alternative UCD approaches: an empathic strategy and technology probing. Our exploration was guided by three research questions:

1. Which methods best enable designers to work successfully outside their own context?
2. What challenges and pitfalls arise?
3. Can we develop and improve UCD methodology to better support designers working on ICT4Dev initiatives?

In an attempt to answer the first question, we refer back to the conclusion sections of Chapter 4 and Chapter 5. In Chapter 4 we concluded that an empathic UCD approach was problematic for two main reasons:

1. The methods and tools used (in particular contextual inquiry and low fidelity prototyping) relied heavily on effective design communication being established between the designer and the target users. Evidence from literature and our findings showed that fostering such an environment in a 4Dev context is challenging due to barriers stemming from differences in language and culture, historical tensions between race groups and knowledge and power imbalances.
2. The appropriateness of the final solution, in particular its ability to deliver value to the target user, hinged on the designer's ability to define goals (within the scenarios of use) that sufficiently aligned with the goals of the users. We found that this was difficult to achieve in a 4Dev design context where daily work practices and processes were not as structured, formal and public as designers schooled in methods derived from developed world organisations might expect.

Low-fidelity design tools or early stage prototypes, typically used in traditional UCD projects, may fail to enable designers to identify and correct goal misalignment early in the design process or to predict the impact of a technology on technology poor social settings. The result is that goal misalignments may only be identified after a high-fidelity prototype is deployed late in the design process.

In Chapter 5 we showed that a technology probing approach may contribute to solving these problems.

To address the first issue, we used Gaver's [53] cultural commentators to strengthen design communication and access user interpretations of their experience with the probe. The resultant narratives, triangulated with the key informant's diary and system log files, gave the designer rich and multi-faceted understanding of users and their context. In addition, this multiple approach yielded design inspiration for extensions to the SnapAndGrab design. Most importantly, this was available early in the design process.

In terms of the second issue, goal misalignment, this does not arise in the case of technology probing, where goals are emergent. We did not prescribe a particular use for the technology probe. Instead, we deployed it and gave users time and space to experience it. We believed that if the users saw value in their interactions with the probe, they would apply it within their daily lives. Our task was to uncover such emergent uses and applications.

A potential weakness of the technology probing approach is that, by narrowing the field of study, it may fail to discover important goals that are not addressed by the probe. For example, a community may discover many uses for a multimedia display – but microfinance or agricultural information needs may be more urgent. The need to combine technology probing with other approaches is discussed further below.

## **6.2 Conclusions**

Our first research question was which UCD methods best enabled designers to work successfully outside their own contexts. This is frequently the case in 4Dev design initiatives, where there may be wide gaps of language, culture, knowledge, gender, age and power between designers and users. As our literature review showed, if these gaps are not bridged the results are often inappropriate or unused technologies. Designers thus need to seek out and develop methodologies that can help to bridge these gaps.

We constrained our study to focus on two approaches that emerged as promising candidates from the literature review. The two approaches explored in this work used several techniques to bridge this gap, including local partnerships with NGOs, key informants, cultural commentators and training assistance. All of these tools involved the active participation of intermediaries from within the users' context. Of the two approaches, public technology

probing, built on Hutchinson et al.'s [70] notion of technology probing and Gaver's [53] polyphonic assessment of design, proved to be more effective in helping the designer bridge communication gaps.

We believe this can be attributed to three main strengths of our public technology probing approach:

- The approach leveraged multiple interpretations [42,145] of the probe's utility (namely logs, diary and polyphonic assessment).
- We did not prescribe how the users should use the technology, but provided them with space to explore its utility and apply it within their lives if they saw value in it. The goals were emergent, not prescribed.
- Our evaluation of the probe utilised cultural commentators who shared the same language and culture as the users, thus bridging several of the language and cultural barriers that prevented the designer from engaging directly with the users.

Our second research question asked what challenges and pitfalls arise when these methods are applied. Our employment of an empathic UCD approach encountered two major challenges. First, there were multiple, dynamic forces at work that made it difficult to predict the effect of deploying a new technology in a technologically poor environment. A contextual analysis did not successfully uncover the users' true goals and motivations within the timeframe of the research. It was only after a high-fidelity prototype was deployed that the underlying issues were uncovered. It might be argued that the success of a contextual analysis or ethnographic study depends on the time allocated to it, and a longer period in the field may have uncovered these issues. However, in practice the time available for designers to immerse themselves in local contexts and thoroughly understand them is always constrained. A method that may take a year, five years or ten years to yield sufficiently detailed understandings is not pragmatic.

The second challenge was that the quality of design communication in a 4Dev design process is affected by factors including language barriers, cultural differences, historical tensions and knowledge and power imbalances. The effect is that popular low-fidelity prototyping techniques are ineffective as early stage design tools. Users may experience the design process as being intrusive, judgemental or simply confusing. The strength of a technology probe is that it opens up the design space to allow more active exploration by users and

potential users, without fear of judgement.

Our final question was how to develop and improve UCD methodologies to better support ICT4Dev designers.

We conclude that HCI does have methods, tools and techniques available that enable designers to work outside their own context. However, it lacks an overarching HCI4Dev method to guide the application of UCD within an ICT4Dev initiatives. It is too early to define such a method, but our work has shown that public technology probing, along with our framework for evaluating technology probes in situ, is an important addition and will assist designers to work successfully outside their own context.

There is, however, a caveat. In Chapter 2 we mentioned that a shortcoming of technology probing is that the design direction is heavily influenced by the technology's utility. The emergent scenarios of use, and therefore the emergent goals, will be shaped by the utility of the technology probe. This is the key to a probe's success: by narrowing the scope of design activities it focuses design communication around the probe's utility and not on ambiguous, low-fidelity design artefacts. At the same time, however, important livelihoods problems and opportunities for ICT interventions may be overlooked. Other discounted techniques, such as rapid contextual inquiry, suffer from a similar problem in that they focus on key individuals, processes and artefacts – again important livelihoods issues may be overlooked.

We therefore conclude that technology probing alone is not enough. As Harper and Carter [61] point out, designers may lack the necessary degree of sensitivity for local practices when pursuing new technologies. Limiting the design scope prematurely increases the risk that the designer will lack this sensitivity for pertinent livelihoods problems or needs evident in the community. A combination of an empathic and technology probing approach to UCD together may be the most promising way to develop locally appropriate ICT systems that have a positive livelihoods impact and pertinently address the most urgent issues facing communities, particularly in technologically poor environments.

A hybrid design approach would start with the designer conducting a contextual analysis using tools from empathic UCD (such as a rapid ethnography using key informants [103]). Here the designer tries to develop an appreciation for the local needs and livelihood problems. The scope of the design process is not prematurely constrained by the utility of a particular

technology.

The designer would then add a series of technology probing activities, chosen for their possible application to the livelihoods needs identified in the first phase, to engage users and explore their perspectives on a new technology. We found Gaver's [53] polyphonic assessment of design to be very effective in this regard.

The first activity provides inspiration about needs; the second provides inspiration about technology applications. The designer's role is to identify the areas where these overlap and opportunities for modifying the technology to meet the need.

### 6.3 Summary of contribution

As mentioned, there is currently no overarching HCI4Dev framework or methodology available for designers wishing to work in a developing-world context. Literature in the area reflects on the suitability of methods used in particular cases, but does not generalise these reflections. In addition, there is little or no work that has specifically set out to assess methods.

This thesis has made the following contributions to the development of such an overarching framework:

1. We have identified the limitations of an empathic UCD approach in a 4Dev environment, where design communication is challenged and may fail to uncover users' true goals. More specifically, we highlighted the shortcomings of paper prototyping as a design tool, and the dangers of goal misalignment between users and designers because of wicked social-cultural problems.
2. We have developed a strategy for evaluating a technology probe, applying Gaver's polyphonic assessment in a 4Dev environment.
3. We have validated the usefulness of the Bridges.org RA/RI accessibility criteria, and added to them by highlighting the role of assumptions and beliefs about technology ownership and who is permitted to use it.
4. Two publications based on this research [96, 100] explored the suitability of UCD within 4Dev contexts and the importance of partnerships and proxies.

In addition, to enable this design research we developed the novel SnapAndGrab media sharing system [98, 99] that had a positive livelihoods impact on its users.

Our research findings also suggest the need to be mindful that taking an ICT4Dev approach already narrows the scope of research. In the case of MuTI and MuTI mobile, the researchers were following a development agenda that led them to focus on building a medical information system. A more unconstrained focus on actual user needs may have opened entirely new design pathways. Attention to the details of the nurses' daily lives, for example, may have highlighted the need to refine the human resource allocation practices of the Department of Health so that staff were not isolated in communities far from their homes.

Similarly, following a development agenda may have obscured the value our Zakhele users attached to their family and community relationships. Real user needs and desires may differ substantially from those imputed to them by outsiders such as funding agencies, NGOs, government departments and academics. Even when an empathic approach to discovering these needs is followed, the focus of this investigation is already narrowed from the start when a development agenda is followed.

## **6.4 Future work**

### **6.4.1 Probing new environments of use**

The findings from the SnapAndGrab field study have encouraged other researchers at the author's university to use the technology probe to explore other complex environments, including a project looking at media sharing and consumption on public transport. SnG has been ported to run on a mobile phone mounted inside the vehicle next to the driver. Images (visual codes) are printed and located near passengers' seats. Passengers are then able to take photos of the printed images and send them to the SnapAndGrab system via Bluetooth.

### **6.4.2 The use of proxies as design tools**

In our research we found that design communication could be strengthened through the use of design proxies. In the case of technology probing, we utilised Gaver's [53] cultural commentators as a proxy for the designer. The commentators belonged to the same culture as the target users and spoke the same language, thereby addressing several communication barriers that would have made it difficult for the designer to gather design feedback.

In the MuTI Mobile project we used the training assistant as a proxy for the target users when they were unable to schedule time to participate in design activities. Our key informant AS also acted as a proxy for the users in the participatory workshops, airing their views based on his interactions with them during the training sessions. This partly compensated for knowledge and power obstacles that prevented them from participating.

The use of proxies encourages designers to rely less on their own knowledge, abilities and assumptions. Involving skilled and knowledgeable local people (key informants) into all facets of the design activities as proxies or facilitators assist with design communication. Integrating the use of design proxies into a UCD design process is a key area of future research.

### 6.4.3 Community searching

The SnG log files showed that use spiked whenever new content was added. This suggests the possibility of building a system that will learn about user preferences, search the Internet for related content and download it for presentation on the display (another researcher has in fact begun building such a system). This in turn creates the possibility of using the log files of what is downloaded by users to build a profile of community interests.

### 6.4.4 Media consumption in the home

The evaluation of the SnapAndGrab technology probe identified an emergent social practice of users downloading media at Learn to Earn and then consuming the media at home with their families. As discussed in Chapter 5, this suggests that there is potentially great demand in developing world contexts for in-home consumption of communally shared media.



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# Appendix A: Laboratory questionnaire

Date: \_\_\_/06/2007

Age: \_\_\_\_\_

Occupation: \_\_\_\_\_

Sex: Male / Female (Please circle the appropriate word)

Home Language: \_\_\_\_\_

\*\*\*\*\*

*Please read the following:*

*This study is **NOT** evaluating you, the user, or your skills. We are researching a new interaction technique that utilises large screen displays and Bluetooth enabled camera phones. We need your help in determining if such a technique is suitable for public information systems in South Africa.*

*Please understand that your participation is voluntary and you may choose to stop at any time. Your participation is greatly appreciated.*

\*\*\*\*\*

If you would like to be part of any future studies relating to cellular phone research please provide us with your email address below:

\_\_\_\_\_

*\*We will **NOT** give your email address to any 3<sup>rd</sup> party nor will we send you spam*

Many Thanks

Andrew Maunder (amaunder@cs.uct.ac.za)

## Pre-Questionnaire:

1. Have you ever used the camera feature on your cellular phone? YES/NO
  
2. How would you best describe the various ways in which you use/have used the camera feature of your phone? Circle the appropriate letters AND use the numbers to give an indication of how often you would use the camera for the given purpose. 1 = RARELY .....5 = A LOT

- |  |                   |
|--|-------------------|
| a. Taking pictures at an event                     | 1...2...3...4...5 |
| b. Taking pictures of friends or family            | 1...2...3...4...5 |
| c. Taking pictures of a interesting/amusing things | 1...2...3...4...5 |
| d. Recording videos of friends or family           | 1...2...3...4...5 |
| e. Recording videos at an event                    | 1...2...3...4...5 |
| f. Recording videos of interesting/amusing things  | 1...2...3...4...5 |

3. Have you ever used the Bluetooth features on your cellular phone? YES/NO

- a. If you answered NO, why not? And if you answered YES, what do you like/dislike about the Bluetooth features on your phone?

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4. Do you ever share any of your pictures or videos? YES/NO

- a. How would you normally do this? Circle the appropriate answer.
  - i. Via MMS
  - ii. Via Bluetooth
  - iii. Both

5. What factors would influence whether you choose to use MMS or Bluetooth?

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6. If you answered YES for question 5, what types of files have you been sent by someone else?

*Examples: photo, video, audio, contact details, calendar card, text file, PDF, Web page, mobile*

*application etc.*

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- a. Did you always know where to find the files after you received them? YES/NO

### **Post-Questionnaire:**

1. Could you imagine using the Snap&Grab Board in an everyday public setting such as a shopping mall/train station? YES/NO

Why do you feel this way?

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2. How would you change the Snap&Grab Board to make it more useful?

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3. Considering that Bluetooth transactions are effectively *'free'*, what other factors do you think would affect your decision to use the Snap&Grab Board in an everyday setting?

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4. List the media package you thought was the most interesting. Why? Also make up an imaginative

media package and describe it below.

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5. Regarding the “*UCT Radio+*” media package. Would you prefer to know the exact song title or artist name before you download the song? YES/NO

If YES, Why?

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If NO, Why not?

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6. Did you know where to find the various files that were sent to you by the Snap&Grab Board? Circle the appropriate letter.

- a. YES, I knew where to find all the files that were sent to me.
- b. NO, I was unable to find any of the files that were sent to me.
- c. SORT OF, I was only able to find some of the files that were sent to me. List the files types you were able to find below. Example: photo, video, music, web page, text

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List the file types that you were unable to find.

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7. Do you feel that the total time taken to complete a Snap&Grab transaction is too long for what its worth? YES/NO

a. If YES, would more interesting/applicable content change your mind? YES/NO

If YES, give some examples.

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b. If NO, do you think this type of product could work in an everyday, public setting? YES/NO

If YES, what do you think is the key selling point of the Snap&Grab Board?

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If NO, what changes would you make to the Snap&Grab Board?

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## **Appendix B: Cultural commentator narratives**

### **Research Report**

*Project: Learn To Earn Board-X*

**Supervisor: Andrew Maunder**

**Researcher : LS**

## **ABOUT THE PROJECT**

This report is the result of a research initiative by Andrew Maunder a PhD Computer Science student and has been completed by LS and MX. On first meeting with Andrew I was given a brief about the project and he detailed what was required of me. Andrew works with a group of women in a community business centre in Litha Park, Khayelitsha. Learn To Earn is a foundation that offers previously unemployed women training and employment opportunities. The women attend sewing lessons and continue to work for the company and produce work for the mainstream retail and service businesses. Andrew did not tell us much about the technology that he had facilitated along with his supervisor. X is what I shall now call the technology. As a researcher I was merely told that it was a technology that used mobile phone technology and media exchange. Fourteen women had been given Samsung E250 handsets and were being assisted with the technology by one of the office administration graduates from Learn To Earn. The 17<sup>th</sup> and 18<sup>th</sup> of June were the days that myself and MX went to visit the ladies and figure out a few things.

## **OBJECTIVES**

The following details the objectives that came up from meetings with Andrew, while structuring a research plan. From the perspective of someone who had not invested much in X, I was taking a neutral position and the aimed to absorb as much as possible without being too selective and subjective. To avoid assumptions and preconceived ideas, Andrew ensured that we knew nothing much about the overall project. The main objective was to figure out the vision the ladies had for X and how it impacted their lives. The usability of X was a major factor as it affected most of the overall implications. Is X useful and why? These are some of the questions and ideas we approached the research with.

1. The changes that X had caused and how they are dealing with them?
2. The positive implications and the negative results were also elements that we were aiming at achieving.
3. I also wanted to find out if the use of the technology, even though for a relatively short period, whether it had made them more confident with other similar technologies?
4. Was this a nuclear experience or could it be a link to a community of techosavy women?

My anticipation to find out what X was had been growing for a while and I was very eager to know what X was about. Just from the meetings and the detailed context, I assumed X would be something I would find interesting but figure out very quickly. I was under the impression it was a technology I had used before but disguised for easier use for mature women. My ideas were however challenged and X proved in a very subtle way to be revolutionary. I assumed the multinational company that was sponsoring the project was Google or Microsoft. Overall the aim of using researchers who did not have a jaded version of things was to find out the 'real' perspective.

With all the detailed objectives an approach was necessary. Mine was to come from a place of little knowledge, therefore allowing the experience to be more fulfilling. There is a certain kind of ethnographic writing that allows one to be assimilated into the subject that they are researching, I was not aiming for this kind. The aim was to be part of the experience but still maintain awareness about the overall plan. This allowed me to get closer to the 'real' perspective but still fulfil my requirements.

#### **DAY ONE-17 may 2008**

After a short briefing session with Andrew we headed out to Learn To Earn in the afternoon to see the ladies around their lunch break. The area is about 30 min away from the city and relatively far if one travels using public transport. The Learn To Earn Centre is in Litha Park and has a sewing centre, a woodwork centre and a graphic design institute with a Macintosh lab and internet access. The place has a warm and hopeful feeling about it. On the first day I will hesitantly say I felt a bit at home. X is situated in a semi-recreational part of the sewing room. X looks or is a black Samsung Plasma screen that is prominent from when you enter the room. NV, the office administration took us on a mini-tour but we halted so that we would get familiar with the technology through the ladies. My first thought was to touch the screen; I thought it was touch screen enabled. The titles and visual are very clear and concise and there is no mouse or any other navigation device I assumed I would have to touch and I did. The screen has different blocks that show different media products. Music videos, pictures and ring tones amongst other things. It does however not feel like a computer in the monitor-keyboard-desktop sense. I then noticed a tiny apple mac gadget - I assumed to be the 'powerhouse' of the project. I then started thinking about how X utilised mobile phones after the fact that there was a television monitor sunk in.

## **CASE STUDY ONE: SD**

SD has been working at Learn To Earn for a relatively long period of time and was previously unemployed. She does not know much about current technology and marvels at the simple novelty of sewing. She enjoys sewing and is a very fulfilled mother who loves her kids. X has been a blessing to her she says as it has allowed her to share the magic that is technology with her children, one she says comes from rural Eastern Cape and has not been exposed to the city and its amazing ways. However, when we asked her to show us how to use it she struggled with the phone even before she got to X. She couldn't find her Bluetooth function on her phone even though it was activated already. She has taken a very keen interest but she needs a lot more practise with X but with the NV's assistance she will learn to be more confident about using X.

She does understand concepts such as phone memory and can explain the full function of a memory card. She says what hampered her use of the technology was the lack of memory on her phone. During the research she raised the issue with Andrew and he bought a new memory card with adaptors for other technologies. The biggest constraint that she has would be her lack of confidence in using X. She has an appreciation for X , and says the presence of X has made her aware of things she can learn about her society and what she can teach her children, she mentioned the picture of Nelson Mandela and Robben Island. She expressed a need for content that is strong on both the educational and religious fronts. What is also interesting is that CM can fairly work with X but she has no idea how to share content using Bluetooth with other ladies.

## **CASE STUDY TWO: FN**

We spoke a bit about the technology to FN but we wanted her to take us through a quick tour. We asked her to show us how it works. FN then proceeded to activate her Bluetooth. She has a memory card and has stored videos and pictures. She had the most content amongst all the ladies and was very keen on downloading. However, when it came to X she became very nervous using it in our presence and I think that hindered her process and she was therefore not entirely successful in downloading her stuff. She took a picture of a part of the screen with the phone camera. The picture was the Rebecca Malope video and she then told us she would be able to play the video just from taking the picture. We were convinced that this was not the case. I have never come across such a technology and with that in mind concluded she was a

bit confused about the way X works but I still wanted to know how she managed to get so much stuff from X.

NV had previously assisted her. She loves the idea of X in their workspace and it is generally a breath of fresh air to the group. She says she does find X tricky but wants to give herself more time to get used to X and then she will fully reap the benefits of using X. She also mentioned that X could be used as a tool for sponsors and clients to communicate with them. Sponsors could put up details and the ladies could use the information to contact them. She also feels Learn To Earn as an organisation could do with a bit more sponsorship. With X she wants to get more practice and wants more music content.

From the two women I have selected above we could tell the general feeling about X, at least from the older ladies. They have a huge appreciation for X and believe X has a positive influence on their environment and in time they will grow to learn more about X. They also seem to like the content. The technology is not 'getting in the way' but is a challenge they are willing to take on if in the end they find the content worthwhile. They have also built a sense of ownership around X and as the ladies feel connected around it.

The Graphic Design students were all under the impression that only the ladies could use it. Later in the report I shall detail how the women who had not received the phones respond to X. Generally the environment is much more relaxed in the workspace with X around. During lunchtime the ladies can sit and chat around X and assist each other. All the ladies agree that without the help of their peers they would not even know half of what they do. They feel learning to use the technology together has helped them grow together in learning and has eased them into the idea of the new technology.

After FN had tried to show us how to use X, we attempted to follow the instructions. 'Snap-Grab-Send' is the catchphrase. I was under the impression the catchy phrase would maybe confuse the ladies but they were very comfortable with the instructions. We then proceeded to try it out and the results were surprising.

## **DAY TWO**

We aimed to speak to a lady who had not received the phone and ask her how X influenced the environment and what she saw as the vision for X. BH says he was not working when the phones arrived and so she missed the training. She says she wants to know a lot more and she

is keen to learn the next time there is a training session. She says she has learnt a bit about Bluetooth technology from the other ladies. BH raised a very important question- What is X and what does it do? This might be clear to us but because the ladies could not call it anything but 'that TV Andrew brought' maybe they struggled to understand its function. All the ladies know what X could do but what X was remained a mystery to them. They cannot call it a computer and it is not a TV or a cell phone. What is X?

BH feels very distanced from the rest of the group as she feels like she is not part of the growth and experience. She says the other ladies put on their headphones and listen to music and view their video and they do not share. I figured this is something the ladies would have to deal with on their own and would not influence X. BH says it has created a sense of community and she envies them for knowing so much about the technology while she remains clueless. Overall she thinks it is a very nice idea but she would like to know more about it.

After successfully downloading a video and two ringtones from X we carried on with the research. Now we felt confident and wanted to see how the other ladies felt about this. On day one most of the ladies we spoke to expressed similar thoughts and opinions. CM is one of the younger ladies and she has downloaded most of the available content and wants more. She only uses what she has downloaded when she gets home and she does not really review it at work. In a discussion with Andrew about the time being a crucial factor in the success of many technologies, I assumed that the quicker is better. This is why I assumed that the ladies would be frustrated with the time the machine takes to change the main screen to show more content. I quickly learnt that time and speeds are contextual theories and that the novelty of 'old-school slow' is what gave X its special edge. X does not need to be super fast as the women do not actively download. They do it while they work and seeing as though they will spend the whole day at Learn to Earn the speed is fine.

CM at first showed a high level of confidence when she spoke about X, but as we carried on and got into how X actually worked and how she got media from X she started hesitating and therefore fumbled. She loves the fact that X has brought her much closer to her co-workers as they are beginning to share things about their lives through the pictures and this they had not been able to do previously.

She has a slight fear for the misuse of X. She fears that because you cannot readily remove material you put up on X you could easily embarrass others and put up pictures that they do

not want to be shared. CM likes the pictures of Robben Island and wants to see more similar media. She says this lets her break out of the world she knows and because she does not know what to expect she finds that more exciting. She says she does not mind if men or other people who are in and around the sewing area use it, as long as they all understand that Learn to Earn is a Christian foundation and therefore the material cannot be offensive. All the women carry traditional Christian values and therefore are all interested in the gospel aspect of the material. She also expressed a keen interest on the bible reading addition and hopes to see more of the same range.

NY is the woman who knows most about how to use X. She says she has not had enough time to share her knowledge with the rest of the ladies because she has had exams as she is schooling while she is studying. NY last used X last week and took pictures from the soccer option. She enjoys the music and she can detail exactly how you download material from X and could easily switch her Bluetooth. She says it is good to know that she does not have to wait for other people to have new media and that she can go straight to the source. She is very excited that she is part of something that is new and fresh to the community at Learn to Earn. She is much younger than the ladies we spoke to earlier and the fact that she is studying while she is working might be the reason she is much more advanced in comparison to the other ladies. She mentioned that she hopes there can be on hand assistance for the rest of the ladies because she is not always there to assist them as she studies part time.

NM1 never had a cell phone before Andrew and X arrived. She says she used to run away from cell phones when they rang and has now changed her entire perspective. It is also interesting to find out that she has only come into contact with cellular phones recently and her first cellular phone is a camera phone. She loves Andrew but cannot understand him and so she likes taking quick lessons from NV. She is very happy to have been given this experience a try and it has opened her up to a new world of possibilities. She says now she cannot live without cell phone technology and has fully indulged in X and its functions. She finds it easy to use, it has helped her connect with her friends as she exchanges pictures of her grandchildren with them through X. Other women also get the opportunity to share parts about their lives that they could not previously explore. NM1 is most happy about the new sense of community and friendship that the ladies have created around X.

NM2 last used X the day it arrived. She says time is a factor that has stopped much of her

growth with the technology. She says she is often too busy to download stuff. She showed her children the stuff she got on the first day. She like most of the ladies wants more lessons from NV so she can feel confident enough to explore X on her own. She says that with the help of the other ladies she can learn a lot more and from now on she wants to be more active in the learning process. She is excited that they are becoming more united as a group over a TV that is set with moving images and music. She finds it very difficult to use, unlike all the ladies we spoke to. I think she needs more lessons more than anything.

NN says that X does not work with other phones and only on the phone that the ladies were given. She has not used X much but says in time she will use it a lot more. She says the pace of the moving pictures on the screen is fine as most women only have time to download at lunch time. She says the content is fairly cross-over and that as a 21 year old she does not feel left out in any way.

LM like NN says she shares her music via Bluetooth with friends and her children. This has made them more technosavy and they have both become the sources of new material for their friends.

PX has just learnt how to use the Bluetooth but does not know how to use in connection with X. She is then planning to use X a lot more than she previously did.

MB is very happy with X and can use it very well.

## **CONCLUSION**

The ladies are very excited about X and are in need of more practise and lessons about X. The technology is a welcome change to how they normally use cellular phones. They are in the process of forming a long term vision for X. For now X is a new experience that has made them know each other better and has opened them up to technology and its ideas. The usage of X is limited because the ladies need more training and want to understand how X is. X, I feel needs a lot more time to fully grow and be part of the ladies and their everyday experience. It is a special 'thing' whose effects cannot be fully documented, but I hope this report has shed some light on matters relating to it.

## “Snap, Send and Grab Technology Report”

Prepared by MX

The “Snap, Send and Grab” technology was given to a group of fourteen women from a township known as Khayelitsha from a group known as Learn to Earn. This was done so that the usability of the technology can be investigated. The women were also given the Samsung E250 cell phones in April in preparation for the Technology. The Technology was given to them afterwards. After three weeks of getting used to their phones they had access to the technology. Our investigation started on the 17th and 18th June, conducted by me and LS (we both had no clue how the Technology worked), so that we can find out how familiar they were with the Technology. The following results were obtained from the interactions and interviews we had with the women.

The first woman we spoke to was, SD. This is what she had to say about the Technology: “I have three children, one in Grade 9, one in Grade 6 and one in Grade R. This Technology has helped me interact with my children more as I show them some of the things I take from it. There are very educational videos in the technology and I’m happy. It has helped me more personally to strengthen my relationship with God as there is a Gospel video in there and bible readings”.

SD claimed that she did not use the Technology because she did not have a memory card. When we asked her to show us how to use the Technology, she failed to successfully show us though she had claimed to have been comfortable with the Technology. She knew she had to take a picture from the Technology screen and send it back to the Technology but her lack of confidence with technology in general led her to fail in downloading a picture from the screen. She then referred us to FN who seemed more confident with the Technology.

FN had the following to say about the Technology: “I love this Technology that Andrew gave to us. I wish it contained more gospel music and more gospel videos.” She claimed to have downloaded video and a bible reading from the screen. When we asked her to show us how the Technology worked, she took a picture of what she wanted and activated Bluetooth on her

phone. She went on to tell us that the video was going to play.

LS and I did not believe what she had told us. We could not believe that the video was going to play by just taking a picture from the screen. FN went on to say: “I use the Technology to get music but I ask NV (a young woman familiar with the Technology) for help when I get stuck. This Technology has helped change my life and I wish all the women had received the cell phones because we would have bonded even more, we now share our pictures”. She went on to say that she wishes the Technology was available for children and men. She did not know that the Technology was usable to anyone who had a cell phone with Bluetooth and could take pictures.

FN was trying in vain to download items from the screen but led us to try and figure out how the Technology worked on our own. We then discovered that what FN had told us was true but that she did not take the final step, which was to send the picture back to the screen. This got me thinking on my own. FN was very confident that she could use the Technology and claimed that she had downloaded a few items from the screen before. Was the Technology easy to use?

We then started downloading items from the screen for ourselves. LS uses the Samsung E250 too and he had no problem downloading from the screen. I use the Samsung E340 and I could only get pictures from the screen. I could not download ring tones and music. During the time we spent downloading the items we wanted from the screen, I noticed that I did not like that I had to wait for the screen to change on its own to see all the items that were on offer. I also did not like the fact that I could not download all the items that I wanted. I felt like it was because I did not use the same cell phone as the women.

CM said she seldom used the Technology. She did not have a specific reason for that. She seemed to have been more excited about getting a phone rather than the exposure to the Technology. When we asked her about the screen, this is what she had to say: “I use it for music and every time when I download something, I go and listen to it at home and watch the videos at home”.

For someone who claimed not to use the screen all the time, this was rather contradictory. It then dawned on me that she did not want to look like she was not happy for the screen. The screen is in their workplace and most of the women say they use it during lunch, which is why

they are not too familiar with it. Some women sacrifice going to lunch so that they can finish their work for the day. This could be one of the reasons that they do not download items from the screen.

The screen definitely started some discussions in the work place. BH who was not part of the women that had received the cell phones had the following to say: "I was not at work when they [the women who received cell phones] received their phones. I am very interested in knowing more about this screen. I hear them talk about Bluetooth all the time and envy them when they listen to their music. I wish I knew more about it. The screen is a nice idea because it brings us all together. When I also have my phone, I will be able to share my pictures with all my friends in the work place". BH went on to explain that the screen is a source of entertainment. BH's comment made me realise that the women talk about the Technology. For someone who was not part of the fourteen women, she came across as very informed about how the screen actually works and the purpose of the screen.

LM claimed that she can use the Technology. "I use it all the time. I have downloaded music and I can share my music with others". LM had one issue with the technology though. She has two sim cards for her phone. The other sim card is a contract sim card. She claims that she made one call and it charged her R75 (Seventy Five Rands), and suspects that the Technology was responsible. She continued to use the Technology after the airtime incident.

She is thankful for the Technology because it has helped her relationship with her husband. She watches the videos that she downloads on the technology with her husband at home. It is evident that the technology is not only helpful to the work place. Most of the women comment on how it is helping them strengthen their relationships with their children, friends and husbands outside the work place. LM could not stop talking about how she likes the Technology. She seemed confident about using it but could not show us how to download items from the screen. She easily described how it is done. Her interest in the technology was very obvious.

After speaking to LM, a new slide with new content appeared on the screen. LS and I quickly went to the screen to download. LS was able to download it and I was not. We again discovered another little problem with the technology. What happens if you send something by mistake to the screen and you want to take it back? No one seemed to know. It was at this

point that I gave up on trying downloading items onto my phone.

We went to see the graphic design students to see if they have ever used the Technology before. They said they had not used it because they were under the impression that it was only available for the women. They agreed to try it out and see if they would be able to use it.

NN said the same thing that all the women have been telling us. She likes the Technology. She uses it when ever she gets a chance. “I send pictures back and forth; I love the content but wish there would be more Gospel items on the screen. We are now able to share with each other things we never thought we would be able to”.

NN raised a very important point. The women usually share things with their desk mates at work, with the people that are closer to their sewing machines. She commented on how they can all share with each other their lives regardless of their seating arrangement at work. Even the women that do not sit next to each other are now able to share things.

NM1 was the most enthusiastic about the Technology. She did not own a cell phone before and had no idea how it worked. This all changed when the Technology was introduced to their lives. She has always been scared to use anything that had to do with technology, in general, before. “I don’t know how my life was like before I received a phone from Andrew. I can’t imagine life without a phone now. This Technology has helped me to be more comfortable with other technological objects. I’m not afraid to try things out now. This is a source of entertainment to all of us [women], we laugh together and it is so easy to use. I can’t believe it took me so long to familiarise myself with Technology and cell phones.”

NM1 is one of the women who sacrifice their lunch so that they can finish their work. This is the reason she had not attempted to download items from the screen since the day they were taught. When we asked her it is done, she easily explained to us. Considering that she had never owned a cell phone before, it is quite evident that the technology is very user friendly.

NM2 was the most surprising of all the women that we spoke to. She last used it the day it arrived. She seemed not interested in the technology. It was surprising because she is the youngest of them all. She is 21. She claims that it is difficult to use, but from her facial expression it was obvious that she was not interested in learning how to use the screen. She has a few items that she downloaded from the screen in her phone. She says if she had more

time, maybe she would give it a try but she is always busy.

PX was the same as NM2. The last time she used the screen was when it was delivered to them and she downloaded everything with the help of NV. Unlike NM2, however, she was able to explain the process of downloading items from the screen. She used her phone to explain as she could not leave her desk.

NY is one woman who frequently uses the screen. The last time she used was last week before we came and she downloaded items without anyone's help. "I took the soccer pictures from the screen. It has helped my knowledge with technology and I now know better. The screen has introduced an idea of peer learning to us. It is fun to learn how to use the technology together and grow right in front of our eyes". Her enthusiastic for the screen was matched by the number of items she uses it to download. She has almost downloaded everything and can not wait for the new items to be loaded to the screen. She wishes that the new items would be gospel music and gospel videos.

MB is excellent at using the Technology. She has not been using it because she has been absent from work due to her school exams. She has no problem downloading anything and takes the shortest time to download items from the screen. "I have been going to school the last couple of weeks so I have never had the opportunity to use the screen as much as I would like to. I love it".

MB only received an introductory guidance on how to use the screen and has no problem to download things. This could be because she feels confident. Unlike the other women, who also know how to download, she is also very confident. Maybe the fact that she goes to school is helping her to have more confidence than the other women.

The 'Snap, Send, Grab' technology is very easy to use. Though it has its shortcomings, mentioned in the report, it is obvious that it is a good idea. The only reason that some of the women were still struggling with the Technology was because they lack confidence. It is obvious that the screen with the right items, for the target audience, will be a success, no matter where it was.