UNIVERSITY OF THE WESTERN CAPE

Usability and Content Verification of a Mobile Tool to help a Deaf person with Pharmaceutical Instruction

by

Michael B. Motlhabi

A thesis submitted in fulfillment of the
degree of Master of Computer Science

in the
Faculty of Natural Sciences
Department of Computer Science

Supervisor: Prof. William D. Tucker

February 2014

UNIVERSITY of the
WESTERN CAPE

Declaration of Authorship

I, Michael B. Motlhabi, declare that this thesis titled, *Usability and content verification of a mobile tool to help a Deaf person with pharmaceutical instruction*, and the work presented in it is my own. I confirm that:

- This work was done wholly while in candidature for a research degree at this University.
- Where any part of this thesis has previously been submitted for a degree or any other qualification at this University or any other institution, this has been clearly stated.
- Where I have consulted the published work of others, this is always clearly attributed.
- Where I have quoted from the work of others, the source is always given. With the exception of such quotations, this thesis is entirely my own work.
- I have acknowledged all main sources of help.
- Where the thesis is based on work done by myself jointly with others, I have made clear exactly what was done by others and what I have contributed myself.

Signed:

Date: 26-02-2014

UNIVERSITY of the
WESTERN CAPE

Dedication

This dissertation is dedicated to the living memories of Adinda Freudenthal and Gary Marsden who have been proud and supportive of my work and who have shared the many uncertainties, challenges and sacrifices for completing this dissertation.

May their souls rest in peace....

UNIVERSITY of the
WESTERN CAPE

UNIVERSITY OF THE WESTERN CAPE

Abstract

Faculty of Natural Sciences
Department of Computer Science

Master of Science

by Michael B. Motlhabi

This thesis describes a multi-disciplinary collaboration towards iterative development of a mobile communication tool to support a Deaf person in understanding usage directions for medication dispensed at a pharmacy. We are improving usability and correctness of the user interface. The tool translates medicine instruction given in English text to South African Sign Language videos, which are relayed to a Deaf user on a mobile phone. Communication between pharmacists and Deaf patients were studied to extract relevant exchanges between the two users. We incorporated the common elements of these dialogues to represent content in a verifiable manner to ensure that the mobile tool relays the correct information to the Deaf user. Instructions are made available for a Deaf patient in sign language videos on a mobile device. A pharmacy setup was created to conduct trials of the tool with groups of end users, in order to collect usability data with recorded participant observation, questionnaires and focus group discussions. Subsequently, pre-recorded sign language videos, stored on a phone's memory card, were tested for correctness. Lastly we discuss the results and implications of the study and provide a conclusion to our research.

UNIVERSITY of the
WESTERN CAPE

Acknowledgements

I thank my lab mates for their motivation and for staying behind with me on all the late nights in the cold BANG lab. I would also like to thank my supervisor Prof. William Tucker for his unwavering support during hard times (past & present) and always making me feel smarter than I really am during our weekly meetings.

I also thank the Deaf Community of Cape Town, University of the Western Cape School of Pharmacy for their collaboration and South African-Netherlands Research Programme on Alternatives in Development (SANPAD) for financial support. Thanks also to Meryl Glaser, Mariam Parker, Prangnat Chininthorn, Adinda Freudenthal and to all interpreters who helped me with this project.

Thanks also to Telkom, Cisco, Aria Technologies and the THRIP (Technology and Human Resources for Industry Partnership) initiative of the South African Department of Trade and Industry for financial support via the Telkom Centre of Excellence (CoE) programme.

Lastly and most importantly I thank my sisters, Princess and Gloria, and also my mother, Gertrude Motlhabi, who have been the source of my strength and who continue to inspire me to be better.

UNIVERSITY of the
WESTERN CAPE

Contents

UNIVERSITY of the
WESTERN CAPE

UNIVERSITY of the
WESTERN CAPE

UNIVERSITY of the
WESTERN CAPE

List of Figures

UNIVERSITY of the
WESTERN CAPE

List of Tables

UNIVERSITY of the
WESTERN CAPE

UNIVERSITY of the
WESTERN CAPE

Abbreviations

ADS	**A**utomated **D**ispensing **S**ystem
ADSL	**A**symmetric **D**igital **S**ubscriber **L**ine
AI	**A**rtificial **I**ntelligence
API	**A**pplication **P**rogramming **I**nterface
AR	**A**ugmented **R**eality
ASL	**A**merican **S**ign **L**anguage
ASRAR	**A**utomatic **S**peech **R**ecognition and **A**ugmented **R**eality
ASR	**A**ugmented **S**peech **R**ecognition
ATM	**A**utomatic **T**eller **M**achine
AVC	**A**dvanced **V**ideo **C**oding
BANG	**B**ridging **A**pplications and **N**etwork **G**aps
BSL	**B**ritish **S**ign **L**anguage
DCCT	**D**eaf **C**ommunity of **C**ape **T**own
DEAFSA	**Deaf** **S**outh **A**frica
EHC	**E**uropean **H**ealth **C**ommission
fps	**F**rames **p**er **S**econd
GB	**G**iga**b**yte
H.264	A standard for video compression
HCI	**H**uman **C**omputer **I**nteraction
HTML	**H**yper**T**ext **M**ark-up **L**anguage
ICT	**I**nformation **C**ommunication **T**echnology
ICT4D	**I**nformation **C**ommunication **T**echnology for **D**evelopment
IID	**I**terative **I**ncremental **D**evelopment
IT	**I**nformation **T**echnology
ISDN	**I**ntegrated **S**ervice **D**igital **N**etwork

UNIVERSITY of the
WESTERN CAPE

kbps	**k**ilo**b**its **p**er **s**econd
MMS	**M**ulti **M**edia **S**ervices
NGO	**N**on-**G**overnmental **O**rganization
NMF	**N**on-**M**anual **F**eatures
OSDE	**O**bjective **S**tructured **D**ispensing **E**xamination
PC	**P**ersonal **C**omputer
PIN	**P**ersonal **I**dentification **N**umber
PO	**P**ost **O**ffice
RAM	**R**andom **A**ccess **M**emory
ROI	**R**egion **o**f **I**nterest
TRS	**T**elecommunications **R**elay **S**ervice
SAPS	**S**outh **A**frican **P**olice **S**ervice
SASL	**S**outh **A**frican **S**ign **L**anguage
TB	**T**erabyte
TESSA	**TE**xt and **S**ign **S**upport **A**ssistant
TISSA	**T**elephone and **I**nterpreting **S**ervice for **S**outh **A**frica
TTS	**T**ext-**T**o **S**peech
TTY	**T**elephone **T**ypewritter
UCT	**U**niversity of **C**ape **T**own
UI	**U**ser **I**nterface
UWC	**U**niversity of the **W**estern **C**ape
VIS	**V**ideo **I**nterpreting **S**ervice
VRS	**V**ideo **R**elay **S**ervice
XHTML	**E**xtensible **H**yper**T**ext **M**ark-up **L**anguage
XML	**E**xtensible **M**ark-up **L**anguage

UNIVERSITY of the
WESTERN CAPE

Chapter 1

Introduction

This thesis describes a mobile application developed to facilitate communication between a hearing pharmacist and a Deaf patient at the hospital pharmacy. Consider a Deaf patient after consulting with a doctor now in possession of a paper prescription with pharmaceutical instructions and a list of medicines that the patient has to be treated with. The patient would take that prescription and a device running the application and hand over both items to the pharmacist who can then share pharmaceutical instructions with the patient without needing to understand South African Sign Language (SASL). We call this system SignSupport and it can explain in SASL pharmaceutical instructions to a Deaf person and even remind them when to ingest their medicines. A series of pre-recorded sign language videos which are embedded in Extensible Markup Language (XML) are used to translate English text to SASL which the patient can understand because that is what the patient prefers. Section 1.1 of this chapter discusses the objectives of this study and why it is relevant to Deaf people. Section 1.2 introduces a Deaf non government organization which is our target group, defines Deaf with a capital 'D', and describes in detail the background work that has been done on mobile and desktop platforms for communication between Deaf and hearing people. Section 1.3 summarizes this project and Section 1.4 provides an outline of the entire thesis.

UNIVERSITY of the
WESTERN CAPE

1.1 Aims and objectives

The primary aim of this research is to deliver a communication tool that can be used by two people who use two different languages to communicate, specifically in our case between SASL and English. The tool allows a Deaf patient to confidently collect medication from a non-signing pharmacist without worrying about the communication barrier between the two parties. The aim of the research is to optimize the use of telephony technology to assist South African Deaf people in communication by using their preferred language. The long term objective of SignSupport is to be able to close the communication gap between hearing and Deaf people by providing a tool that can facilitate communication in any given context. SignSupport supports communication of only one context. The idea is that this research will form a foundation on which the next version of sign language tools can be based.

The interface discussed in this thesis is specific to Deaf mobile phone users. We have come up with a design that caters for the needs of disabled and functionally illiterate users and not just a generic user interface that has been morphed for convenience. We also wanted to increase patient safety and compliance to medicines since many Deaf people cannot understand the reason why they are given a certain type of medicine and when and how to ingest it.

UNIVERSITY of the
WESTERN CAPE

Another aim of the study was to engineer a way to systematically record and load SASL videos on a system of this nature. We formulated a set of rules that ensure that when a SASL video is displayed to convey information to a Deaf person, that video appears at the right time and displays the correct information. These rules can be used on other communication systems which work in a restricted domain.

1.2 Background

This section is a description of the work that has been conducted between our research group and a non government organization in Cape Town on telephony technology for Deaf and hearing users. We started by introducing what it means to be Deaf and a Deaf non-governmental organization (NGO) with whom we collaborate.

1.2.1 Deaf with a capital 'D'

Deaf with a capital 'D' refers to a person who uses SASL as his/her primary language to communicate. A cultural identity is defined by the use of SASL. The principal difference between deaf with a small 'd' and Deaf with a capital 'D' is based solely on a person's preference rather than the degree of hearing loss. Generally, South African Deaf people tend to have low levels of basic education and literacy [20, 26]. Since Deaf people are mostly functionally illiterate, most Deaf members in the community are underemployed (70% of Deaf people are unemployed compared with the 25,6% of hearing people) or can only be employed in low paying jobs that offer few if any benefits [57]. Deaf people in South Africa have an average education of Grade 7 and only about 20% of the total Deaf workforce has Grade 12 [55]. Deaf people are also classified as disabled and this also adds to the difficulty of finding well paying jobs that can improve their standard of living. In South Africa SignGenius has found that 4.3% of the South African population is disabled. There are about 383,408 Deaf people which translates to 22.2% the of disabled people [55]. However, the actual number is higher than the number reported by Statistics SA namely 1,500,000 compared with 383,408 [55]. This is partly due to the fact that parents do not record their children as being Deaf and a large number of Deaf people have never filled in a census form. Combine the low population of the Deaf community with their inability to communicate via text/voice with most of the rest of the population and you find that most governments struggle to consider the needs of their Deaf citizens. These issues create an environment that is disempowering for Deaf people.

UNIVERSITY of the
WESTERN CAPE

There is a discrepancy when it comes to the statistics about deaf/Deaf people in South Africa. Various sources post different numbers, STATSSA and SignGenius are considered in herein this because their information seems to support one another. It has always been a challenge to get an accurate count of how many people are Deaf, deaf or use hearing aids. This is because in most cases children are not counted as parents find out much later that their children have a hearing disability.

In the past the South African government introduced a communication service called Telephone Interpreting Service of South Africa (TISSA) that was meant to enable Deaf people to have easier access to government services (see Section 2.1.4). TISSA is one example a of government driven Information and Communications Technology (ICT) project that is geared to help Deaf people. Unfortunately, programmes like these are not sustainable and are soon defunct because of political reasons and lack of sustainable funding. Since Deaf people cannot communicate with hearing people using SASL, it is necessary to devise a solution that they can be held responsible for. Currently Deaf people use text-based applications on their mobile phones. Applications such as WhatsApp®, Gtalk®, SMS and internet video applications that are not designed or optimized for sign language usage. These communication methods are useful but do not offer Deaf people the ability to express themselves clearly since 75% [57] of Deaf people are text illiterate. Yet we have found that they do communicate with each other in broken English using these media [62].

1.2.2 Deaf Community of Cape Town

A Deaf NGO in Cape Town — Deaf Community of Cape Town (DCCT), is the source of participants for this research. This group was chosen because it encourages Deaf people to communicate in SASL and because of its long history with our research group. DCCT was founded in 1987 to serve the needs of Deaf black and coloured residents of the Western Cape province. The most important thing to note is that DCCT is run and managed by Deaf and Hard-of-hearing members.

UNIVERSITY of the
WESTERN CAPE

Over the past decade DCCT has been working in collaboration with the University of Cape Town (UCT) and the University of the Western Cape (UWC) on Deaf telephony research [38, 59]. Figure 1.1 shows the different versions of SignSupport and how each version was used as initial requirements for the next iteration. DCCT has approximately 2000 members who meet every month on the 3rd Sunday [62]. Also Deaf members are offered English and computer literacy classes and have access to the internet. DCCT is therefore a centre of Deaf culture and education in Cape Town.

1.2.3 Previous work

This section describes the work that has been done on Deaf video communication technology between Bridging Applications and Network Gaps (BANG) and DCCT over a period of more than 10 years. We concentrate on the evolution of SignSupport, shown in Figure 1.1 as this is where we base our user requirements and implement our agile

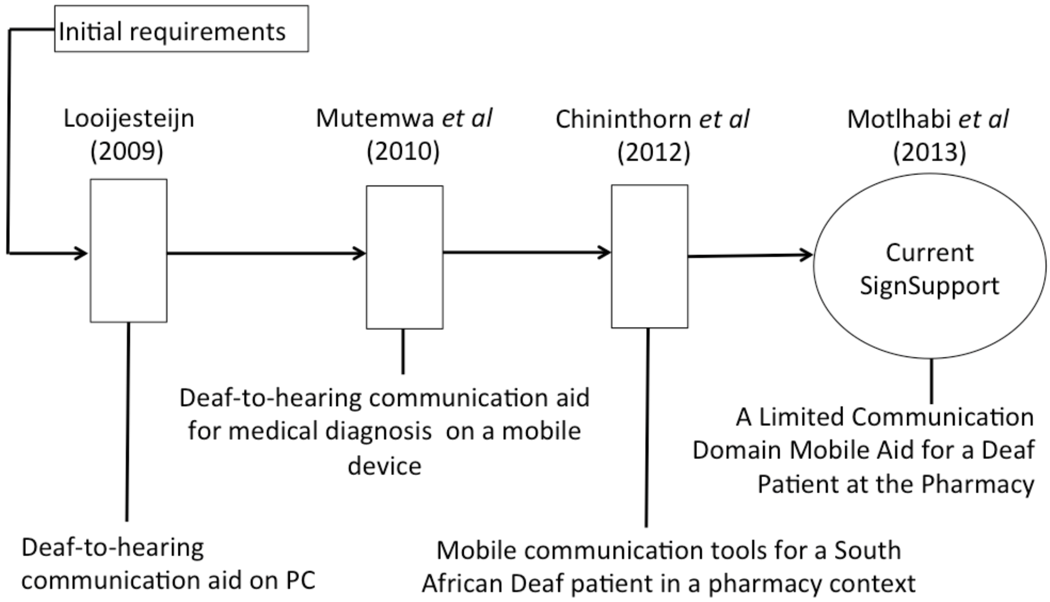

FIGURE 1.1: **Incremental development.**
Showing incremental design and development of SignSupport over a number of years. This shows how each project has used the one before as the initial requirements for the start of the next implementation.

UNIVERSITY of the WESTERN CAPE

iterative development methodology. The following versions show how user requirements have been refined and optimized. This section shows how SignSupport has evolved from a Personal Computer (PC) application [37] to a Symbian mobile phone application using a guided set of webpages [44] to a more robust self-contained smart phone [42]. Also we show its evolution from Mutemwa's mobile prototype intended for the doctor context [44] to Chininthorn's medicine dispensing system [11].

1.2.3.1 Looijesteijn's PC mock-up

A mock-up was the first step in the development of the concept for all SignSupport versions. Looijesteijn designed and implemented a PC mock-up telecommunication solution to be used by Deaf people to communicate with a hearing doctor using SASL and English text, respectively [37]. Initially, the user requirements were to develop a communication aid that allowed Deaf people to interact with each other because Deaf people wanted to communicate within their own social circles rather than with hearing people [37]. As a result of generative sessions, communication problems experienced by the Deaf community arose and were studied in a very general manner to devise a solution that was appropriate for the needs of Deaf people at a hospital. The mock-up asked a Deaf person questions in SASL. After the Deaf person answered the questions, the answers were presented to a hearing doctor in plain English. The doctor read the summary of symptoms and responded using an English lookup dictionary. A Deaf person then watched a corresponding SASL video of the response [37]. This idea was moved to a Symbian S60 mobile platform in the next iteration of SignSupport.

1.2.3.2 Mutemwa's mobile prototype

Mutemwa's research involved a prototype that allowed a Deaf person using SASL to tell a hearing doctor how s/he is feeling and provide a way for the doctor to respond in a fashion that a Deaf person can understand [44]. Mutemwa's prototype was requested by Deaf users after they had experienced Looijesteijn's PC mock-up. This prototype is different in that it ran on a mobile phone and not on a PC. The prototype was built for a mobile phone browser by embedding SASL videos inside the Extensible HyperText Markup Language (XHTML) web pages using Adobe Flash. The prototype asks medical questions in SASL, arranged in a way that helps identify a medical problem. SASL videos are loaded with the help of a content authoring tool which helps to populate video in a context free manner, allowing for multiple scenarios to be added as needed [44].

UNIVERSITY of the
WESTERN CAPE

The system then provides a summary to the doctor in English text on the device itself. However there were major issues that needed to be resolved both on the prototype and on the function domain. Although the application was meant to communicate information to and from both users, the implementation at the time only passed information in one direction, from the patient to the doctor [44]. This was a serious limitation because the patient could use the application to let the doctor know what was wrong but the doctor could not communicate back to the patient. The other limitation was that Mutemwa's prototype worked only on a Symbian S60 operating system and was not generalized [44]. This version of SignSupport also had usability problems that severely hampered its functionality, like the limited questions that a doctor could ask a patient and the lack of detail in the summary screen.

Apart from technical and design problems that came up during the research, the field which was chosen for the prototype was also found to be vast and difficult to study. In order to create a lookup dictionary that would support the actions of the doctor, a communication plot of the domain had to be mapped (see Figure 3.16). This proved to be a very challenging task that cannot currently be solved in the mobile space because of the natural limitations of an application that is designed for a cellphone.

1.2.3.3 Chininthorn's design

Chininthorn, an industrial design engineer from Delft University of Technology, redesigned SignSupport [11]. The design was a follow-up on the two implementations discussed above. Many attributes of the design were carried down from Looijesteijn's PC mock-up and Mutemwa's mobile prototype. A fundamental difference was that Chininthorn's design was for a pharmacy context. SignSupport moved from the doctor application because that context was too large to encompass all the conversations that could take place. The pharmacy context is small enough to study most of the conversations that take place. This meant that she could form a meaningful conversation in the pharmacy context as compared with the doctor context. Conversations are recorded in SASL and stored on the phones memory card. Chininthorn's primary objective was to design a feasible communication aid for pharmacists and Deaf people. Deaf patients are at high risk when it comes to the pharmacy context. The high risk is due to the fact that Deaf patients could take their medicines incorrectly. This is often the case because of the lack of communication during treatment of Deaf patients and pharmacists involved in the treatment cycle [11]. The communication aid solves five key issues that Deaf participants raised during Chininthorn's data collection, and they are as follows:

UNIVERSITY of the
WESTERN CAPE

1. Why are you being treated? (explanation of the medical condition).
2. How to ingest your medicine? (dosage forms and quantity).
3. When to ingest your medicine? (time of day and frequency).
4. Built-in reminder system (automatic vibrating alarm alerts).
5. SignSupport should also serve as a portable electronic patient background history file.

To implement SignSupport in a different context a design methodology called Vision in Product design approach (ViP) was used as a guide to tackle the design tasks [31]. A human centered design approach was also applied which involves all users of the product, both Deaf patients and pharmacists.

1.3 Current iteration

This version of SignSupport is still a communication application that works on a mobile device. However, SignSupport is not just a communication application between two parties who do not use the same language but it is also a personal reminder that alerts the patient when it is time to ingest their medicine or when they are about to run out of medication. It was designed to take advantage of a limited communication domain which we define as a public hospital pharmacy.

Our version of SignSupport allows a pharmacist to share pharmaceutical instructions with a Deaf patient without the pharmacists needing to learn or understand SASL. SignSupport uses pre-recorded SASL videos to communicate with a Deaf patient and English text to communicate patient information to a pharmacist.

A Deaf patient will hand over a paper prescription and a device running SignSupport pre-installed with SASL videos to a pharmacist who reads the paper prescription and interacts with SignSupport by inputing medical instructions relating to the patients illness. We decided to use real sign language videos as opposed to avatars because currently automatic sign language translation cannot guarantee enough accuracy for medical use. According to Ghaziasgar and Connan, only 60% of the signs can be successfully and consistently recognized [25].

UNIVERSITY of the WESTERN CAPE

1.4 Thesis outline

This chapter has laid the groundwork for the current version of SignSupport. Chapter 2 describes related work. Firstly we discuss technology that has been geared to help Deaf people to communicate with hearing people. We look at design factors that influence the success and/or failure of ICT in developing regions for Deaf people. Secondly we look into Automated Dispensing Systems used in the field of medicine and how they have been tested for content correctness during medicine dispensing to reduce errors and improve patient safety.

Chapter 3 presents the methodology used to build the current version of SignSupport. Research questions are detailed and explored in this chapter. We also propose a solution that answers the research questions. We also introduce the multidisciplinary team of experts and their contribution to the study. Software engineering principles and community-based co-design principles are discussed and their use is justified here. The system's user interface is shown in this chapter, also the experimental design method for collecting data from the participants and from the system during content correctness. Ethical considerations are also discussed.

Chapter 4 discusses the process of data collection and analysis. We provide a detailed discussion about how the user interface has been received by both sets of users and how user feedback has changed the interface and the usability of the entire system. Content correctness results are analyzed for SignSupport compared with other medical dispensing systems discussed in Chapter 2.

Chapter 5 concludes the thesis. The contents of the thesis are summarized. A conclusion is drawn based on the results discussed in Chapter 4. It provides lessons that were learnt during the length of this study and also offers suggestions for working with Deaf participants and sign language interpreters. We explain the limitations of the system and the optimal conditions under which it will perform. Future work is also suggested.

UNIVERSITY of the
WESTERN CAPE

1.5 Role of the author

This research was a collaboration of a multidisciplinary team, and each of us played a different role and contributed with a unique set of skills (see Section 3.2.2 for member roles). Below is a brief description of the contributions made by the primary researcher (author). Since the project had been running for a number of years some foundation had been made by the previous researchers. My primary role was to analyze the design sketches designed by Chininthorn which outlined the user interface of the current version of SignSupport that I alone implemented in an iterative fashion. During the course of these development iterations I chaired meetings with rest of the team members and showed new functionality, problems and progress that have been made since the last meeting. After coding the interface and including all the elements that were agreed on by the rest of the design team, I recorded the SASL videos, edited and loaded them onto the system and verified their correctness by running a closed experiment with the interpreter and pharmacists. Once the rest of the team members were satisfied with the application and agreed that it was complete I prepared training sessions with Deaf participants at DCCT. I arranged for two interpreters to be present in order to help interpret the consent forms and help mediate the session. The training session was conducted with PowerPoint (SASL video based presentation). After the training session we held a focus group session with Deaf participants. The session was followed by a trial session at UWC which was co-led by myself and a pharmacist. This session involved both pharmacy and Deaf participants. The rest of the roles fulfilled by the other four members of the team can be found in Section 3.2.2.

UNIVERSITY *of the*
WESTERN CAPE

Chapter 2

Related Work

This chapter provides a discussion of the literature that is pertinent to our work. Firstly we discuss technology that has been geared to help Deaf people communicate with hearing people. We look at the interfaces and different types of implementation that have been used to improve usability, and the methods used to achieve those interfaces. Secondly we look into Automated Dispensing Systems used in the field of medicine and how they have been tested for content "correctness" during medicine dispensing to reduce errors and improve patient safety. Section 2.1 presents underlying ICTs for Deaf people. Section 2.2 discusses Automated Dispensing Systems and methods used to verify that the information/prescriptions being given to patients is correct. Section 2.3 summarizes the chapter and provides a description of how usability of ICT systems for Deaf peopleTTYs and verification testing for automated systems can be used together to design and develop a more user friendly system that provides users with accurate information.

UNIVERSITY of the
WESTERN CAPE

2.1 Underlying ICTs for Deaf people

2.1.1 Text and video relay services

Telecommunications Relay Service (TRS) is a service that allows for communication between Deaf and hearing people using text and voice in real time with the help of an interpreter [64]. Communication is achieved by making use of a telephone and a

FIGURE 2.1: **Teldem TTY.**
Showing a keyboard interface that is similar to the one found in laptops and personal computers. An interface that favors text literate people.

Telephone Typewriter also known as Tele Typewriter (TTY) [49, 64] which can be seen in Figure 2.2. A typical TTY is a device about the size of a laptop computer with a QWERTY keyboard and a small screen that uses a Light-Emitting Diodes (LED) or Liquid-Crystal Display (LCD) screen to display the information that has been typed (see Figure 2.1). Once the interpreter has received a voice message from a speaking caller s/he then types the message on the TTY keyboard and it is transmitted in real time to a Deaf person on the other side of the line. A Deaf person then responds with text and the interpreter voices the message to a hearing person on the other side of the call.

UNIVERSITY of the
WESTERN CAPE

Text relay services have one major drawback: they are text-based and many Deaf people are functionally text illiterate and thus can not use such systems effectively [64] especially in South Africa [27]. TTYs do not use sign language and make use of a complicated user interface that is intimidating to anyone who has not used a personal computer before. Moreover the TTY interface was designed for text literate deaf and hard-of-hearing users. TTYs are popular in the United Kingdom, Germany and Australia because their governments subsidize such systems [48] in order to afford disabled people the same quality of life as everybody else. In most developing countries, much like South Africa the government does not subsidize TTY services thus making them unavailable [27]. In South Africa and many developing regions the Deaf literacy rates are very low thus rendering the service useless anyway.

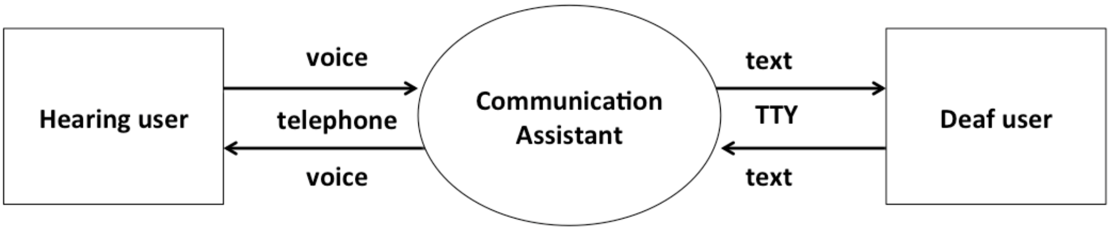

FIGURE 2.2: **A schematic showing text relay service.**
Showing text-based text relay service and how the information is exchanged between users. This demonstrates how a hearing user uses a telephone to communicate by voice, translated to text by the communication assistant to a Deaf person and vice-versa.

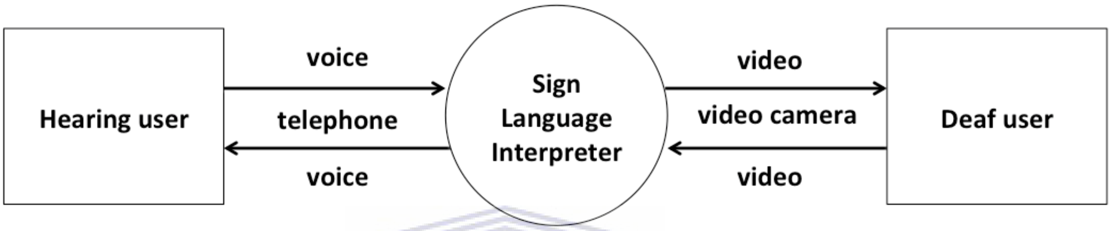

FIGURE 2.3: **A schematic showing video relay service.**
Showing how video relay service functions, and how users communicate through the help of the interpreter. Also showing how a Deaf caller needs more expensive equipment and high speed internet connection.

UNIVERSITY of the
WESTERN CAPE

A Video Relay Service (VRS) also known as a Video Interpreting Service (VIS) is a communication service that allows Deaf or hard-of-hearing individuals to exchange video or voice messages with someone not signing in real time via a sign language interpreter (see Figure 2.3). Deaf people naturally prefer this form of communication opposed to using TTY services [49] because it allows them to use sign language [27].

VRS works as follows; video equipment connects the VRS with a TRS operator called a communication assistant so that the VRS users can see and communicate with each other in a signed conversation. The VRS caller uses a television or a computer with a web-camera device and a broadband internet connection to contact a VRS communication assistant who is a qualified sign language interpreter. The two parties then communicate with each other in sign language using a video link. The VRS communication assistant relays the conversation using voice and sign language back and forth between the two users as shown in Figure 2.3. VRSs are popular among Deaf users because they don't have to type or read their conversation [49]. VRSs are favourable compared with TTYs, however they require a Deaf user to have a high definition camera in order to capture

FIGURE 2.4: **Sign language video transmission on MobileASL.** Showing a concept of how MobileASL sends sign language video over a cellphone network. It also shows the orientation of the sign language video communication (picture-in-picture and portrait orientation) on a commercially available cellphone. [from MobileASL: http://mobileasl.washington.edu]

all the signs clearly. Moreover the user has to have a high speed internet connection as mentioned above. Most homes in South Africa do not have internet and most Deaf people do not posses the means to acquire such expensive equipment to allow them to make use of this technology. The architecture of VRS is such that a Deaf person has to spend more money than the voice caller who only needs a standard home telephone. This is a major limitation when it comes to getting more Deaf people to use the system outside first world countries.

UNIVERSITY of the
WESTERN CAPE

2.1.2 Mobile sign language communication

An example: MobileASL

MobileASL is an ongoing video compression project that uses American Sign Language (ASL) as its medium of communication on a mobile device. MobileASL has been developed to enable Deaf people to use low to mid-range commercially available mobile devices to send sign language video over a mobile network (see Figure 2.4). The aim of MobileASL is to make video communication possible on a mobile device without the need for specialized equipment like a high-end video camera [8], but instead to use the equipment that comes standard with the phone. Video manipulation is performed on the sign language videos in order to make the video smaller, but intelligible, and to reduce the cost of sending a video over the network, *i.e.*, lower than conventional Multi-Media Services (MMS) charges.

As shown in Figure 2.4 MobileASL makes video a priority unlike cellphone service provides who prefer to give voice and text priority [10]. For example one can only record and send an MMS video of a fixed size (in South Africa the maximum is 300Kb) [40, 61] and the recipient can only receive the MMS video after it has been altered by the service provider at the nearest base-station. The service provider changes the frame rate and the bitrate which almost always results in a poorer video than the one initially sent by the user. The standardization of MMS taking place at base-stations makes the sign language videos unintelligible and thus unusable for sign language communication. MobileASL performs pre-processing of the videos while the video is still on the sender's mobile device [8]. This is done to minimize and prevent the processing that will take place at the base-station. The MobileASL team concentrated on three video properties as described below:

- **Bitrates:** Three different bit rates were chosen for research and testing, 15, 20 and 25 kilobits per second (kbps). These three bitrates were chosen in a attempt to accurately portray the United States mobile phone network scenario. Because of the visual nature of sign language, users preferred the highest bit rates and the optimal download rate for mobile service providers has been estimated at 30kbps and the upload at about 15kbps. It was decided to use use 25kbps regardless of the different frame-rates and region-of-interest (ROI) values of the video [8].

- **Frame rates:** Two different frame rates were tested, 10 and 15 frames per second (fps). To set a benchmark, at the beginning of the project interpreters were interviewed/consulted about what the fps should be and they all agreed that there is no significant difference between a sign language video recorded at 10fps compared with 15fps. They also found that the difference between a video recorded at 15fps and 30fps is negligible whereas at 5fps the signs become very difficult to watch and thus a low frame-rate renders the videos unusable for ASL [8].

- **Region of interest:** Three different ROI values, -0, -6, -12 where negative values represent reduced quantizer step sizes out of 52 possible sizes. The three regions of interest are the hands, face and upper body movements of the signer. They also consider non manual features, which are actions produced by any part of the body other than the hands and these would include actions of the eyes, mouth, cheeks, face, head, shoulders and torso [36]. The justification for choosing these

UNIVERSITY of the WESTERN CAPE

ROIs is that they are the most active regions for relaying information since signed languages use the signer's whole upper body and facial expressions to sign as opposed to just using their hands [8, 9]. A Deaf person using ASL or any signed language can make use of non manual signs to convey questions, negations, general responses or attitudes. The signer may use non manual question markers such as furrowed eye brows and hunched shoulders or raised eyebrows and open mouth to indicate a questioning attitude [36]. For this reason a clear sign language video is essential for acceptable communication. MobileASL enhances the quality of the sign language video on these regions and reduces the quality of the video on areas that are not of interest like the background. The result is a smaller video that can be transmitted over a cellphone network and also be considerably more intelligible for sign language compared with a standard MMS video message [13].

Since MobileASL uses commercially available mobile devices (like the one shown in Figure 2.4) the technology is readily available to Deaf people. Preliminary tests show that given the new video compression techniques it is possible to transmit intelligible sign language videos reliably over a cellphone network [8, 9, 13]. Deaf people have received MobileASL well and have shown an interest to use it in their daily lives for communicating with other Deaf people. One problem is the infrastructure that has not been set up by service providers to handle video requests better than is currently the case [8].

2.1.3 Automated translation attempts

Section 2.1.1 discussed how Deaf people use ICT to communicate with hearing people with the help of a mediator in the form of a sign language interpreter, by either using text through TTY or sign language video through VRS. Section 2.1.2 discussed attempts at sending sign language video over a cellphone network and what video attributes to consider in order to produce acceptable sign language video. This section presents a different method of translating sign language without the help of a human interpreter but by means of Artificial Intelligence (AI) techniques. An example, which describe these techniques is discussed below.

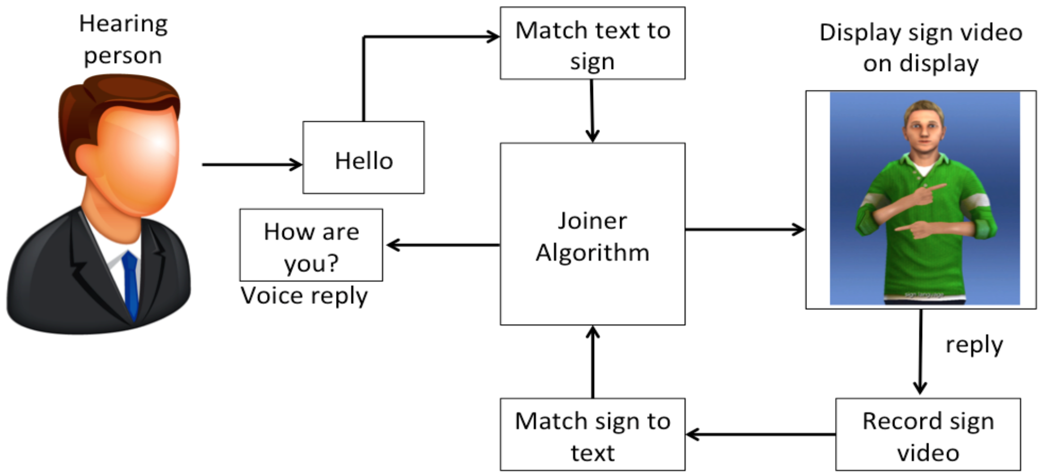

FIGURE 2.5: **Conversation flow on the ASRAR system.**
Showing how the exchange of information using text from a hearing user which is then converted to sign language which the Deaf user sees in the form a of a signing avatar on their phone or personal computer.

An example: ASRAR

Automatic Speech Recognition and Augmented Reality (ASRAR) is an automatic sign recognition and a translation system that uses a video camera to capture the image with signs [39]. ASRAR was developed to research ways in which Deaf or hard-of-hearing people can use their mobile phones to communicate with hearing people. A Deaf or hard-of-hearing person records themselves with a video camera on their mobile device and ASRAR detects the signs in the image. It then recognizes the signs and translates the results of the signs that have been recognized into a target language such as English or Arabic. ASRAR combines Augmented Reality (AR), Automatic Speech Recognition (ASR) and Text-to-Speech (TTS) to develop a system capable of sign language translation on a commercially available mobile device [39]. ASRAR works as follows; a hearing person records their voice and sends the recording to a Deaf person who will receive a sign language equivalent of the voice message.

Figure 2.5 shows that the system takes the narrator's speech and converts it to readable text and shows the text on AR displays. Since most Deaf people are functionally text illiterate [26] the translated speech from a hearing person appears on the monitor together with a human signing avatar. Once the user's speech is captured ASRAR uses the ASR engine that writes the text with translation instructions to a text file. Every time the hearing user voices a word the ASR engine captures the word which is then analyzed and processed. Theoretically ASRAR can store a complete sentence that the

UNIVERSITY of the WESTERN CAPE

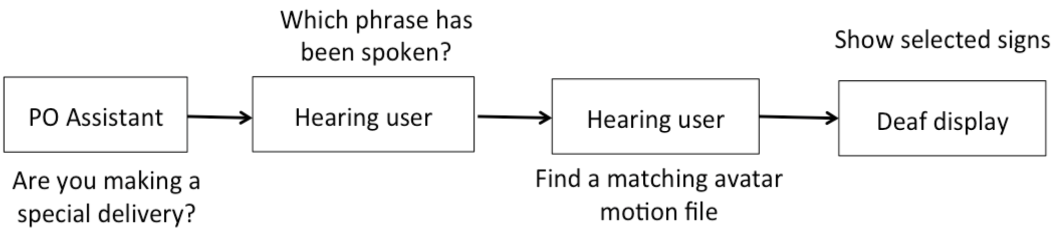

FIGURE 2.6: **Phrase conversion to BSL by TESSA.**
Showing how tokens are collected in a sequential manner to eliminate other choice possibilities until the final sentence has been formed and an avatar has been generated to ask a deaf customer a question.

narrator voices [39]. A Deaf person records and sends a sign language video in reply (see Figure 2.5) over a cellphone network with their mobile device and a hearing person receives the text equivalent of the signed message [39].

ASRAR gives Deaf and hard-of-hearing people an opportunity to independently control and manage conversations with hearing people without the help of a sign language interpreter. ASRAR can also run on a PC. The only extra hardware needed is a microphone, speakers and a display monitor. To get the video and the speech of the user the ASRAR system uses a built-in camera, microphone and display on the mobile device. Today's mobile devices have these features built into them, which makes this system even more accessible to Deaf users.

UNIVERSITY of the WESTERN CAPE

There are many different ways in which sign language can be captured and stored for the purpose of automation. Capturing systems can involve using a combination of headgear, gloves, and a body vest, which collect detailed information on the body movements and facial expressions associated with a sign. Most automated systems like TESSA and ASRAR achieve translation by using capture sensors which is a method of allowing a computer to track the movements a person makes and then, through software express it in a spoken and written language. The sensors are connected to the host computer through a serial cable and the computer using advanced motion capture algorithms to analyze the signers movements analyzes the signs. Some wearable clothing like gloves must be trained for each individual's hand much like voice recognition, although training is a quick process these gloves cannot as yet capture entire signs [58]. All these methods require very expensive equipment such as wearable clothing fitted with motion sensors and high definition cameras. The information/actions are then recorded onto a computer and represented as an avatar.

2.1.4 Assistive scenario-based ICTs

In sections 2.1.1 and 2.1.3 we discussed how ICT and automated translation methods are part of academic research in the Deaf community. Efforts have been dedicated to improving how Deaf people communicate with hearing people over large distances using technologies like MobileASL [9], TTYs and VRS. In this section we discuss the use of ICTs to aid communication between hearing and Deaf people on a face-to-face level. We discuss how ICT has been used to assist Deaf people at public places such as a government Post Office (PO). An example of such an assistive application is discussed in detail below.

An example: TExt and Sign Support Assistant (TESSA) is an example of an automated translation system that does sign language translation for a Deaf person at a PO to assist in the completion of posting mail [15, 21]. TESSA combines speech recognition technology and virtual human animation to enable a Deaf person to communicated with a post office assistant. The assistant speaks into the microphone which is then recognized by a computer speech recognition system (see Figure 2.6). The speech is converted to British Sign Language (BSL) and signed by a virtual human to relay the information in BSL to a Deaf person [15, 21]. Below the avatar is also English text that corresponds to the sign being displayed on the computer monitor facing a Deaf person. The movements of the avatar are first recorded from a human being with sensors at various points on his/her body in order to capture important movements (hands, face and upper body) [15]. The movements are then labeled and stored onto the system and used to animate the avatar when required. A human being is capable of making thousands of movements during signing. The sensors that are placed on the human are calibrated to capture and record only specific movements that the research team deems crucial. These captured movements form part of the most common phrases that a Deaf person uses to complete a transection at the PO. Figure 2.7 shows a scenario where a postage transection is performed with the help of TESSA.

TESSA was first developed to function as a closed/limited communication tool at the PO. Currently the TESSA system can recognize about 90% of the conversion/phrases that are needed by a Deaf person to complete the transection [15]. Although the system was designed for the PO, in theory it can easily be moved to a different context because of the ease with which lexicons can be produced. The problems Deaf people have with

UNIVERSITY of the
WESTERN CAPE

FIGURE 2.7: **TESSA at a post office with a deaf customer.**
Showing how a PO clerk and a Deaf person at the counter about to perform a transection. An avatar coordinated the interaction between the two users. [from TESSA/ViSiCAST: http://www.visicast.co.uk/news/Tessa.html]

automated systems like TESSA and ASRAR is that they are impersonal. During the TESSA trials Deaf participants raised concerns about the idea of having to communicate with a computer while they are standing next to a human being [15]. They fear that in the future they will be forced to interact with machines only and that hearing people will never be bothered to learn sign language.

UNIVERSITY of the
WESTERN CAPE

An example: In 1998 the South African cabinet approved the implementation of a pilot TISSA. TISSA was a telephone/video interpreting service [46]. The aim of TISSA was to provide a language solution where language is a possible communication barrier when providing government services. TISSA was a joint government project where different government sectors were called together to plan and design the entire project.

TISSA was first implemented at the South African Police Service (SAPS). Forty police stations were identified where the pilot TISSA was to be available. TISSA was also intended to be piloted at the Departments of Health, Land Affairs and Labour to assist in identifying a further 20 sites where TISSA could be implemented. Here is a scenario of how TISSA works. A member of the community visits a clinic or police station and finds that the service provider is unable to use sign language. The service provider video calls the interpreting service using a videophone. SASL relay communication was established using Integrated Service Digital Network (ISDN) [46]. The service provider, a police officer or a nurse, for example, will dial the TISSA call centre. The operator at the TISSA call centre will then connect the caller to a sign language interpreter, who will be able to speak and sign to the members of the community through a web camera. However, the TISSA call centre was not operational all day seven days a week. It was only operational five days a week, from Monday to Friday during office hours, from 8:00 AM to 4:00 PM, which could be an inconvenience should a member of the community require assistance outside those operation hours.

TISSA was conceptualized and planned as a people-centered project. It employed community-based methods to design a system that functions in a complicated domain. TISSA had a multidisciplinary team of expects looking at different aspects of the system [46]. TISSA showed great promise in trying to bridge the divide caused by language. However TISSA was unsuccessful in achieving many of its goals. TISSA with SASL was piloted in 2002, it was later relaunched without SASL interpretation [46]. Many believe that government bureaucracy and politics interfered with the project. Others speculate that TISSA tried to penetrate too many spheres of society too soon. At the time of implementation the technology available to carry a project of this magnitude did not really exist in the South African context [46].

UNIVERSITY of the

2.2 Verification for automated medical dispensing systems

Automatic Dispensing Systems (ADS) are medical storage devices that dispense medication electronically in a predictable fashion. They not only dispense but can track medication use in the hospital pharmacy. The principal advantage of such systems is that they can fill and dispense thousands of prescriptions in a single day and can therefore relieve pharmacists to consult with patients who need specialized care or detailed explanation of their medication.

2.2.1 Automatic Dispensing Systems

ADSs come in many different forms. Large ones are located at the hospital pharmacy and manage the whole storage and dispensing of medicines. Other types of ADSs are at the bedside of the patient and provide medicine periodically at the appropriate time. The popular ones can be found at nursing stations inside the hospital/clinic. Below is a description of the three most commonly used systems in America, the United Kingdom and Australia.

FIGURE 2.8: **McLanghlin dispensing machine.**
Showing a bedside dispensing machine that is loaded with medications that are prescribed for a patient, with an automatic reminder system.

- **The McLanghlin dispensing system** is a bedside dispensing machine the size of a small desktop computer and it uses two additional components (1) a programmable magnetic card and (2) a pharmacy computer. The McLanghlin system is a locked system that is loaded with medications that are prescribed for a patient (see Figure 2.8) [28]. When it is time for the patient to ingest their medication (known as dosing time), the automatic dispenser drawer unlocks to allow the patient to retrieve their medication. The McLanghlin system is unique because it has a reminder system that is visual and audio based. When it is time for the patient to take their medication a light placed above the patient's door that is connected to the dispenser illuminates and an alarm sounds off from the speakers in the room [3, 28]. Depending on the dosage time only certain medications are made available to the patient as each drawer contains different medicines that unlock only at the appropriate time. One major weakness of the McLanghlin system is that only certain types of medications can fit into the device's compartmentalized cabinets. However, these cabinets can easy hold dosage forms such as tablets, capsules, small pre-filled syringes and ophthalmic drops [28].

- **The Baxter dispensing system** is different from the one discussed above because it uses a microcomputer to pack unit-dose tablets and capsules for oral

FIGURE 2.9: **Baxter dispensing machine.**
Showing the Baxter dispensing system with its specialized calibrated canisters that are designed for each medication. The top right contains a unique dose type to reduce dosage errors. The most common source of dispensing errors are introduced by human intervension, when the hospital staff manually loads the medicines into the machine.

UNIVERSITY of the
WESTERN CAPE

administration as opposed to having the nurse/pharmacist pack patient medication like the McLanghlin system. Because this is a large system it is installed at the pharmacy and not in the patient's room. The Baxter system stores medicines in specialized calibrated canisters that are designed for each medication (see Figure 2.9) [34]. These canisters are given a number location which is a mechanism designed to reduce mix-up errors when dispensing. To retrieve medicine from the Baxter system a pharmacist or nurse sends an order to a computer at the pharmacy that is running the software to control the hardware. A tablet is dispensed from a specific canister and the medicine is ejected into a strip-packing device where it is labeled and sealed. The system reads instructions from a computer and hands out out medication [34]. The Baxter system takes no care to remind the patient that it is the appropriate time to ingest their medication. Instead this patient reads the packaging and will have to remind him/herself to take their medication.

- **The Pyxis Medstation** is another different example of an ADS (see Figure 2.10). These machines are often compared with Automatic Teller Machines (ATM) because of their accessibility to patients and hospital staff. They are usually kept

FIGURE 2.10: **Pyxis Medstation dispensing machine.**
Showing the Pyxis Medstation dispensing machine that is kept away from the pharmacy and closer to the nursing stations where they can be easily accessed by everyone. This is a self-service system, where patients use the system to dispense their own medication. This is an example of one of the most error prone dispensing machine types.

away from the pharmacy and closer to the nursing stations where they can be easily accessed by everyone. Although they are not kept at the pharmacy the Medstation still interfaces with the pharmacy computer [6]. Medstations accept orders from patients, nurses and pharmacists who carry a magnetic card that allows the transection to be made.

UNIVERSITY of the WESTERN CAPE

A user inserts a personalized magnetic card into the system just like they normally would at the ATM. A dispensing interface is displayed on the screen of the Pyxis Medstation. Once the user has entered the card into the system with the correct password, the patient profile is displayed and viewed for verifying orders. The system already knows which medicines should be dispensed and what doses are appropriate for a particular patient. The information about the patient is loaded onto the card by the doctor during consultation [6, 28]. One drawback of the system is that the station has to be filled with medication manually and frequently by the hospital technicians. The other is that patients complain about losing their magnetic cards because they do not visit the hospital often [28]. It was later suggested that the system be used only for patients who are being treated for chronic illnesses since these patients frequent the hospital facility for prescription refills [6].

2.2.2 Empirical evaluation of Automatic Dispensing Systems

ADSs are considered mission critical medical systems. This means they have to be tested for correctness to ensure patient safety is not compromised. ADSs generally store data like medical history, patient demographics, drug information and diagnostic tests all of which is important data that needs to be consistently correct when dispensing medicine. Therefore ADSs need to be tested to show that a given system works and has a low error rate compared with its human equivalent (pharmacist). When testing ADS the most prevalent method has been to concentrate on two conditions; (1) to determine the error rate during dispensing in a controlled setting and (2) to determine the main mechanisms for errors. A more detailed breakdown of the two focus points highlighted above is discussed in the sections that follow.

2.2.2.1 Dosage and unit verification

ADSs are loaded to capacity with medications in a controlled setting. Once the system is ready to dispense, researchers use the pharmacy computer to feed the ADS with a randomized list of prescriptions with different dose calculations (one tablet once a day or one capsule twice a day). The ADS then processes the instructions and at the correct time opens the drawer with the appropriate medication. However, not only is the type of medication checked, so is the dose. For example, two patients can be prescribed the same medication at different doses. Dose and unit verification includes the time at which the patient is presented with the medication if the system being tested is a bedside ADS like the McLanghlin system [6]. Testing ADSs is a long and time consuming process. Thus, for much larger systems like the Baxter system, tests are normally done in a semi-real environment like a hospital where the ADS is tested in short phases over a long period of time [3]. Since ADSs do not only dispense but also fill prescriptions, and label medicine containers, the most effective way to verify that indeed the correct processes are being followed and the system always produces the desired results is to observe and monitor ADSs over a period time..

UNIVERSITY of the WESTERN CAPE

2.2.2.2 Instruction verification

Instruction verification has to do with the directives a patient receives on how to use their medicine. ADSs print medicine instruction either on paper or on the medicine container. To verify that the correct recommendation/warnings have been provided, researchers select medication that has a specific/unique instruction to input the medication on to the system [3]. When the ADS dispenses that medication it also provides a printed instruction sheet that will be compared with the initial instruction sheet the experimenters had before the test was began [28]. Verifying that the ADS yields the correct information to the patient is essential in patient safety and system acceptability in hospitals.

2.2.2.3 Selection and input error verification

These are human errors and they are the most difficult to discover because they are hard to predict. The system is given information about a patient (patient background and patient history) that is correct during verification testing. The system uses patient medical history to check if the patient is being given the correct medicine that does not clash with their current treatment. To test for selection errors the system is deliberately given information that contradicts the patient data to imitate an input or selection error from the pharmacist [34, 51]. For example,cannot a patient with an allergy to penicillin will be prescribed penicillin and those instructions will be given to the ADS. If the ADS realizes that this patient can not be prescribed penicillin it rejects the input and asks the ADS operator to select an alternative medication. In this example, should the system show an interrupt then the system passes, otherwise it fails the verification test.

UNIVERSITY of the
WESTERN CAPE

2.2.2.4 Dispensing verification

A verification test for dispensing focuses on two variables; (1) dispensing medication to a patient at the wrong time and, (2) dispensing medication to a wrong patient. These errors are common for systems like the McLanghlin ADS [3]. Larger systems like the Baxter system are not tested for dispensing errors because they only dispense medicine from the pharmacy. The pharmacist is the operator who enters the instructions for dispensing instead of the patient doing it for themselves. In this scenario a pharmacist acts as a checkpoint for the patient and verifies that a prescription is valid [51]. The pharmacist is therefore able to resolve the error before it reaches the system. Thus for large ADSs operators (pharmacists) are intensively trained to detect dispensing errors.

Smaller ADSs are also susceptible to dispensing errors. Systems like the Pyxis Medstation and the McLanghlin have to be tested internally as opposed to training operators to handle the error before it happens. Since bedside ADSs are fully automated and left to run for long periods of time the nurses only replace the medication and let the ADS run until the patient is discharged from the hospital. Should the patient change rooms while at the hospital (as is common practice to move patients from room to room) the ADS will continue to run and dispense medication even when the patient is no longer in that room and could potentially dispense the wrong medication to a different patient. To verify that the correct medication is dispensed to the correct patient the system periodically asks the patient and the clinician to authenticate the patient with a password that is unique to the patient [28]. In the case of the Pyxis Medstation authentication/verification is done through the patients' magnetic card when they were admitted into the hospital [6]. Timing whether the patient is given the correct medication at the appropriate time is done in the lab through stress testing and round the clock observations.

UNIVERSITY of the
WESTERN CAPE

2.2.3 Lessons learnt from ADSs

ADSs are dispensing systems, much like SignSupport. They are systems that perform the work of pharmacists with non negotiable outcome of pharmaceutical instruction. The same with SignSupport, the instructions are finite and once they are set they cannot be explained differently for the patient because these are limited domain communication systems. Both systems require the doctor to have issued a prescription to the patient, that prescription forms the initial point of data input into the systems (for both ADSs and SignSupport). There are several differences between SignSupport and ADSs discussed in this thesis. For example, ADSs are automated and thus act as a form of self-service system were the patient does not need a pharmacist. SignSupport relies heavily on the pharmacist being present during the dispensing process and being in charge of the process. Although with SignSupport the communication with Deaf patients is passive, the pharmacist is integral to SignSupport since a pharmacist has to collect and package the medicines while ADSs have an automated packaging system. One fundamental difference is that ADSs are not personal machines that a patient can take home (except if the patient is extremely rich). They are big and expensive and can be found in hospitals only (currently no ADSs are installed in clinics). Perhaps the most important difference between SignSupport and ADSs is that ADSs only communicate via printed text. This is a problem when it comes to dispensing medicine to text illiterate patients. It was important to study ADSs because they possess some attributes that are important for understanding how to structure pharmaceutical instructions. There are some classifications that need to be considered when structuring the pharmaceutical instructions and forming sentences. For example:

- **Dosage and unit errors** refer to the correctness of a dose that a patient can have for a specific medicine (see Section 2.2.2.1). In SignSupport there is a separate screen activity with evenly spaced, pre-programmed doses so as to minimize mistakes that normally happen when dealing with a 9-digit number pad.
- **Instruction errors** (see Section 2.2.2.2) are important in making sure that the patient is given the correct information about the medication they are taking (see Section 3.3.1.2). A review screen is put in place at the end of every item dispensed using SignSupport (see Section 4.1.8.4 and Table 4.2).
- **Selection and input errors** (see Section 2.2.2.3) are the errors that a pharmacist can make while entering the information on the system. These are human errors due to fatigue or lack of concentration. There is very little we can do about these but it helps knowing that they exist. In SignSupport we remedy this problem by providing a review screen that gives the pharmacist a second chance to see the selections that have been made and the opportunity to change them if they are not satisfied.
- **Dispensing errors** (see Section 2.2.2.4) occur when there is a switch in the ordering of patients and you have one patient receiving medicine that was intended for another patient. In SignSupport we combat this issue with a section of the dispensing that requires a Deaf patient to show proof of identity.

UNIVERSITY of the
WESTERN CAPE

The four factors raised above are problems that are faced by ADSs that SignSupport also had to deal with if it were to be a success. We learned the limitations of ADS and addressed them within SignSupport.

2.3 Summary

We discussed how ICT has been used to provide communication between hearing and Deaf people. We explained how Deaf people can use TTYs and VRSs to communicate with hearing people over large distances with the help of an interpreter. We also showed the limitations of these systems. TTYs favour text literate Deaf people and VISs require expensive equipment like web camera and high speed internet connection (see Table 2.1).

TABLE 2.1: **How SignSupport compares with other ICTs for Deaf people.** Showing that SignSupport has a combination of attributes that make it unique. Other ICTs for Deaf people require an external connection of some sort (internet or human input) in order to fully serve their function. This is a major limitation when dealing with developing regions where users do not have the money to spend on internet services.

	SL video	Text	Avatars	cellphone	PC	Internet
SignSupport	✓	✓		✓		
TTY		✓				✓
VRS/VIS	✓				✓	✓
MobileASL	✓			✓		✓
ASRAR		✓	✓	✓	✓	✓
TESSA		✓	✓		✓	
TISSA	✓				✓	✓

UNIVERSITY of the
WESTERN CAPE

From Table 2.1 we see a number of ICT products geared towards Deaf people compared with SignSupport. Table 2.1 shows that MobileASL and ASRAR are similar to SignSupport because they both work on commercially available cellphones. However, unlike ASRAR and TESSA, SignSupport does not use automatic sign language translation because it does not offer enough accuracy [25] to be used for mission critical environments like in healthcare. SignSupport gives priority to sign language videos the same way MobileASL does, but SignSupport's videos are all stored on the phone's memory card while MobileASL's videos are sent over the network. Most of the ICTs for Deaf people discussed in this thesis and in the 'real world' require an internet connection (see Table 2.1) to be fully functional. That is not true for SignSupport as it is completely self contained.

Table 2.2: **How SignSupport compares with other medical systems.** Showing the attributes that SignSupport has in common with different types of ADSs. All ADSs are tied to a PC and others need internet connection in order to update medical supplies. This also shows that all ADSs use text only to register/communicate information, a format that is not suitable for Deaf people who are mostly text and computer illiterate in developing regions like South Africa.

	Video	Text	cellphone	PC	Internet
SignSupport	✓	✓	✓		
Bedside ADSs (McLanglin)		✓		✓	
Pharmacy ADSs (Baxter)		✓		✓	✓
Open access ADSs (Pyxis)		✓		✓	✓

According to the classification standards set by the European Health Commission (EHC) our system is medical software [23]. Similar to ADSs, our system is a dispensing software and holds important patient information that needs to be correct at all times. To protect patient information our system uses a four-digit PIN while the McLanghlin and the Pyxis Medstation systems use programmable magnetic cards and passwords respectively. To remind the patient that it is the appropriate time to ingest their medication our system uses vibrating reminders on the mobile device while systems like the McLanghlin ADS use sound and visual alarms [28]. To communicate pharmaceutical instruction pharmacists input information/instructions in English text and our system finds the appropriate sign language video [28, 42]. VRSs discussed in this thesis and many others not discussed herein use text to communicate pharmaceutical instructions (see Table 2.2). This discriminates against people who are text illiterate in the same way ADSs and voice relay services do to Deaf people. Unlike ADSs, our system is not restricted to its location because it runs on a cellphone, patients can use our system anywhere, making it accessible and convenient. Chapter 3 discusses the methods used to design, develop and implement a system called SignSupport that acts as an interpreter between a pharmacist and a Deaf patient.

UNIVERSITY of the
WESTERN CAPE

Chapter 3

Methodology

In this chapter we discuss strategies that we used to design, develop and verify a system we call SignSupport. Section 3.1 introduces research questions. Section 3.2 explains the methods we used in answering the research questions. We discuss community-based co-design, a method used to involve research participants in the process of design. We also introduce a multidisciplinary team of experts and their roles in developing SignSupport. We discuss the software engineering process that was used. Section 3.3 explains how to apply these methods to address the usability and content verification of the system. Section 3.4 shows both the frontend and backend evolution of SignSupport and how it has evolved through iterations. Section 3.5 portrays ethical considerations and how participants were included in the study. Section 3.6 summarizes the chapter.

UNIVERSITY of the
WESTERN CAPE

3.1 Research questions

The research question for this project is as follows: How do we design, develop and implement a communication tool with two different interfaces on a mobile device to seamlessly facilitate the transaction of medicine dispensing at a hospital pharmacy between a Deaf person and a hearing pharmacist while ensuring that the information sharing between the two is accurate? This can be broken into two parts:

1. how to improve the user interface so that it helps a Deaf person understand pharmaceutical instructions from a pharmacist who cannot use sign language?

2. how to ensure content verification such that English text instructions match the sign language videos in the system and that the information exchange between the two users is always correct?

The first part of the research question investigates how to design a mobile tool interface that will function in a limited communication domain. Looijesteijn [37], Mutemwa [44] and Chininthorn's [12] results serve as a foundation of our user requirements. The need for a specialized and user-relevant interface is important in the success and adoption of any system. For this reason our research group has been working with Deaf users on UIs for many years (see Figure 1.1). The implementation of SignSupport is a direct result of Chininthorn's design. SignSupport's User Interface (UI) been has optimized to work in a limited domain with two users who can not directly communicate with each other. The way in which we optimize the UI is by working with DCCT members to design the elements that will form SignSupport's UI, including elements like icon size, shape and colour, video size (length x width) and haptic (vibration, since this is a phone, haptic means relating to touch) feedback mechanisms.

This implementation of SignSupport is for the pharmacy context. Following TESSA's methodology and modifying it to fit our research needs, we studied the conversations that take place between a hearing patient and a pharmacist. We used a record-book to capture the interaction between a patient and a pharmacist. After the trial was completed we searched through the record-book and searched for critical phrases. We designed a qualifying rule for choosing those phrases. They must have two attributes: 1) a phrase must be common and repeatable, and 2) the phrase must be unambiguous. To retrieve these phrases we conducted interviews and performed roleplay scenarios with senior pharmacy students from UWC and a simulated hearing[1] patient. We asked them to provide information that a pharmacist would typically require or explain during medicine dispensing and we loaded this information onto the system. SignSupport has two different interfaces for the two users who have different needs and education levels [12, 44]. A major requirement of the system is that all the data be stored on the device's memory card. This is because we wanted to reduce network costs and create a system that is self-contained with SASL videos that are as intelligible as possible.

UNIVERSITY *of the* WESTERN CAPE

[1] A hearing patient was used because they could interact with the pharmacists in a way that probes the pharmacist to reveal more about dispensing protocol. A roleplay with Deaf people was later conducted in order to find out where they struggle during medicine dispensing.

The second part of the research question has to do with content correctness and how we verified that SignSupport provides the user with the correct information at all times. Verification of the system was done using SignSupport as a tool and an interpreter in the presence of a pharmacist at DCCT. A set of rules mimicking the natural actions of both users were followed to test the application (see Figure 3.8). We described a scenario which users would normally follow when using SignSupport and had the interpreter explain the SASL videos that were shown on the device's display. SignSupport was used to show that when a pharmacist enters information in English text, a Deaf patient will get the correct corresponding sign language video and vice-versa. We repeat this process on every screen activity, one at a time until we have checked and interpreted every video on the system. Correctness is also concerned with making sure that known dispensing errors are reduced and/or possibly removed [3, 6, 28, 34, 51].

We tested four types of dispensing errors 1) Dose instructions 2) Lecture errors 3) Selection errors and 4) Repetition error (wrong time and wrong patient) as explained in Section 2.2.2 for medical dispensing systems. Pharmacists drafted random prescriptions (39 in total) with simple but unique pharmaceutical instructions that were entered onto SignSupport. At the end of each entry SignSupport showed a script summary that confirmed that information entered was indeed captured by the system correctly. In this way we could verify that the system performs two important functions without fault: 1) SASL videos and English text translation is correct and users relay the information that they intend to share, and 2) the system provides accurate pharmaceutical information to a patient.

UNIVERSITY of the WESTERN CAPE

3.2 Methods

This section discusses the methods that were used to answer the research questions raised in Section 3.1. Section 3.2.1 discusses a method to involve the target community in the design of a solution that benefits them. Section 3.2.2 presents the multidisciplinary research team who was involved in the research process. Section 3.2.3 discusses the iterative design and development used to produce a solution that users conceptualized.

3.2.1 Community-based co-design

The method of community-based co-design was chosen because we were dealing with an already existing community (DCCT) with complex needs which needed a different view-point of design that the research team alone could not fully comprehend. Community-based co-design is a strategy that explores various solution configurations in a multidimensional design environment [4]. The community (in our case DCCT) and the technical/design team work together to produce a system that benefits the community and is in line with their needs. When using Co-design methods, we take the 'back-seat' in the design and development cycle. Priority was always given to the target group. We only monitored the design space and made informed judgement calls on what is possible and what is not. When designing a complex system like SignSupport (complicated because of the users' special needs) in an equally complicated design space (see Table 3.1) we were careful not to impose our own design preferences on the system but rather let the view-points of the community take the lead. Community-based co-design also enhanced the number of potential solutions that the system could take [4, 12, 37, 44].

FIGURE 3.1: **A focus group interaction with Deaf participants.** Showing a design focus group interaction with Deaf participants about to draw/design their version of the UI. After a focus group discussion about what Deaf people need in an application, 9 DCCT staff members were asked to draw on a sheet of paper their ideal version of a mobile application. They were not given any restrictions and encouraged to draw/express whatever interface they wanted. This is the first time participants requested the new pharmacy context UI of SignSupport.

We understood that our research participants had a set of challenges that could inherently discourage them from using the system. Such challenges can only be observed

TABLE 3.1: **Challenges from Deaf and pharmacy participants.**
Showing how these two different communities are confronted by completely different challenges. We define our research as a complex design space because of the challenges faced by users of SignSupport. The participants exhibited vastly different social and economic backgrounds. The participants even use a different language to communicate, and SignSupport had to overcome these challenges.

Participant communities	Challenges
Deaf community	a) Many literate in sign language. b) Many Deaf people are either text or computer illiterate. c) Many use applications made for text literate users. d) Facing high unemployment rates in developing regions.
Pharmacists	a) Resistant to change using legacy systems. b) Limited experience dealing with Deaf people. c) Educated (comfortable with ICT). d) Overcrowding at public hospitals.

over time. The success of community-based co-design lies in the long term relationship between the community and the researchers [4]. Given enough time with a community of interest the researcher can be in a position to uncover more of these challenges and design a system that adequately solves most of the challenges. The SignSupport design team has been involved with DCCT for well over a decade and has developed many different systems for the community, some successful and other not. Building these relationships between researchers and the community made it possible to elicit meaningful information (see Figures 3.1 and 3.2) that contributed directly and indirectly towards a solution that users expect. An open and constant line of communication between the research team and the community was essential in the process of co-design [4].

The BANG research group has had a long and fruitful relationship with DCCT, and hundreds of formal and informal interviews, focus group sessions and questionnaires have been collected. Also hundreds of hours of video footage have been collected to fully build an understanding of the community. Co-design emphasizes the process of collecting data from the community [4], and naturally co-design follows an incremental process as one design outcome in a specific design space becomes the initial point for another design process. In co-design the researcher looks at the entire picture and implements a solution that seamlessly integrates with the behaviour of the environment. While co-designing SignSupport, delivering a solution that simply translates pharmaceutical instructions in SASL was not sufficient to satisfy user needs. We use information about the community that was acquired in the past iterations of design/development. Simply designing and

UNIVERSITY of the
WESTERN CAPE

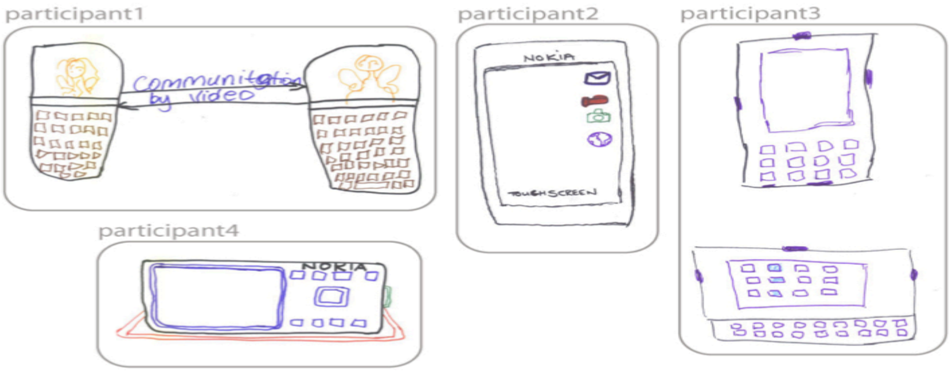

FIGURE 3.2: **Initial designs from Deaf users.**
Showing some of the user interface design drawings from Deaf participants. These drawings form part of the initial user requirements. The four designs that are shown in this photograph represent a common theme among other participant drawings. The drawings were made at the start of the study.

handing over a solution that was developed in isolation has proved to be unsuccessful for many research projects, especially for communities in developing regions [30].

The World Bank infoDEV site lists hundreds of ICT projects that have been unsuccessful [30]. This is because large cultural differences between the designers and the target community. Many Information Technology (IT) solutions from the developed world fail in developing regions [33]. This is because the needs of the targeted communities are vastly different from those in developed regions. This means that even the same systems/tools used for communication have to be designed differently. For example people in developed regions are mostly text literate [26], thus ICT solutions for those communities are text based. However in developing regions the use of text is insufficient because most people do not have basic education that would allow them to be able to read. In the case of DCCT, a special needs group that prefers to communicate in SASL, the problem of ICT's not representing user needs is exaggerated. Since the needs and conditions of users in developing regions have not been extensively explored for the purpose of technology [30, 50], community-based co-design introduced our research team to the realities of life for DCCT members. Human-centered iterative design methods emanating from co-design methods expose an underlying theme that came out of the interaction between the research group and the community. While designing SignSupport we had to constantly engage with DCCT members for new relevant information in order to uncover social structures that are embedded in the Deaf community. During the requirements gathering process DCCT members contributed cultural information that was relevant

UNIVERSITY of the WESTERN CAPE

to the design needs and practices of the community. Social structures are important to the acceptance and adaptation of SignSupport. Community-based co-design was a key to unlocking the complex needs (see Table 3.1) of Deaf users in general.

SignSupport uses formative designs and evaluation in Human-Computer Interaction (HCI) [35, 50]. We identified a stage in the design process where we understand the task as clear as the users. Through Iterative and incremental research done by BANG with DCCT we believe we had successfully captured the needs and practices of Deaf patients and pharmacists users through processes like interviews, questionnaires and focus groups. At that stage we introduced users to the prototype and encouraged them to comment on what they like and what they thought was not needed. The nature of co-design is such that no design output can be labeled as final, only as the current iteration. According to Ramachandran *et al.*, there are five parameters to consider when using co-design in developing regions [50]. Below is a description of those parameters and how they relate to SignSupport.

UNIVERSITY of the
WESTERN CAPE

1. **Understanding the users technology base-line and expectations:** Deaf people use applications on their phones that were meant for text literate people. They use these to chat with each other and with hearing people even if it's with 'broken English'. However they will not use applications developed for Deaf people consistently if the SASL video on that application are not clear enough.

2. **Design tasks to elicit response from users:** In the design of this version of SignSupport we collected data using different methods that have been discussed in the text above [12].

3. **Open the study as a community event:** SignSupport was always DCCT's project and any member of DCCT who wanted to join the study was welcome. SignSupport used a member of DCCT to sign the videos [42], but treats all user participants as experts during design. We did this because we wanted to provide users with familiarity and give them an impression that SignSupport is theirs.

4. **Understanding the efforts of peer learning:** Since most members of DCCT are text illiterate and others are semi-computer literate [42], during the training and trial of SignSupport none of the participants were isolated. They were encouraged to work together and help each other and explain to each other the sections

of SignSupport that were not immediately obvious. Peer learning occurred during training where each participant used their own device. During the activity we noticed that participants were more comfortable asking for help from their neighbours . For example, one participant could not get past entering her name on the system because her finger nails were too long so the touch-screen could not register her input/touches. She immediately asked for help from her neighbor who quickly figured the problem. There are two things to learn from this simple behaviour . The first is that this user is not used to working on a touch screen device (because on a hard keyboard she can press the buttons with her finger nails), and the second is that participants made themselves available to their fellow neighbours when they were needed to help, learn from or teach each other.

5. **Observe social and cultural behaviour :** SignSupport is a multidisciplinary research project (see Section 3.2.2). Throughout the design of this and the previous versions of SignSupport we always had a member of the team who was a link between DCCT and the technical team. This member was always observing and learning new facts about DCCT members and reporting back to the team any information that contributed to the development of SignSupport [42]. She campaigned for system personalization adding the patient's name and profile picture. However some members of the design team did not agree with this at the time, arguing that personalization could make the system less stable as users could upload a large profile picture that could crash the system. In the end personalizing the system proved very useful for users because it gave them a sense of ownership. Once users could see their names and picture on the system, they believed that the information contained inside SignSupport was truly theirs.

UNIVERSITY of the WESTERN CAPE

3.2.2 Multidisciplinary collaboration

This version of SignSupport is a result of a multidisciplinary effort led by this author. This section introduces the design team and their roles in facilitating the design process. The design team is composed of five types of members, each with a unique set of skills, training and background. Members of the design team were strategically selected for their particular skills [29] based on the tasks needed to be completed for this study. Managing five individuals from different fields of expertise was always a challenge and

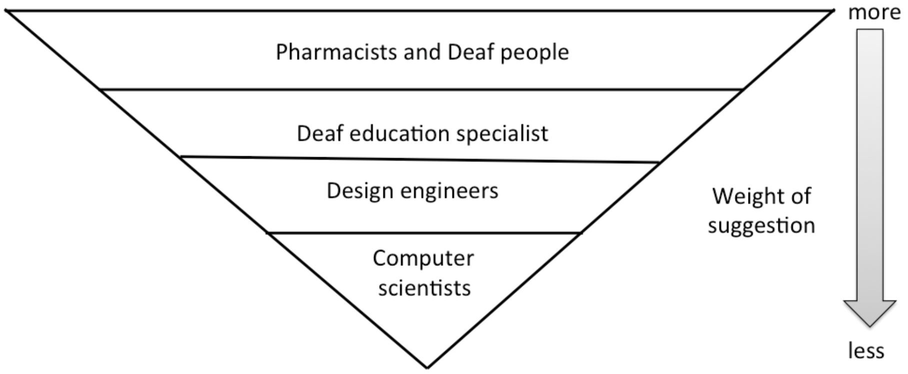

FIGURE 3.3: **Research priority structure on decision making.**
Showing an inverted priority pyramid structure that governed who makes the most critical decisions about how the system looks or which direction the research takes. At the top are the two users of the system who are also part of the technical team as per community-based co-design. At the bottom of the pyramid are the computer scientists who developed, implemented and evaluated the system and its iterations.

every member of the team fulfilled a specific role. Since two types of the members of the team also form part of the research target group we use co-design methods to manage their input and expectations. In our meetings Deaf representatives and pharmacy representatives have the most say into what 'goes' and what must be excluded (see Figure 3.3). To manage our team we developed a priority pyramid as seen in Figure 3.3 which dictates whose contributions weigh more. Without such a system in place, the team could have easily lost focus and drifted from our primary objective. SignSupport is a large system that touches many different areas of life. Thus having a team that represented that widest world-view was not only beneficial but crucial for the success of the system [35]. The best way to achieve the widest world view was to involve all participants through community-based co-design. All team members were involved from the start to the last iteration of design. Any and all changes to SignSupport had to be approved by all members of the team. For example, a change in how a Deaf user enters information on the system could effect the order in which the information is presented to the pharmacist. To efficiently communicate suggestions and changes that have been included or need to be included, the research team held frequent meetings at UWC. Below is an explanation of the members' roles in the research;

UNIVERSITY of the
WESTERN CAPE

1. Deaf participants were in many ways the drivers of the project, they did not just form part of the technical team. They were also primary users of the system. They decide what the project is and how they would like to use it, and most

of the user requirements emanate from them (see Table 3.2). Integrating Deaf user perspectives increases the chance of developing a successful and accepted system. Video quality, simplified login, icon appearance and meaning came from Deaf participants. They also suggested we include medicine reminders which was an important addition to the system as studies show that using care reminders is preferable to using medicine labels and patient memory [1]. Figures 3.1 and 3.2 show how Deaf people were involved in the decision making process and in the designing of the UI respectively.

2. Pharmacists played a critical role in the protocol design aspect of the system, as they are responsible for using the application to input appropriate medication instruction. Pharmacists are active and critical users of the system. Their input brought to bear a number of important pharmacy-oriented directives. Pharmacists were instrumental in designing the application such that it follows a known and standardized logic in the dispensing sequence (see Table 3.2). As healthcare professionals, pharmacists are trained to adhere to strict ethical standards at all times when interacting with patients [56, 63]. Thus we must ensure correctness of the medication usage and description information displayed in the UI (see Section 3.3.2). The system provides an autonomous means for a Deaf user to acquire medicine instruction, given proper input from a pharmacist. The application had to address the following elements: diseases, dosage forms, medicines, instructions, warnings, recommendations and critical pharmaceutical communication [56]. SignSupport is programmed on a limited data capacity medium. Pharmacists were not able to input every possible instruction or pharmaceutical interaction which could possibly occur in a hospital pharmacy setting. Pharmacists were relied upon to arbitrate which were the most critical and common, while still acting within what is absolutely necessary. Training pharmacy end-users was conducted by a pharmacist due to the occurrence of profession-specific terms and concepts.

UNIVERSITY of the WESTERN CAPE

3. Industrial design engineers were responsible for determining the appropriate conceptual model of the system (see Table 3.2). This involved both Deaf and pharmacy participants, and acquiring requirements by means of roleplay, questionnaires and focus groups (see Figure 3.4). They presented this information in the form of a design/sketch on paper that best represented the expectations of both users. They designed the system's UI (see Figure 3.13) based on interactions with end users

over several versions starting from the initial mock-up [37], its implementation for medical diagnosis [44] then to the first pharmacy design [12, 42].

4. We had a language specialist who was a link between the technical team members and the Deaf community members; a bridge between the technical team and Deaf users of ICT. This specialist helped customize the interface (by suggesting system personalization) and logic of the system to seamlessly fit Deaf users' expectations. She also helped analyze the sentences extracted from the roleplay between Deaf patients and pharmacists, and structured the sentences to make sense in SASL (see Table 3.2).

5. Computer scientists were responsible for investigating the intended communication domain and coding the solution that fits that environment. We also had to study how Deaf people use their mobile devices and what type of devices they use and what for. To truly understand Deaf users we visited DCCT at least once a week for a period 20 months. At times the visits to DCCT had nothing to do with SignSupport but were important for learning the culture and lifestyle of the community members. Apart from building trust and a strong relationship with the community we acquired useful information that we could otherwise have missed during formal interactions with DCCT members. We conducted training and trial sessions for both Deaf and pharmacy participants (see Table 3.2). After design engineers presented their depiction of the SignSupport's interface to the technical team, we evaluated their design and decided what was programmatically possible to achieve and what was not achievable either because of time, technology or man-power. Since SignSupport is communication software between users who use different communication mediums (SASL and English text), we had to organize the UI in a manner that does not impede the functionality and usability of the other user.

UNIVERSITY of the WESTERN CAPE

3.2.3 Agile software engineering

This section discusses how SignSupport was iteratively designed. We show how the end of every process is the beginning of another. The development software engineering principle used for designing SignSupport is called Agile software engineering [35]. Agile

TABLE 3.2: **The design team's expertise.**
Showing a summary of contributions of each member during this iteration of the research. This is the first iteration of SignSupport that involved all all the stakeholders.

Multidisciplinary team	Function description
1) Deaf community	a) Project leaders and primary users of the system. b) Provided user requirements. c) Provided initial user interface designs.
2) Phamacists	a) Incorporated the pharmacists code of practice. b) Provided user requirements. c) Secondary users of the system. d) They decide what is important to include in the pharmacy side.
3) Design engineers	a) Change the design context from doctor to pharmacy. b) Conducted roleplay sessions with pharmacists. c) Designed the initial user interface.
4) Language Specialist	a) Link between Deaf users and design team. b) Verified the conversation script. c) Recorded SASL videos. d) Introduced system personalization.
5) Computer scientists	a) Conducted initial roleplay and data gathering. b) Recored SASL videos c) Designed the conversation script. d) Programmed the application. e) Conducted training and trials.

UNIVERSITY of the
WESTERN CAPE

methods follow the idea of Iterative and Incremental Development (IID). The reason for choosing Agile methods is that they emphasize communication and encourage early and frequent feedback from the research target group. In Agile methods, any opportunity to interact with the users on a continuous level is heavily encouraged. This is in line with community-based co-design discussed in Section 3.2.1. SignSupport is a community inspired project with a multidisciplinary team of expects. With Agile development, iteration is important because it is not possible to gather and include all the requirements of a complex system like SignSupport upfront [35]. For example, many details emerge in subsequent iterations of development. Thus, implementing agile methods allowed us to add and remove functionality without anyone getting invested in any possible solution. Many of the models in software engineering are rigid and once implemented very difficult to change later [32, 47]. This limitation was not acceptable for SignSupport. During the design of SignSupport we organized programming tasks in short iterations called sprints (see Section 3.4 for more details) [42]. Each sprint starts with a meeting where team members decide the functionality to be designed or coded. Most occurrences of sprints in SignSupport were in the Deaf patient and pharmacist UI, e.g. the placement, size and meaning of icons were constantly altered to best represent their functionality in the system. Agile sprints do not represent the final version of a UI. They only form a picture for non-computer science members of the team to evaluate their suggestions and test the usefulness of newly introduced changes.

The most important process for realizing SignSupport was the continuous search for user requirements and the refinement of the UI. Iterative user requirements gathering process is important for delivering a software product that users expect at the end of the development cycle [41, 47]. Apart from the requirements that were gathered during the course of this research, BANG has been collecting data from DCCT users for over 10 years. These requirements factor directly and/or indirectly into the current version of SignSupport. Many research projects struggle to gather, document and manage user requirements from their target users [7]. This is not the case with our research as can be seen on Figure 1.1. Every recent project between BANG and DCCT has been incremental and led to this version of SignSupport.

Requirements gathering continuity ensures that the design and development of common attributes that appear in all the different systems (see Figure 1.1) are kept up to date and refined to cater for the specific needs of the target group (DCCT and Deaf people in general) as the group evolves and gets more familiar with ICT. One attribute that benefited from this agile iterative modeling of requirements gathering was the UI. Some research in our group had been concentrating on eliciting usability requirements from users, thus opening our knowledge and expanding our experience in delivering a unique and relevant UI for mobile communication for Deaf people.

Agile methods allowed us to continue to integrate new functionalities suggested by the community (pharmacists and Deaf users) and the multidisciplinary team to SignSupport. For instance we can now add old requirements that users wanted years ago but were impossible to implement because of technology constraints, for example, a larger display to show SASL videos. Our method lets us inherit requirements that were not met in previous versions of SignSupport. An example is; Deaf users wanted to use their mobile devices to communicate in SASL with a clear intelligible sign language video. They also wanted an application that will help to remind them when it is time to take their medicine. SignSupport inherited those UI requirements and implemented them in this iteration. SignSupport is more capable of delivering legacy requirements than any of

UNIVERSITY of the WESTERN CAPE

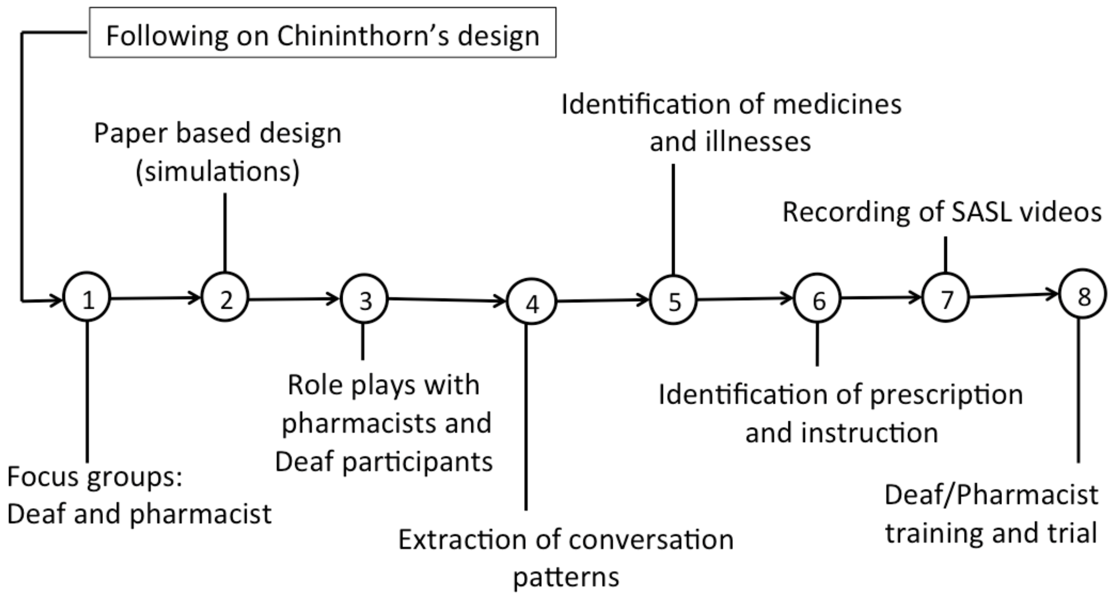

FIGURE 3.4: **Events taken to design and develop SignSupport.** Showing how requirements were gathered from one event leading to another. Each event with end users also acted as a feedback session showing participants how their prior input was factored into the process.

UNIVERSITY of the WESTERN CAPE

its predecessors. Legacy UIs (see Figure 3.10) are the foundation of the design phase of SignSupport. During analysis of those requirements new ones arose and below we discuss the process of gathering specific requirements that are unique to this version of SignSupport. We devised a set of eight events to design SignSupport. Figure 3.4 shows the series of events of how we went about collecting data, conducting training and testing experiments.

Step 1 comprised focus group interviews with pharmacists and Deaf people. From these discussions, the challenges of dispensing medicines to patients with whom they could not communicate, particularly Deaf patients, emerged because pharmacists use spoken language which Deaf patients are unable to understand. Pharmacists expressed that these interactions were often very difficult, leaving the pharmacist unsure if the Deaf patient had actually understood their illness and how to use their medicines.

Step 2 was a paper prototype (see Figure 3.2), as a result of Step 1. This prototype exposed basic user expectations for both target users.

Step 3 comprised roleplay to establish user perspectives for both Deaf participants and pharmacists, respectively and independently. Since the system is intended for pharmacist-patient interaction, it was necessary to mimic a typical routine interaction between a pharmacist and a patient in a hospital dispensary setting. This was done by studying the patient interaction taught to pharmacy students in South Africa, based on the School of Pharmacy's Objective Structured Dispensing Examination (OSDE) sheet, a tool used in assessing students on patient counseling. The OSDE was modified to suit this study, and contained the following elements: Greeting and Patient identification; General history taking; Clinical history taking; Information and instructions to the patient; Patient questions and Closing [43].

Step 4 was an exercise of conversation mapping; video footage of the interaction between the two parties during the roleplay (Steps 2 and 3) was studied. Pharmacies were visited to observe pharmacists interacting with patients in a real-world setting. Mannerisms and behaviors of the two users were observed for the entire interaction between the two, i.e. from the point of the pharmacist's first gesture/word to the patient, through to the closure of the conversation. We studied what the pharmacist said to the patient, how it was said, and at which stage of the interaction it was said. We successfully elicited the common dialogues which occur between pharmacists and hearing patients at public hospitals. The communication flow at the pharmacy was limited in a similar fashion as TESSA, which covered about 90% of the communication at the post office [15].

UNIVERSITY of the
WESTERN CAPE

Step 5 (disease/medicine selection); pharmacists were asked to help identify one hundred of the most common illnesses they thought were important to include in the prototype. Designations of 57 illnesses (see Appendix F; in reality a device with 8 Gigabytes (GB) storage card can hold thousands and thousands of illnesses) were recorded in SASL and stored onto the phone's memory card. Medicine names had to include every possible prescribed medicine for these illnesses. We pulled a list of all legal medicines prescribed at public pharmacies and loaded them into SignSupport. The pharmacy collaborators on this project compiled this medicine database.

Step 6 (identification of prescriptions and instructions); in order for the system to be formatted to be a virtual prescription, we studied real-world patient prescriptions scripted by doctors and mirrored much of the prescription layout and content, and optimized it to fit on a mobile device. The prescription text, instructions on the prescription and the sequence in which these instructions occur were reviewed and incorporated onto the system. This was done to ensure that when the pharmacist dispenses, s/he follows an already familiar natural flow. Note that while the system can act as a virtual prescription, it is not intended to replace the doctor or pharmacist.

Step 7 (SASL video recording); we recorded a finite set of sign language videos to represent the possibilities of diseases, medicines and instructions determined in Steps 5 and 6 (see Figure 3.15) [43]. A conversation script (see Appendix I) was created and used to guide the recording of the sign language videos. An interpreter translated each message together with an informed Deaf staff member of DCCT.

Step 8 (training and trial); Deaf and pharmacist participants underwent training, in two separate groups of 8, on how to use SignSupport. Each session lasted three hours and included a projected presentation followed by hands-on practice with the system running on 8 phones. Participants were encouraged to "play" with the application and provide feedback after their hands-on usage. Each training session was video recorded. Subsequently, both groups then participated simultaneously in a test trial at a mock hospital pharmacy at the UWC campus. Pharmacists had to dispense medicines as per actual prescriptions to Deaf patients at the simulated dispensary. Great care was taken to mimic, as far as possible, the scenario that would occur when a Deaf patient collects medicines at a hospital pharmacy, including not being able to hear their name being called when it was their turn. Deaf patients were asked to present their prescriptions and a SignSupport device to a pharmacist at the counter, who used the system to dispense the medication. Three video cameras recorded the interactions from various angles [43]. After participants finished the trial, they were asked to complete a questionnaire individually, and asked to participate in a combined focus group discussion where they could give more detailed and open-ended feedback. All interaction with Deaf participants was facilitated by a sign language interpreter.

UNIVERSITY of the
WESTERN CAPE

3.3 Applying the methods

This section discusses how we applied these methods to address the research questions. There are a number of experimentation methods used to test different aspects of SignSupport. SignSupport has been used as a testing tool for content correctness, in the same way automatic dispensing systems have been used to test whether they provide the user with accurate information [3, 51]. Effectively we concentrate on two issues: testing the UI and content correctness of the system.

3.3.1 Usability for Deaf and pharmacist users

This section concentrates on the last event shown in Figure 3.4. This was a cornnerstone event. During the design of the system a number of different handwritten prescriptions were studied. SignSupport was designed in such a way that it contains all the essential elements that appear on a 'traditional' paper prescription. This was done to lower the learning curve of pharmacists during the process of dispensing when using SignSupport. However to test if the flow and logic of SignSupport is consistent with the paper-based prescription scripts that are given by doctors, we had to run simulation exercises that mimic the situation at a real hospital pharmacy.

The simulation exercises started with a training session. Both pharmacy and Deaf participants had independent training sessions. Pharmacy and Deaf participants attended training sessions on different days and at different locations. We deliberately scheduled the training sessions in such a way that both groups are trained and ready for the simulation exercise. Deaf participants were trained at DCCT because it was a convenient location for them. Pharmacy participants were likewise trained at the UWC School of Pharmacy. We used final year pharmacy students because they were familiar with medicine dispensing as it is part of their academic curriculum. Training both sets of participants lasted for three hours each.

UNIVERSITY of the
WESTERN CAPE

3.3.1.1 Deaf participants training

Deaf participants were purposively sampled from DCCT. We deliberately selected certain Deaf participants because we wanted to train and test SignSupport with semi-literate Deaf users [43]. Deaf participants were all DCCT staff members who have had experience with ICT research projects. SignSupport training was done with eight Deaf participants because we had eight Android mobile devices with SignSupport installed. A sign language interpreter was also present to communicate instructions from the research team and also to relay information to and from the Deaf participants. The training was divided into four parts as seen in Figure 3.5.

1. **Introduction of the research and the research team.**

   Here participants were made aware of their rights should they choose to participate

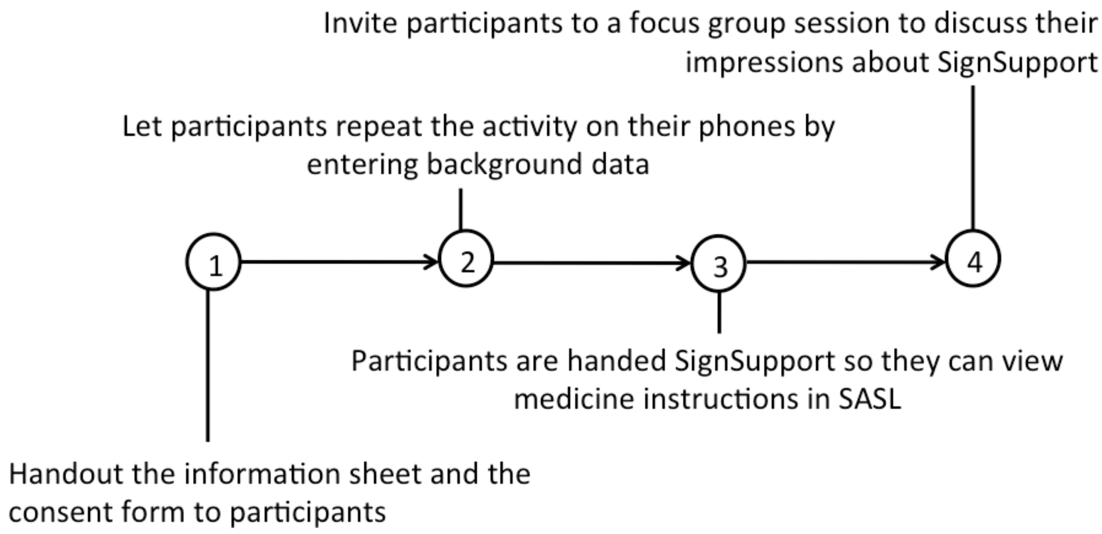

FIGURE 3.5: **Procedure followed during training of participants**
A series of steps showing the procedure followed during training of Deaf participants.

in the training exercise. An information sheet and a consent form (see Appendix A and Appendix D) were given to all participants and all understood and signed it after it was translated for them into SASL.

2. **Introduce SignSupport background setup for Deaf patients.**

   Background setup is a section were a Deaf patient can their summarize medical history and quality of life. In this section of SignSupport, a user answers a set of questions in SASL, for example, does the patient have any allergies? are they pregnant? or do they have access to clean water? All this information is stored in text form for the pharmacists to view before dispensing. This section helps the pharmacists avoid dispensing medication that is not suited for the patient and also limits the need for direct interaction between the pharmacist and the patient. The presentation had embedded SASL videos and looked identical to what Deaf patients would see on the mobile devices [43]. After the PowerPoint presentation demonstration of the UI, users were encouraged to repeat the exercise on actual mobile devices. This was to ensure that they understood the purpose of the exercise and were comfortable with SignSupport. They were asked to repeat the exercise several times on their own. Deaf participants were encouraged to communicate with each other whenever they needed. None of the researchers present during the training gave any assistance to any of the participants.

UNIVERSITY of the
WESTERN CAPE

3. **The medicine dispensing view section.**

   This is the section that a Deaf patient uses to view medicine and accompanying pharmaceutical instructions. We gave PowerPoint presentation demonstrations for the medicine dispensing view section same as for the background data entry [43]. With the help of a pharmacist, we loaded dummy prescriptions on the device for participants to view. Again, participants were allowed to run through the medicine dispensing view section on the phone until they were comfortable with the section. We concentrated on the same attributes as in the background information setup.

4. **Data collection and feedback during training.**

   All research team members were present during the Deaf user training. During the training we were focusing on several key issues such as how users navigate SignSupport with the navigation options provided, e.g. icon meaning, shape and size, and the disappearing keyboard. We also looked as the intelligibility of the sign language videos by asking users what they thought about the videos after the training.

3.3.1.2 Pharmacist participants' training

UNIVERSITY of the
WESTERN CAPE

Student pharmacists were handed the same information sheet (see Appendix A) and a informed consent form (see Appendix C) to complete that explained the purpose of the study and the reason for the training. During the training phase we had eight pharmacy participants who were all given a mobile device that ran SignSupport. Pharmacist participants were introduced to SignSupport in the form of a PowerPoint presentation the same way as the Deaf participants were. Their presentation displayed screen activities that related to dispensing medicine. After watching the presentation that demonstrated the flow and logic of SignSupport, pharmacist participants were asked to complete the dispensing process using SignSupport. Like the Deaf participants, none of the pharmacist participants were assisted by any members of the research team. However, participants were asked to help each other if necessary. During this period participants were asked to make comments about what they thought needed to be changed. This formed part of our user-feedback and as the requirements for the next iteration of SignSupport [43].

3.3.1.3 Deaf/pharmacists' participant trial

A subsequent simulation exercise for SignSupport was conducted at the UWC School of Pharmacy. We created a physical dispensing setting that was similar to many hospital pharmacy dispensing units where all 16 participants from the above trials were involved (see Figure 3.6). The trial for SignSupport was conducted in the form of roleplay. No doctors were used for this study. We made the assumption that the user has already consulted with the doctor and is ready to collect the medication from the pharmacist. The scenario was as follows: a Deaf patient has just finished consulting with the doctor and has been diagnosed with a condition that requires medication. After the doctor consultation, the patient leaves with a paper prescription and waits in a queue. A member of the research team played the role of the hospital staff and was the one who was responsible for collecting Deaf patients from their sitting positions when it was time for them to interact with the pharmacist. The prescription is handed to the pharmacist at the counter in exchange for medication and pharmaceutical instruction. This is a typical scenario in public hospitals. The roleplay exercise is the same as the scenario described above except the patient hands over the paper prescription and the mobile device that has SignSupport installed on it, and opened for the pharmacists to use.

UNIVERSITY of the WESTERN CAPE

Only Deaf participants were given mobile devices running SignSupport [43]. None of the mobile devices were pre-set before the beginning of the trial. Deaf participants had to enter their background information on their own during the trial while they were waiting for their names to be called by the hospital assistant. Usually at the pharmacy, patients are called by name by the hospital assistant. Since Deaf participants cannot respond to their names being called, they had to be fetched and brought to the counter. They then handed both the phone and the paper prescription to a pharmacist who read it and entered instructions onto SignSupport. At the end of every entry the pharmacists received a summary of the operations they had just completed entering and were asked by the system if this is the last entry on the paper prescription. When they finished dispensing all the items on the prescription they handed the phone back to the patient who then watched pharmaceutical instructions, warnings and recommendations in SASL while still at the counter. We repeated this process eight times with different prescriptions, Deaf users and pharmacists participants. Each participant was required to run the simulation exercise only once.

Figure 3.6: **A photograph showing a roleplay in a pharmacy setting.** Showing a roleplay pharmacy setting where a Deaf participant and a pharmacist used SignSupport for medicine dispensing. The setup was made to look like the setup in a real pharmacy and was conducted at the UWC School of Pharmacy dispensing unit. Student pharmacists were given dummy medication and medicine labels so they could follow the exact set of recommended procedures when dispensing.

UNIVERSITY of the
WESTERN CAPE

In this simulation there are no doctors present. The exercise assumes that the patient has already consulted with a doctor and the doctor has drawn up a prescription. The actual origins of the prescriptions are not important, thus eliminating the need for a doctor. The instructions are of most interest in this exercise. The simulation starts with the patient at the pharmacy queue where the Deaf patient is collected by a hearing person playing the role of hospital stuff who walks the Deaf patient to the counter. There are eight Deaf participants and eight student pharmacists in the simulation exercise. Each of the Deaf participants carries a phone running SignSupport and a unique paper prescription (no two prescriptions have the same instructions). We structured the role play this way so we could have student pharmacists enter different pharmaceutical instructions onto SignSupport. This was important in testing that the most commonly given instructions can be mapped by pharmacists using text based options provided by the system and also to test if different pharmaceutical instructions could be understood in SASL as they are shown to the Deaf patient.

Both sets of participants were asked to answer a questionnaire after the dispensing exercise. The questionnaire concentrated on the usability of SignSupport. A SASL interpreter relayed the information on the questionnaire to Deaf participants individually by signing the questions on the sheet. The pharmacists responded in writing. After the roleplay session all participants participated in a focus group discussion that was video recorded. At the end of the trial all participants were encouraged to comment and/or give suggestions about what they liked, as well as what they would not like to see in the next iteration of SignSupport. Results are reported in Chapter 4.

3.3.2 Verification for video position and content flow

SignSupport is heavily dependent on the SASL videos that are pre-loaded onto the phone's memory card. It is therefore imperative that the correct video corresponds exactly to the English text instructions. Section 3.3.2.1 details the first level of verification that occurred when initially recording the videos (see Figure 3.7). A follow up verification procedure is described in Section 3.3.2.2. We devised a set of rules/procedures seen in Figure 3.8 to verify that the videos appear in the correct place and that they actually represent the instructions that the pharmacist had intended.

3.3.2.1 Verification during video recording

UNIVERSITY of the
WESTERN CAPE

Below is a description of how we recorded SASL videos and input the recorded videos onto SignSupport. This verification method helped store videos in the correct location. This is important for relaying correct pharmaceutical instruction (referred to as Lecture errors in ADSs) to the patient from the pharmacist. Figure 3.7 shows a labeled set of rules to follow when editing and recording videos for the first time.

Step 1: Number every screen activity on the system that will display a video. Every number corresponds to a sentence that needs to be recorded on the content script (a script containing all the sentences that need to be recorded in SASL).

Step 2: Label every screen activity on the system with a dummy/placeholder video that explains in English text what sign language message will be displayed on that screen.

Step 3: Once all the activities are labeled, numbered and appear in the correct place, start recording the videos, reading from the content script and translating the text to

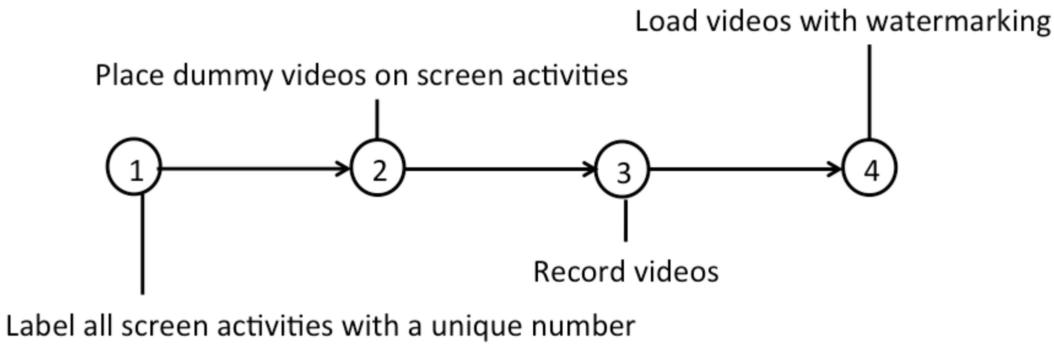

FIGURE 3.7: **Procedure for SASL video recordings.**
Showing how the SASL video recordings transpired. These are the steps taken to ensure that the SASL videos are recorded, edited and stored on the system in a structured way to minimize errors.

sign language with the help of a SASL interpreter. Every video that is recorded is watermarked with the corresponding number from Step 2.

Step 4: Edit the videos, label them and remove the placeholders within the system, then load the actual (not dummy) videos onto the system one at a time using the watermarking numbers from the previous step. There are two ways in which we test whether the correct video has been displayed, which is explained in the next section.

UNIVERSITY *of the*
WESTERN CAPE

3.3.2.2 Verification procedure for content and position

This section details the methods used to verify that SignSupport communicates the correct sign language information for the medication that the pharmacist has conveyed in text. Figure 3.8 shows the sequence of steps taken to verify the correctness of videos in the system.

This section is a breakdown of Figure 3.8. We focus on two parameters. Parameter 1 tests the content of the video, and parameter 2 checks if the video appears in the correct place. We know that the content of the video should match the conversation script and we know the position of the video from the watermarking (see Figure 3.7).

Parameter 1 follows these steps:

Step 1: We transferred all the videos from the phone's memory card onto a computer's hard-drive.

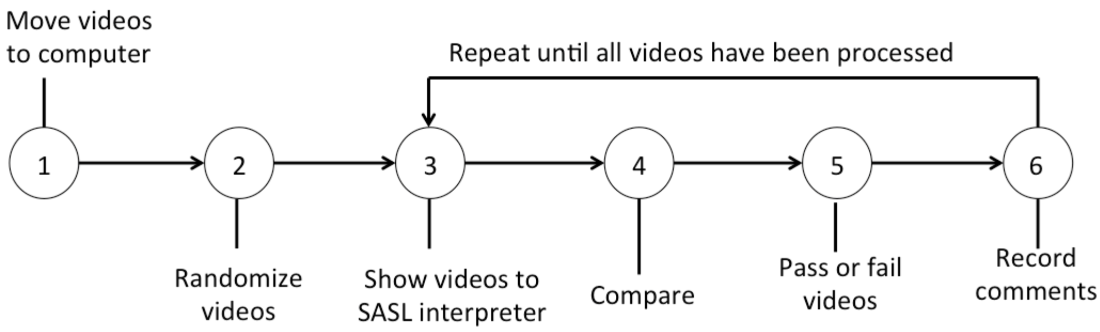

FIGURE 3.8: **SASL video correctness testing process.**
Showing the procedure for verifying the SASL videos loaded onto SignSupport. These steps are crucial in building confidence that SignSupport consistently delivers the correct information at the correct time. This is also the last step on content verification before participants can use the system.

Step 2: We randomized the videos (arranged them in a way that it was not possible for the interpreter to predict the next video) and gave them unique numerical identities.

Step 3: We presented the videos to an interpreter who watched them on a different computer monitor on the other side of the desk and voiced the content of the SASL in English. Here we were expecting a general translation of what the video entailed.

Step 4: After the interpreter watched the video and gave an explanation, we looked at the conversation script with the two variables. Variable one was the number identity of the video. Variable two was the English equivalent of the SASL used in the video. To mark a video as correct/satisfactory, we looked at the number given to that video, listened to the interpreter's explanation and compared it with the one on the script.

Step 5: If a match was found in Step 4 we ticked the "pass box"; otherwise the "fail box" if no match was found.

Step 6: Record comments from the interpreter on how some of the content could have been expressed differently in SASL for the next system iteration. We repeated Steps 3 through to Step 6 until we had viewed and checked off all the videos that were on the system.

Parameter 2 was a simulation exercise and involved using the system to verify the position of the videos, and does the following:

Step 1: We conducted roleplay with the interpreter by running through the entire application. At every stage where she encountered a SASL video, she interpreted it and we confirmed with the script that indeed the video means what it should and appears where it should. We performed this task in the same way a Deaf user using the system would [43].

Step 2: We tested the medicine instructions from the pharmacist. We prepared 'dummy' prescriptions that covered all of the different instructions and permutations that the pharmacist can set. From that comprehensive list we randomly chose the prescriptions that would be entered into the system. After we entered those, we asked the interpreter to explain the message on the SASL videos. Here we were testing whether the English text selections made by the pharmacist are consistent with the information on the videos. To do this we first listened to the interpreter's version and then referred to the conversation script for confirmation [43].

3.4 Prototype design

This section looks at system design through IID using Agile methods. Section 3.4.1 discusses how we collected the conversations that take place between a pharmacist and a patient during medicine dispensing. We extract those conversations and form a conversation script that we later use to decide (pharmacists in the team decide) which of the sentences will be video recorded in SASL and loaded onto SignSupport. Section 3.4.2 explains the current UI and compares it with the previous implementations of SignSupport and gives justification to the design decisions implemented on the frontend. Section 3.4.3 discusses the backend of SignSupport. How videos are looked-up on the system, and the different layers that drive the dispensing process.

UNIVERSITY of the WESTERN CAPE

3.4.1 Conversation mapping

SignSupport holds a limited set of conversations. A set of procedures was drafted that was used to study the conversations that occur in a pharmacy setting. From Figure 3.9, Step 1, we used a set of rules known to pharmacists as the Objective Structured Dispensing Examination (OSDE) which is a document that governs how pharmacists must interact with a patient. Since the OSDE document was drafted to help dispense medicines to hearing patients, we had a pharmacist modify it in such a way that it can be used to dispense for Deaf patients.

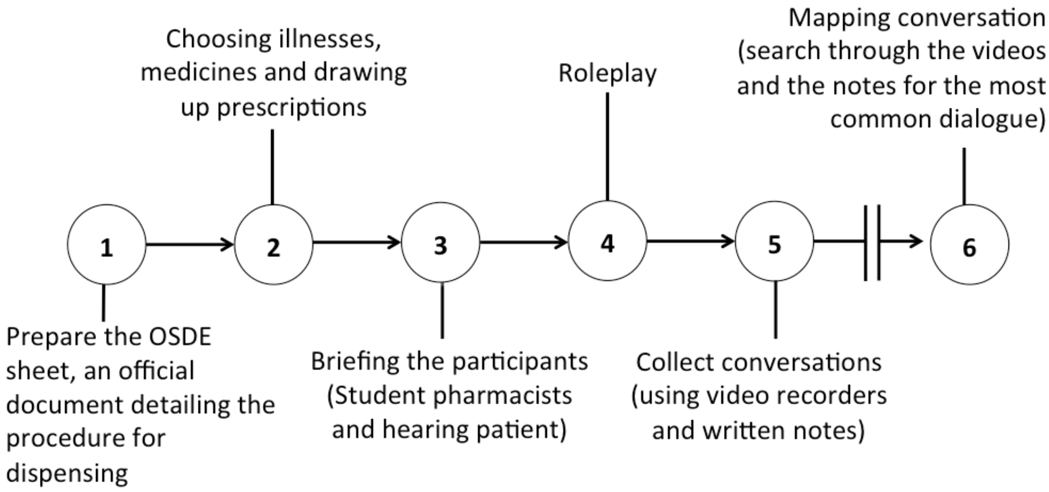

FIGURE 3.9: **Steps taken to capture the conversations in a pharmacy setting.** Showing Steps used to formulate the conversation script that was later used to decide which conversations are recorded and loaded onto SignSupport. The broken line between Steps 5 and 6 show that Step 6 was not done during the roleplay. It is a separate part of the process that was undertaken in the lab after Steps 1 through Steps 5 were completed. Step 6 is also the most important because from this step we generated the conversation script that dictated which sentences were included in the SASL recordings.

UNIVERSITY of the WESTERN CAPE

Step 2 was to decide which illnesses and medicines are going to form part of our roleplay session. We did not choose random illnesses and medicines because we wanted to find out different conversations that occur when patients collect their medicines. So pharmacists chose a specific set of illnesses and medicines in order to drive the conversation in as many different directions as possible. Once those two elements were decided on we had a pharmacist draw up corresponding dummy prescriptions.

Step 3 involved briefing the participants (student pharmacists and a hearing patient) about the purpose of the study.

Step 4 was the actual roleplay where the patient had to go to the counter to collect medicines and interact with the pharmacist. This was the critical stage, here a spoken conversation takes place between the patient and the pharmacist.

Step 5 was about collecting the conversation that took place between the two parties. Before the roleplay session we had set up a video camera in the room (where the patient meets the pharmacists) which was connected to a television monitor on the outside so we could observe and record the interaction. We also took notes when something interesting happened, like when a pharmacist asked a patient a question that the patient does not know, for example, asking a patient if they are allergic to penicillin.

Step 6 was done after all the subjects had participated in the roleplay because we needed to capture every participant's interaction, hence the broken double line in Figure 3.9 between Steps 5 and 6. Here we re-watched the roleplay video and looked for these elements; Greeting and Patient identification; General history taking; Clinical history taking; Information and instructions to the patient; Patient questions and Closing. Once these seven elements has been identified in the conversation we write them on the conversation script as candidates for inclusion in SignSupport. If they are repeated across different participants then we classify them as strong candidates that will form a complete sentence instead of just a fragment like the warnings and the recommendation videos.

3.4.2 SignSupport frontend evolution

This version of SignSupport is the first to run on a capacitive touch sensitive display. The previous version of SignSupport ran on a Symbian phone [44] that was not touch screen enabled. This change benefits the user because touch screen phones provide immediate tactile feedback to the user. Since SignSupport is for semi-computer literate Deaf people and computer literate pharmacists. A touchscreen implementation of SignSupport offers users a way to directly manipulate on-screen objects. This simplifies the UI for both sets of users. To navigate SignSupport users tap on the object and the system captures their input and provides haptic feedback to ensure the user that an action has been received [43]. Figure 3.10 shows the two different interfaces from Mutemwa's implementation on the left to the current device on the right.

Users are dependent on icons to interface with smart phones. This is an important issue just for all types of users. It is of greater important for Deaf/illiterate users since they rely on graphical representation of information in order to understand what needs to be done next. According to Blankenberger and Hainj, visual aspects such as graphics and icons, are essential elements of user-device interaction. They are used extensively in interface design on the assumption that visual icons are capable of transcending language barriers and of presenting meaning in condensed form [5]. We wanted Deaf users to recognize the meaning of the icons without any additional instructions because this is a personal application and it is possible that Deaf users might not have help at home to help learn the system. To do this we worked with DCCT members to design the

FIGURE 3.10: **SignSupport's user interfaces.**
Showing a photograph of SignSupport's user interfaces from the previous generation implemented by Mutemwa on a Symbian phone to the current version of SignSupport's interface implemented on an Android phone with a fully touch sensitive user interface.

UNIVERSITY of the
WESTERN CAPE

icons in with respect to content, colour, shape and size. In icon design there are several criteria that an icon must satisfy. These are as follows: legibility, distinctiveness and comprehension [17]. SignSupport icons are important because they fulfill two functions: (a) they remind the user what section of the application they are in, for example at every home screen activity there is an icon with a picture of a house on the top left of the screen. This icon is shown on other screens where the user can go home if they wish. It is this consistency that allows the user to communicate with SignSupport for the first time with minimum assistance. (b) They emphasize the action that the user needs to take in order to continue to the next section. When a Deaf user wishes to view their prescribed medicines, they see a picture of themselves next to their names or when they want to exit the application they can find the exit icon on the bottom of every home screen activity. The first step was to make the application icon bright in colour and recognizable (because SignSupport is medical software we chose the colour red as red is the colour associated with health practice). The legibility of an icon depends on the degree of the visibility of the icon, which, in its turn is dependent on the display resolution [52, 54]. Since the different pixel densities across mobile platforms affect the physical size of the icon we programmed SignSupport icons to have three degrees of resolution, which are High, Low and Medium. This helps the icons resolution to stay consistent regardless of the screen size SignSupport will be installed on. If icons are too small to be legible, then they become too difficult to understand. This was the reason we prefer to run SignSupport on larger screens of dimensions 460 x 700. The icons are designed to be self-explanatory. This helps with users understanding their function and thus improving user satisfaction. SignSupport is designed to work on every screen size, which is fully touch sensitive. There is no impact on design by screen size since all the objects that form the interface will adjust dynamically to the screen size. However for the purpose of sign language (being a visual language) it would be better/preferable for the user to install SignSupport on a phone display that is as large and as bright as possible so that the sign language can be legible.

As can be seen in Figure 3.10 the change in the UI is apparent: users do not need to navigate the system with hard key buttons that are far from the action being performed. The right of Figure 3.10 shows that the user directly selects the icon that represents what they want. Icons and navigation form a huge part of user satisfaction and for this reason they were designed to be intuitive and to inform users about their meaning. The right of Figure 3.10 shows how accurate icons can be presented to users to improve their understanding of the system and to reduce the time it takes for users to learn the system. Changing the UI to a touchscreen has improved user experience of SignSupport. SignSupport now has a larger screen to display intelligible SASL video that users have been asking for since the previous implementations of SignSupport [12, 44]. Deaf participants at DCCT have asked for a larger SASL video (length x width), SignSupport displays a SASL video of 640 x 700 (l x w) and at 30 *frames per second* [43]. MobileASL has been struggling with making sign language videos intelligible [8] since their project started. It has proven very difficult to provide clear sign language videos that are transferred over a cellphone network. SignSupport does not need to send or receive videos over a network; all videos are local which gives us an advantage of storing high resolution videos on the system [43].

UNIVERSITY of the
WESTERN CAPE

The sign language videos stored in the device's memory card are an average length of 2:00 minutes and they were all recorded at the same location with the same background and lighting conditions over a period of two days. We removed the sound since Deaf

```xml
<VideoView android:id="@+id/your_video_view"
          android:layout_width="wrap_content"
          android:layout_height="wrap_content"
          android:layout_gravity="center"
/>
```

Figure 3.11: **SignSupport's video display canvas in XML.** Showing a snippet of code detailing how SASL videos are displayed using XML. This shows how SignSupport's interface is coded in such a way that the device's screen size does not affect how the video is shown.

people do not need it. To reduce the size of the videos we set all videos to black and white as suggested by Looijesteijn [37]. This is because pixels have only one property, i.e. colour . The colour of a pixel is represented by a fixed number of bits [2]. The more bits, the more subtle variations of colors can be reproduced and thus the larger the video. For this reason we chose to make the videos black and white. This allowed us to essentially give each pixel either a black or white colour resulting in a smaller video.

The UI was coded with XML, a language that allows the definition of tags, while having the qualities of HTML [60]. The XML code in Figure 3.11 is a typical example of how SignSupport handles SASL videos to be displayed over as large an area of the screen as possible as seen in Figure 3.10. Initial designs of SignSupport did not use the entire display of the device to show a SASL video Figure 3.10. During development the design team decided to make the videos cover 70% of the display's real estate because this is one of the most requested attributes from Deaf users. Changing the UI in this fashion changes how the user experiences the system [32, 41]. It also changes the architecture of the backend in a significant way. Next we discuss different backend architecture designs and how each was iteratively improved upon based on the lessons learnt in the previous cycle of development to be able to handle the new interface more efficiently. The structure of the backend has been modified in cycles to handle new functionality. Each cycle from Figure 3.12 is discussed in detail below.

Linear navigation (see Figure 3.12 Cycle 1) was introduced to users after they had been interviewed via focus groups (see Figure 3.1) and had drawn their own depiction of the solution (see Figure 3.2). A design engineer sketched a design that was coded and deployed on an actual device. The first prototype was monolithic and used a linear approach to system navigation. This approach was acceptable for small applications

UNIVERSITY of the
WESTERN CAPE

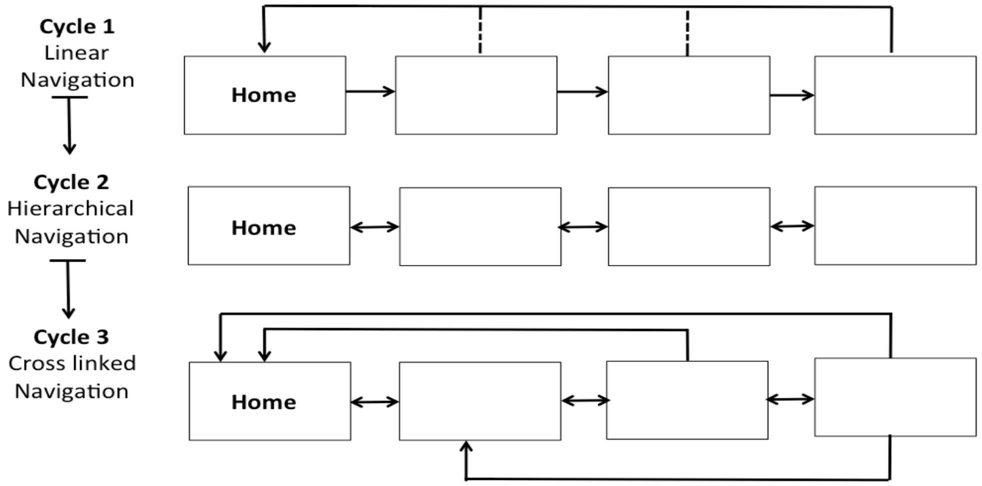

FIGURE 3.12: **User interface navigation evolution in SignSupport.** Showing a representation of the user interface navigation used for the system where the box structures represent the user interface and the lines in between the boxes represent code and flow of logic.

with about three or four screen activities. This was undesirable and eventually deemed unacceptable as the current prototype contains over fifty screen activities [24]. Moreover, people made errors and needed to go back to the previous screen. The linear navigation approach gave us an idea of how to organize and structure screen activities, so that we could start to address them in a more efficient way [42].

UNIVERSITY of the
WESTERN CAPE

Hierarchical navigation (see Figure 3.12 Cycle 2) was introduced in the second iteration and came in two forms; when a screen activity had multiple drop-down menus as can be seen in Figure 3.13, and between screen activities that appear to the user at different stages. Although there were two different implementations for hierarchical navigation, the application algorithm was the same for both. The difference was how we aggregated the data that had been entered into the system. The case of moving from one video-playing activity to the previous or next proved to be challenging because of the high frame rate and resolution of the sign language videos stored on the memory card. Limited processing power of the mobile device appeared to cause the application to intermittently fail when loading the videos. We later discovered that the *AndroidMediaPlayer* programming interface caused the error, as it could not play videos back-to-back on different screen activities [41]. We remedied this problem by creating a buffer activity that separated the video activities and allowed the device to redistribute its resources/memory and prepare it for the next video activity [43]. When collecting data from multiple screen activities, the data from the user was written to a file similar

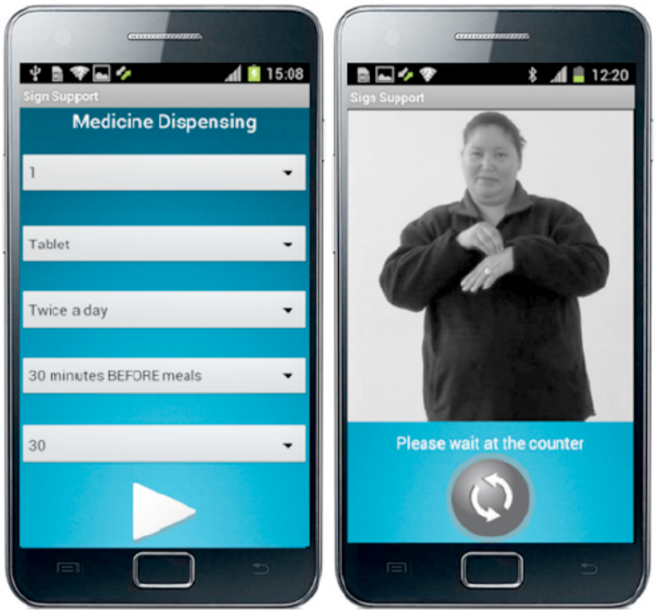

FIGURE 3.13: **Pharmacist and Deaf user interfaces.**
Showing pharmacist's interface to dispense medication (left) and also showing the medicine dispensing screen that is text-driven, on the right of the figure is a Deaf person's view of information in sign language.

to ASRAR (see Section 2.1.3) and kept there until all of the instructions/tokens were collected (see Figure 3.14), and at each stage the user could go to the previous activity and re-enter an instruction (see Figure 3.12). Should the user make an error, it was not necessary to go to the end and repeat the entire process, and s/he could go back one screen activity at a time. The former design was not suitable, as it wastes time and led to user frustration.

UNIVERSITY of the WESTERN CAPE

Cross-linked navigation (see Figure 3.12 Cycle 3) is a combination of the two approaches discussed above. The system has areas where a monolithic navigation style is required. This is mostly true for the Deaf UI, for example, the one-time only set-up of patient background information. Hierarchical navigation was used for pharmacists because of the playback challenges mentioned in Cycle 2. The system's back button could not be used for this cycle because it does not call the buffer activity but calls the *AndroidMediaPlayer*, which is not suited to our needs [42]. To solve this problem, we created a softkey button inside the application and disabled the device's 'Back' and 'Menu' buttons. This meant navigating the system is only possible from inside the application. We can control not only the direction of flow but also the process that leads to a specific event. Disabling the device's function key buttons serves a double purpose; (1) if the system is

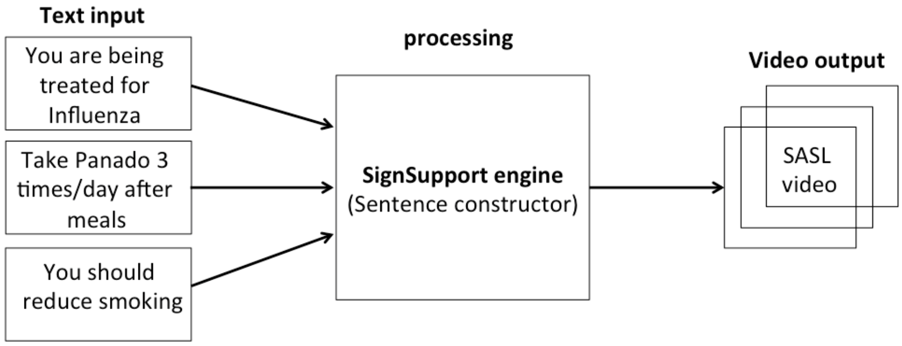

FIGURE 3.14: **SignSupport's sentence constructor.**
Showing a diagram detailing the Sentence constructor of SignSupport. Every time they pharmacist enters an instruction, the SignSupport engine captures the instruction in a text file. The SignSupport engine algorithm needs an updated version of the text file, which means every token must first be saved in a text file. When a patient tries to view their medicine instruction, we aggregate all the individual instructions to form a complete sentence. This newly formed sentence is the name of a SASL video stored somewhere on the memory card.

not built for technologically fluent users, then the purpose of these function keys is not immediately apparent to users and can lead to confusion [53], and (2) disabling function keys affords us the required flexibility to deliver a more robust and seamless conversation flow that loads videos reliably. The cross-linked approach also increases the productivity of the pharmacist during dispensing as it allows him/her the flexibility to move back and forth, and make adjustments spontaneously. Thus far we have explored a number of different designs as seen in Figure 3.12 with different outcomes. The cross-linked design is therefore a combination of Cycle 1 and 2.

UNIVERSITY of the
WESTERN CAPE

3.4.3 SignSupport backend evolution

SignSupport's backend is divided into several layers (as seen in Figure 3.15) for dispensing medicine and providing pharmaceutical instruction. Below is a description of the layers that are responsible for communicating that information.

Layer 1 contains possible medical conditions, currently restricted in number (57 in total Appendix F) to code and trial the prototype [42].

Layer 2 holds a list of all the medicines that are available for those medical conditions in public pharmacies. Videos from Layers 1 and 2 appear on different screen activities at different times, so these parameters are labeled with the same name with which the

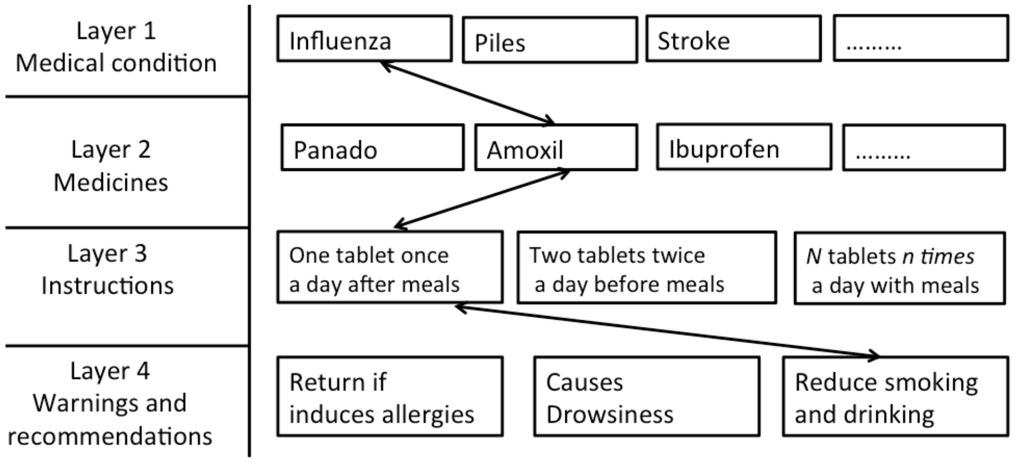

FIGURE 3.15: **A layered view of the pharmacy backend.**
Showing a view of the pharmacy backend that indicates how a prescription is encoded, where every layer represents a possible set of instructions a pharmacist can give to a patient. A selection from every layer is captured and stored in a text file by the SignSupport engine which forms a sentence for the patient concerning a particular medication. The bi-directional arrows in the sketch show that the pharmacist can move back and forward should s/he make an error on a specific layer.

SASL videos are stored. To fetch and play them, we reference the name of the disease or medicine from the correct directory on the memory card.

UNIVERSITY of the
WESTERN CAPE

Layer 3 holds combinations of prescription instructions with different permutations. Videos in this layer are recorded as complete sentences in sign language. A selection of one item on each of the axes forms a token (see Figure 3.16). This token is written to a file that is later accessed and read similar to ASRAR. We aggregate the data contained in these files to form a token sentence [42]. This sentence matches the file name of one of the sign language videos on the memory card.

Layer 4 holds combinations of possible warnings and recommendations for the Deaf user and uses the same lookup algorithm as for Layers 1 and 2.

As seen in Figure 3.15 a Deaf patient reviews a prescription in a four-stage sequence. For videos in Layer 3, we recorded a limited number of complete sentences instead of stitching together fragments because they would not make sense in sign language [43]. We concentrated on three prescription factors: frequency, quantity and dosage event as seen in Figure 3.16 [42]. Selected values for the three parameters limits the pharmacist from making selections that are not pre-loaded and thus limits the communication flow.

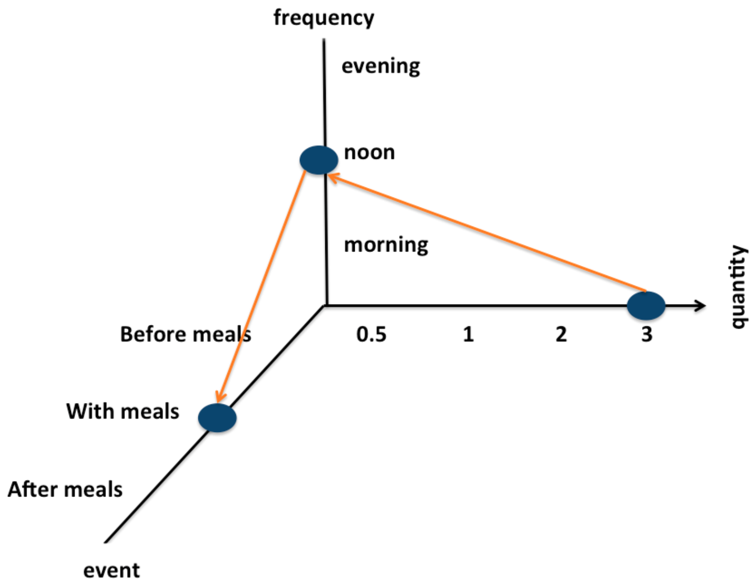

FIGURE 3.16: **A three dimensional graph of the different permutations.** Showing a three dimensional permutation matrix. Every time the pharmacist dispenses medicine they select one point on each axis. We designed the dispensing logic to follow the plot because it follows the logic of the paper prescription. We take the selections/tokens made from each axis and form a complete sentence. The new sentence refers to a SASL video that relays pharmaceutical instruction.

UNIVERSITY of the
WESTERN CAPE

We can restrict the domain of communication because we have captured all the conversations and their flow, and loaded them on the phone [42]. The TESSA research group studied restricted domain communication and covered about 90% of the exchanges [15] that occur at a PO. We used similar techniques to ensure that we reach high percentage levels of the communication exchange in the pharmacy context. We store all sign language videos on the phone's memory card. This means all communication is effectively limited to what has been stored on the phone, and does not cost the Deaf user anything at all to use the application [43]. Since SignSupport contains a limited conversation flow, it can still be used without cellphone reception or internet acces.

3.5 Ethical considerations

To conduct the research discussed in this thesis an ethics clearance certificate had to be acquired from UWC Science Faculty Ethics Committee. The Ethics clearance allowed us to conduct roleplay, interviews, focus group discussions, training and testing experiments with human participants. Both Deaf and pharmacy participants were given information sheets and consent forms for data collection. An interpreter was employed to relay information to Deaf participants, therefore we needed an additional consent form for the interpreter to safeguard the interpreted information (see Appendix B). The information sheets introduced the researchers, explained the purpose of the study to all participants, including the interpreter (see Appendix A). Consent forms (see Appendix C and Appendix D) were drafted for both our group of participants and the interpreter (see Appendix B). Appendix E allowed us to use participants likeness during video recording to feed the study. Furthermore none of the participants were allowed to participate in the experiments, any video recordings, surveys or questionnaires unless they agreed to the terms in Appendix E. Each of the participants agreed voluntarily, following what the consent form: such as the volunteer's identity will not be revealed unless they agree to do so (Appendix E compelled all active participants to agree, otherwise they cannot be part of the study), and they were free to withdraw at any time from the research. The interpreter signed all of the printed/written materials intended for Deaf participants.

Data was collected using video recording of experimentations, questionnaires, focus groups and informal interviews. Data gathered from the questionnaires and the experiments was transcribed. Videos and pictures were stored on a computer, which had a password that was only known by the researcher. The interpreter was used to facilitate communication between researchers and participants. The interpreter was notified that the information s/he is about to hear was confidential and that s/he could not make use of it and that the participants privacy must be reserved. The interpreter had to able to sign in SASL, and speak English fluently to ease communication between the researcher and the participants. Also since all the sessions conducted with participants were video recorded, participants were also asked to approve the use of their likeness in the form of photographs, videos, on websites or in presentations (see Appendix E).

UNIVERSITY of the
WESTERN CAPE

A power imbalance exists between the researchers and the participants. With pharmacy students the imbalance is because they were being watched by their lecturer who was a member of the team, so in some cases they might have given responses that we wanted to hear. The imbalance with Deaf participants could have also been caused by the Deaf participants, members of a marginalized community, wanting to please the researchers.

3.6 Summary

Section 3.1 introduced the research question and splits it into two parts: the first part concerns user interfaces for Deaf participants and pharmacists. The second part concerns content verification on a medical system.

Section 3.2 presented the methods used to answer the research questions. We discussed how the technical team and the participants worked together using community-based co-design and how participants designed their own solution with the technical team managing the process. We also discussed the contributions of the multidisciplinary team and how they influenced the system. Lastly in this section we introduced a software engineering method that enabled us to iteratively design and develop SignSupport in such a way that the current output serves as the start of another iteration.

Section 3.3 discussed how we applied the methods explained in Section 3.2. At first, we concentrated on usability of the system. To fully comprehend the usability of SignSupport we had to purposefully select semi-computer literate Deaf participants at DCCT and senior pharmacy students at UWC and run training and simulation exercises. We also created two different UIs for both users so as to cater for their specific needs. The second part of this section involved content verification. Secondly SignSupport is classified as medical software [23] that shares crucial information with patients, we had to show that all the information shared is correct and intended. Just as ADSs are tested for correctness so was SignSupport.

Section 3.4 discussed the frontend and the backend of SignSupport. We showed how the SignSupport differs from its predecessors, and also showed different cycles that we went through until we found the most suitable one for the system. We showed how the UI can be modified to accommodate users who have different needs.

Lastly, we discussed ethical considerations in Section 3.5. The next chapter presents the results of the study.

UNIVERSITY of the
WESTERN CAPE

Chapter 4

Results

This chapter presents and discusses results from user focus group discussions, informal interviews, questionnaires, trials and content and position verification. We discuss the results for each procedure that was undertaken to improve the system's functionality and UI. The results discussed in this chapter are a consequence of iterative development. There are two key areas of data collection, usability and verifications, and for each we explain the sample, procedure, results and we conclude with an analysis of those results. Section 4.1 details the events that led to the creation and evolution of SignSupport's UI. We show how each event produced results and how those results influenced SignSupport in the next iteration. Section 4.2 discusses video recording, content and position verification results. Lastly, Section 4.3 summarizes and concludes the chapter.

UNIVERSITY of the
WESTERN CAPE

4.1 Usability events

4.1.1 Focus group sessions

This section chronicles the events depicted in Figure 3.4. For each data collection event, we describe the sample, procedure details, the results and analysis, of one event to another. Table 4.2, summarizes this section.

4.1.1.1 Sample

Focus groups were conducted with both Deaf and pharmacy participants. We had sixteen participants in total, eight were Deaf participants from DCCT and eight were senior pharmacy students from UWC. There were no selection criteria for Deaf participants. Any Deaf person from DCCT was allowed to participate in the roleplay exercise. The selection criteria for pharmacy students was that they had to be in the final year class and not able to communicate in SASL.

4.1.1.2 Procedure

Deaf participants

Role plays with Deaf participants were conducted at DCCT with an industrial design engineer. The first step was to organize an interpreter to facilitate the session between the researchers and the participants. The purpose of the study was explained to all participants through the interpreter. Deaf participants were seated at a round table (see Figure 3.1) where they could all sign to each other and the interpreter. Once everybody had assumed their position, they read and signed a consent form (see Appendix B and Appendix D). Participants were asked to discuss what problems they face when dealing with public service providers like doctors and pharmacists.

UNIVERSITY of the
WESTERN CAPE

Student pharmacists

Role plays with student participants were conducted at UWC School of Pharmacy with the lead pharmacist. They were given a consent form (see Appendix C) before the commencement of the focus group. Student pharmacists were introduced to the research and the discussions with Deaf participants were shared with them. From that they were asked to discuss their experience when dispensing medication to Deaf patients. They discussed the methods they normally use to help dispense to a patient who they cannot communicate with because of language barrier.

4.1.1.3 Results

From the roleplay session held at DCCT Deaf participants repeated that they need more assistance at the hospital pharmacy but they cannot afford an interpreter because SASL interpreters are expensive and rare in South Africa. They suggested a system that works on a smart phone, and that can translate English text instructions from a pharmacist into SASL. They also mentioned that they needed a reminder system built into the system to keep track of when to ingest their medication.

Pharmacists suggested that Deaf patients either bring an interpreter to the pharmacy or the hospital should employ pharmacists who can communicate in SASL. They suggested this because they said pharmacists are required to learn more that one local language[1] in order to practice pharmacy.

4.1.1.4 Analysis

After the roleplay the technical team decided to take the direction given by Deaf participants. We looked at developing a mobile application that contained a limited conversation flow between a pharmacist and a Deaf patient. Since Android is free and open source we thought that might be a good platform on which to develop SignSupport. The other reason is that at DCCT, many Deaf people already have Android smart phones which they use in a very limited capacity.

UNIVERSITY of the
WESTERN CAPE

4.1.2 Paper-based designs

Once participants had chosen the medium on which they would like to receive help, we brought along a design engineer to help Deaf participants design the system.

4.1.2.1 Sample

Nine Deaf participants met at DCCT with a SASL interpreter and a design engineer to design the interface of the application they had discussed in the focus groups. Pharmacists were not involved in the design at this stage.

4.1.2.2 Procedure

Deaf participants were invited to sit at a round table on which they were given a brief explanation about what task they were expected to fulfill. The interpreter facilitated

[1]Note South Africa as 11 official languages.

the communication process. The following items were placed on the table for Deaf participants to use: different colored pens, rulers and blank sheets of paper on which they could draw their ideal interface.

4.1.2.3 Results

All nine Deaf participants drew a version of how SignSupport might look. Most of the drawings showed communication in SASL. The drawings also showed a sign language video that filled most of the screen and the design of the application was shown to be on smart phones as seen in Figure 3.2.

4.1.2.4 Analysis

We handed over these sketches of designs to design engineers (part of the technical team) to refine the designs and create a full UI for SignSupport. When the Deaf participants were making their drawings, they only drew one screen that summarized what they expected. Design engineers broke down the most common elements that appeared on the different users' designs.

UNIVERSITY of the
WESTERN CAPE

4.1.3 Role plays with participants

Role plays with student pharmacists were conducted at UWC School of Pharmacy. Here we wanted to capture the conversations that take places between a patient (not a Deaf patient) and a pharmaciss during medicine dispensing. A different roleplay exercise was also conducted with Deaf participants at DCCT. Here we were interested in observing the language communication barrier between the pharmacist and the Deaf patient.

4.1.3.1 Sample

This was the first roleplay session conducted with senior pharmacy students. There were ten senior pharmacy students and one simulated hearing patient. A hearing patient was used in order to ask the pharmacist questions so we could monitor the responses and include them in the application. The other roleplay session was conducted with four DCCT staff members who were semi text literate.

4.1.3.2 Procedure

Pharmacy participants

Student pharmacists were briefed and asked to agree to read and sign the information sheet (see Appendix A) and a consent form (see Appendix C). A video camera was placed in the room and connected to a television monitor in a separate room where the lead pharmacist (part of the technical team) was seated with the OSDE sheet. A simulated hearing patient was given two prescriptions, one for Hypertension and the other for Influenza. Pharmacists were asked to dispense medication and instructions for these conditions.

Deaf participants

For the roleplay conducted by the design engineer at DCCT, each Deaf participant was briefed about the experiment with the help of the interpreter. The interpreter was asked to translate the contents of the consent form (see Appendix D) given to Deaf participants. A mock pharmacy setup was created where the roleplay was to take place. We assumed that the patients have already been diagnosed. Patients were handed fake medical prescriptions and asked to wait in a queue until the pharmacists came to get them. The pharmacist who was played by a fellow researcher then collected the patient at the queue to the dispensing counter. When they arrived she proceeded to read the paper prescription from the patient and placed the medicines on the counter in front of the patient. At this point she started to give out pharmaceutical instruction in spoken English and some simple hand gestures (we found that professional pharmacists do this with Deaf patients in real life). Then she pointed at the medicine labels on the medicines, showing the patient where to find the instructions for each medicine. At the end, the pharmacist asked the patient if they had any questions. Each dispensing session in the roleplay lasted between 2 to 8 minutes. We repeated this process four times with different Deaf participants who all had different prescriptions. The interpreter, although present during the roleplay, did not take part in any of the dispensing sessions.

UNIVERSITY of the
WESTERN CAPE

4.1.3.3 Results

Based on the interaction between the pharmacists and the hearing patient, we recorded all the conversations that took place. We captured the behavior of both the patient and the pharmacist.

We got to observe the challenges faced by Deaf patients when collecting medicines at the hospital pharmacy. After the roleplay a focus group discussion was held where patients reported that they understood very little of what was being communicated. They also added that because they had doubts about the medical instruction they would be reluctant to use that medication. Strangely after each dispensing session the pharmacist asked the patient if they understood the instructions and all the patients nodded their heads as if to say yes. When the pharmacist asked the patient if they had any questions, the patients always shook their heads side to side, indicating no.

From both roleplay we saw the methods that pharmacists use to try to pass on pharmaceutical instruction and we concluded that those methods are not efficient. This led Deaf patient to be afraid to give an answer that might cause further interaction between them and the pharmacist.

4.1.3.4 Analysis

The roleplay conducted with Deaf participants confirmed that we needed to develop a tool to help pharmacists and Deaf patients during medicine dispensing. It was clear from the roleplay conducted at DCCT that we needed to develop a tool that will convert pharmaceutical instruction from English text to SASL for a Deaf patient.

UNIVERSITY of the
WESTERN CAPE

After a few roleplay with pharmacists, we noticed a pattern. Although the pharmacists had dispensed for two different conditions, the structure of the dispensing process was evident and predictable. The dispensing process contained the following elements: Greeting and Patient identification; General history taking; Clinical history taking; Information and instructions to the patient; Patient questions and Closing. Capturing the dialogue between the patient and the pharmacists helped structure the conflict resolution screens where flow is important.

4.1.4 Extraction of conversation pattens

This process involved organizing the conversations that were collected in a previous event.

4.1.4.1 Sample

The individuals who were responsible for deciding which conversations to be included in the system were the members of the technical team. However, the pharmacist was the one who had the final word as this is her field of expertise.

4.1.4.2 Procedure

We downloaded the roleplay videos recorded with pharmacists from a video camera onto a computer. We transcribed the conversation that took place between the pharmacists and the patient. We did this for all the interactions and for both the medical conditions that were treated.

4.1.4.3 Results

After the transcription we scanned through the entire document with all the conversations and looked for instructions that were compulsory. For instance, all medicine warnings were automatically identified and formed part of the conversation script. We also took great care in understanding the way in which pharmacists gave pharmaceutical instruction, for example, when a pharmacist gives dose instructions there are a number of ways they could voice them. One could say “take 1 pill once a day” or “take 1 pill once every 24 hours”.

UNIVERSITY of the
WESTERN CAPE

4.1.4.4 Analysis

A conversation script (see Appendix I) was developed that did not include all the conversations that occur during dispensing medicine, but only those that occur most often. After the conversation script was composed, it was used to record the videos that would later communicate instructions to the patient in SASL. A member of the technical team (the pharmacist) then pointed out that it would be better if the patient also gave the pharmacist a summary of their background. The patient background information was then included into the conversation script. Usually a patient does not need to give the pharmacist this information (unless asked), but since communication is a problem in this scenario, this information had to be included.

4.1.5 Identification of medicines and illnesses

This process involved finding medicines and illnesses that needed to be populated into the system. Student pharmacists were tasked with finding a hundred illnesses that are common to them while doing their internship at local pharmacies around Cape Town.

4.1.5.1 Procedure

We called a meeting with ten senior pharmacy students and asked them to provide one hundred illnesses that they encountered most during the time that they have been dispensing medicines. Each student pharmacist was asked to provide a list of ten illnesses. If there were illnesses that were repeated, we asked them to discuss what other illness they would like to add. A list of medicines was gathered from the South African Department of Health [18] and all the medicines were loaded onto the application.

4.1.5.2 Results

A list of illnesses was finalized and readied for video recording. The medicines names were loaded onto the application as text.

UNIVERSITY of the
WESTERN CAPE

4.1.5.3 Analysis

We soon realized that from the list we received we could only record 57 illnesses (shown in Appendix F) because the illnesses were given to us in medical terms. This became a huge challenge because natural spoken language is far more developed in this regard than SASL or any signed language for that matter. Illnesses like cardio-vascular disease or jaundice are difficult to sign without finger spelling. We also reduced the dosage forms to oral medicines (capsules and tablets/pills) because we conducted roleplay with oral dosage forms only.

4.1.6 Identification of prescriptions and instructions

In this section we discuss how we managed to identify the most important elements of traditional paper prescriptions and incorporate these attributes into the system for seamless dispensing.

4.1.6.1 Procedure

We asked pharmacists to provide the technical team with different type of prescriptions that a doctor can give to a patient. We also asked for the different types of information that can be provided in the prescription.

4.1.6.2 Results

We converted the paper prescriptions into an electronic prescription with all the original elements of the paper based prescription. These included dates, doctor's name and hospital name.

UNIVERSITY of the
WESTERN CAPE

4.1.6.3 Analysis

Including everything that was on the paper-based prescription made the process of dispensing long. This was undesirable given the crowded nature of public hospital pharmacies. We reduced the information on the prescriptions to only the essential parts. We chose to leave out dates because SignSupport already captures that to form a reminder. The name of the hospital and the doctor who drafted the prescription were excluded on our version of the electronic prescription. That information can easily be found on the patient card that is kept at the hospital. To include this information would be a pointless redundancy that does not serve any of the users of the system.

4.1.7 Recording SASL videos

This section details the process of recording SASL videos at DCCT using the conversation script. The videos were recorded with the help of a DCCT staff member who was first briefed about the purpose of the exercise. She was given a consent form (see

Appendix E) that allowed us to record her while signing. An interpreter was present and also a Deaf education specialist (technical team member) assisting with the process.

4.1.7.1 Procedure

Recording room setup

We first had to find a room that was well lit. Secondly we chose a white background because at the time of the recording our Deaf participant was wearing a black sweater. There had to be a clear contrast between the background and foreground for the signs to be intelligible (see Figure 3.13).

Video camera setup

We placed the video camera on a tripod stand for stability, and at a distance that captured the entire upper body of the signer. Then we put it approximately 2 metres away from the signer and marked that position on the floor. Since we could not guarantee that the signer would not move from that spot and because the recording happened on different days, we marked the spot where she stood so we could always record videos from the same distance.

UNIVERSITY of the
WESTERN CAPE

Video recording

A conversation script was given to the interpreter who read it and relayed it to the Deaf participant who was signing the videos. The script was divided into three different sections, 1) Background information set up script, 2) Conflict resolution screens with Deaf-Pharmacist interaction and, 3) Dispensing, warnings and recommendations script, and every sentence was numbered (see Appendix I), thus each time the signer signed correctly we ticked off that particular sentence and moved to the next on the list.

4.1.7.2 Results

At the end of two days of recording, 180 SASL videos had been recorded and were ready to be edited and loaded onto the application.

4.1.7.3 Analysis

Out of the 180 videos that were initially recorded 35 needed re-recording because they were either ambiguous or their true meaning could not be determined.

4.1.8 Training and trial

SignSupport was tested for usability in the form of roleplay between Deaf and pharmacy students. Two training sessions were carried out as specified in Section 3.3.1. The focus was on usability testing including monitoring user interaction with the system, and identifying potential design flaws that need to be addressed in the next prototype. A physical setting to replicate the scenario where a Deaf person visits a public hospital pharmacy to collect medicine(s) was set up in a controlled environment for the trial. The trial sessions were then followed by individual questionnaires (see Appendix G and Appendix H) and a focus group discussion involving all participants. Training and testing was conducted on Samsung devices. At the time of the trial roleplay session, we used these specific mobile devices because they had the same hardware interface and looked nearly identical to one another. Using identical Android devices and versions directed the focus to SignSupport since users who excelled in using their own system could easily help others in the group. It needs to be emphasized that although SignSupport was trialled on the devices mentioned above, it will behave in the same way when installed on other Android versions in the range of 2.3.3 to 4.0.1.

4.1.8.1 Sample

According to Nielsen, any number of users that is greater that 5 is enough to uncover up to 85% of the problems of a system [47]. Eight Deaf (n=8) participants were selected from DCCT who were all semi-computer literate. Five out of the eight Deaf participants were part of the adult computer literacy classes at DCCT and are reasonably familiar with everyday ICT. SignSupport was not designed to be used by children but can be used by an adult on behalf of a child. Throughout the event activities, registered SASL interpreters were used, all of whom have worked with DCCT and BANG before in social and academic capacities, respectively. We also had eight Senior pharmacy students from UWC School of Pharmacy. All these participants were both computer and text literate.

4.1.8.2 Procedure

Deaf participants

Deaf participants were invited from DCCT to the School of Pharmacy at UWC for the SignSupport trial. When they reached the venue they were briefed about how the roleplay was going to be conducted and the rules to follow. All participating Deaf users were given a number and a mobile device that had SignSupport pre-installed but not set up. The number that Deaf participants were assigned was identical to the number of the mobile phone they were given. This helped in identifying which users had which mobile phone without using the participants' names. This was important later when the researchers were accessing participant profiles on SignSupport since their profiles were password protected. Deaf participants were assigned a pharmacist who had a matching number so patient 1 used mobile phone 1 and received pharmaceutical instruction from pharmacist number 1. Participants were asked to sit on one side of the room separate from the pharmacists. They assumed their positions in the lab and a scenario describing the pharmacy was explained. Once they were informed about the rules of the roleplay, they were asked, through the interpreter to turn on their mobile devices, set up a four-digit PIN and input background information into the system while they waited for a 'dummy' prescription to be handed to them [43]. After a couple of minutes waiting, Deaf participants were given a dummy prescription and informed that they had just consulted with a doctor, been diagnosed and were waiting in a queue for medication collection from a pharmacist. Patients were informed that it was their turn to collect medication by a member of the research team acting as a hospital staff member. The simulated hospital staff member fetched patients waiting in a queue one at a time to the pharmacist counter where the Deaf patient handed over the paper prescription and the mobile device running SignSupport to the pharmacist who then dispensed 'dummy medication'. After the dispensing transaction, the pharmacist gave back the device with pharmaceutical instruction to the patient who was then asked to review the instructions while still at the counter. When the Deaf patient was satisfied with the SASL explanation just viewed on SignSupport, s/he took the medicines and left the counter. When one patient left the dispensing counter another was called and the same process was repeated until all the participants had been called forward. Deaf participants were then asked to answer a questionnaire (see Appendix H) and participate in a focus group discussion immediately after they had finished with the roleplay [43].

UNIVERSITY of the WESTERN CAPE

Pharmacy participants

Senior pharmacy students were randomly assigned numbers that matched a Deaf patient's number and a mobile device running SignSupport. Since we wanted to create an environment that matches the real pharmacy scenario, student pharmacists were asked to wear professional attire. They were also asked to sit on the opposite side of the room away from the Deaf participants to avoid any interaction before the roleplay. Pharmacy participants were asked to approach the counter, and patients were called to the front to collect their medicine. The pharmacists used the phone and the (dummy) doctor's prescription (prepared earlier) to dispense medication without directly communicating with the Deaf patient because that was impossible as none of the pharmacists knew how to communicate in SASL. Pharmacist participants were also asked to answer a questionnaire (see Appendix G) that enquired about the usability of the software and what they would like to see improved [43]. After all participants had finished with the roleplay exercise they were invited to answer a questionnaire and to join a focus group discussion where they were asked to provide feedback.

Interpreters

In all events that required the interaction of Deaf participants, an interpreter was booked to facilitate communication between Deaf participants and hearing members of the research group. When Deaf participants entered the mock-up pharmacy dispensing room at theroleplay UWC School of Pharmacy, they were briefed by the research technical team and the information was translated into SASL. During the trial, sign language interpreters were responsible for taking instructions from the roleplay leader and conveying those instructions to Deaf participants. All verbal or written instructions that were shared during the trial were translated into SASL by the interpreter. However, once the roleplay session started the interpreter did not assist any of the participants with using the system. To elicit responses from both user types, we handed them a paper questionnaire and used sign language interpreters to read and interpret the questionnaire for the Deaf patients because we always assumed that they were text illiterate. The sign language interpreter was instructed to interpret the contents of the questionnaire as closely to its written counterpart as possible for all Deaf participants in order to elicit consistent results. Pharmacy participants were left to answer the questionnaire on their own because they can read and write. At the end of the roleplay all participants were invited to take part in a focus group discussion. The interpreter was asked to stand

UNIVERSITY of the
WESTERN CAPE

in a position where all the Deaf participants could see her when she signed and where she could be heard by everybody listening. Next to the interpreter we placed a video camera that recorded video footage of the participants and also captured her voice.

4.1.8.3 Results

During roleplay we were able to uncover some usability issues. Figure 4.1 shows three important aspects. Firstly, out of eight users four reported that they did not get lost while using the system while they were setting up their personal information or viewing pharmaceutical instructions. User navigation for Deaf participants is dictated by the videos they are watching. The other half of the Deaf participants found navigating the system very challenging. This was a surprise to the technical team since Deaf participants had been in a training session only 24 hours earlier. None of the these participants seemed to struggle in the training session. During the focus group discussion that was conducted after the roleplay some Deaf participants reported that they were confused by the number of medicines that appeared for them to review. The problem was that all the medicines had the same icon with different labels in text. Having one icon represent many different medicines was confusing to the Deaf participants because in the training only one medicine example was shown. Although half of the Deaf participants reported that they occasionally got lost in the application, they showed improvement after they had been helped by other participants who were sitting next to them. We later discovered that it was not the application itself that was confusing for some of the participants, but the idea that they had to 'touch' the screen was slightly daunting for them. For instance, dealing with the virtual keyboard on the Samsung devices was a relatively new experience for them (especially the older participants) because Android keyboards differ from phone to phone.

Secondly, all Deaf participants said they prefer to use SignSupport to collect their medication from the pharmacist as seen in Figure 4.1. They reported that it was much easier for them to use SignSupport as opposed to trying to interact directly with a pharmacist who cannot communicate in SASL. SignSupport has a built-in reminder system. This means SignSupport is not just important for them while at the pharmacy counter for explaining pharmaceutical instruction but also important for reminding them when

UNIVERSITY of the WESTERN CAPE

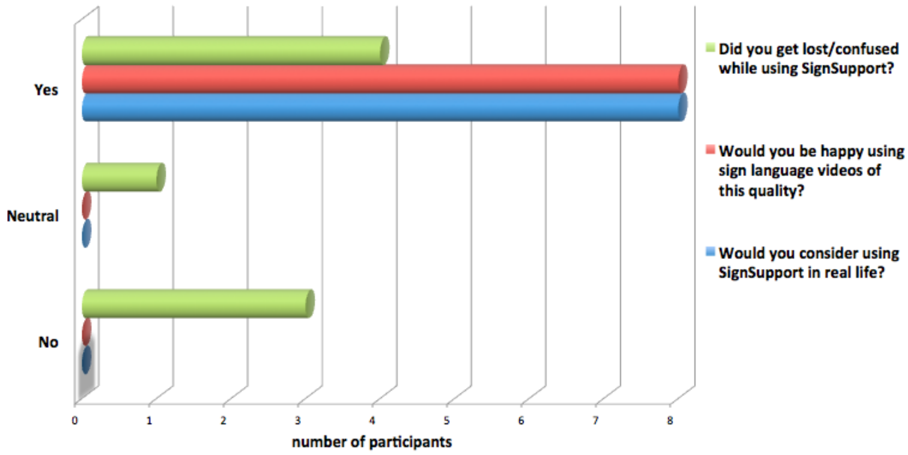

FIGURE 4.1: **Deaf trial results.**
Showing Deaf user navigation results. Showing the results for navigating the entire system. Navigation instructions are given by the signer at the end of the video after the intended information has been shared with the user.

to ingest medication or when they were about to run out of medication. This made SignSupport even more attractive to Deaf participants.

Lastly, there was a general agreement among Deaf participants (even from those who struggled) that it was easy to use and they would use it in real life. Deaf participants accepted the system. However, they expressed concerns that pharmacists and other patients would not accept the software at real pharmacies because they feared that they would be singled out and seen as being different from other patients. We explained that the hospital staff would be informed of the technology when it is ready for deployment.

UNIVERSITY of the
WESTERN CAPE

Pharmacists had no problems navigating or using any part of the system for dispensing. They quickly understood what the system was for and how it worked. During the training session (the first time they had seen the system) they were already suggesting complicated changes like having the patient view the prescription instructions at the counter. This change was significant for the pharmacists' code of ethics. From the system's point of view, it meant that the entire Deaf user side of the application had to be joined with the pharmacist side, a feature that was previously not there. The student pharmacists we worked with in this trial were relatively young which explains their speedy learning of the system. These participants come from a rich culture of smart phone applications and learning how to use cellphone applications was easy for them.

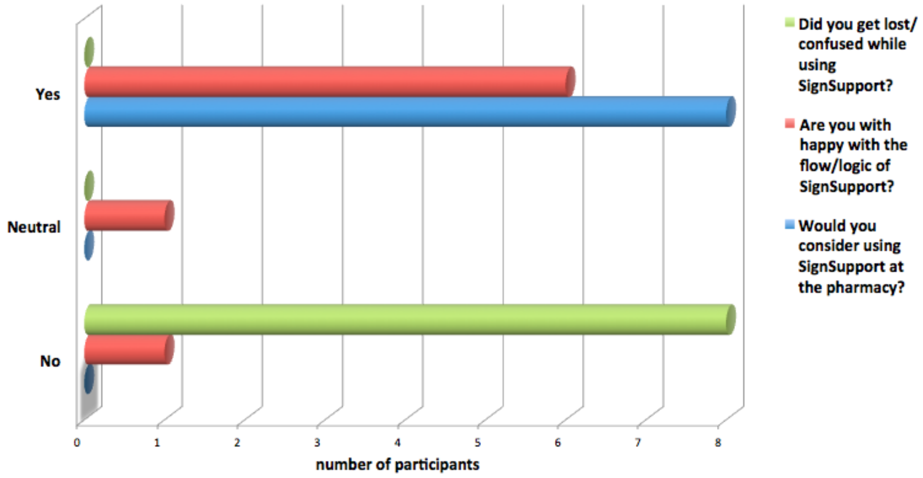

FIGURE 4.2: **Pharmacist trial results.**
Showing the pharmacists' user navigation results. This graph shows the results for navigating the entire pharmacy dispensing side of the system.

Figure 4.2 shows how the application was received by the pharmacy participants. These questions were asked after student pharmacists had performed the roleplay. The questions investigated how pharmacists feel about navigating the system and if they would consider using it in real life to dispense medication to a Deaf patient. Concerning navigation of the system, all pharmacy participants showed complete fluency after having just a short training session. Figure 4.2 shows that none of the participants had problems navigating the system and they always understood which part of SignSupport they were in and what they were doing there. From Figure 4.2 we can see that 87% of the pharmacy participants were satisfied with the flow and logic of SignSupport.

It can be seen from Finally Figure 4.2 that 100% of the student pharmacists will use SignSupport to dispense medicines and to share pharmaceutical instruction with Deaf patients if given the option. Pharmacists reported that the system was easy to use. They suggested that it was much better to use the system to dispense medicine to a Deaf patient than to try to fumble through explaining instructions with broken gestures. The average dispensing time using the system was 4:23 minutes (see Table 4.1). In the first run of roleplay, pharmacists dispensed medicine without SignSupport and their average dispensing time was about 9:55 minutes per hearing patient. Pharmacists reported that the system was direct and succinct when giving explanations and instructions.

UNIVERSITY of the
WESTERN CAPE

TABLE 4.1: **Comparing dispensing/collecting with and without SignSupport.** A comparison of how the process of dispensing differs when using SignSupport. This also shows the differences between dispensing to a hearing patient and a Deaf patient.

Dispensing	without SignSupport	with SignSupport
Time (minutes)	9:55	4:23
Language	variable	SASL and English
Patient-pharmacist interaction	direct	passive
Pharmacists preferred	–	preferred SignSupport
Deaf participants	–	preferred SignSupport
Dispensing procedure	flexible	rigid
Alarm	none	present

4.1.8.4 Analysis

During training Deaf participants seemed to be more relaxed and more willing to help each other. This led us to assume that they were comfortable with how to use the system. In hindsight we could have practiced more complicated examples on how to better use the system, or even if we had spent an extra hour performing drills it would have benefitted Deaf participants. The change of environment did not help calm the nerves of Deaf participants. They had been trained at DCCT and the trial was conducted at UWC, a new environment that could have affected their performance.

UNIVERSITY of the WESTERN CAPE

In the focus group session that was held at the end of the roleplay some Deaf participants raised the issue of having had one icon represent multiple medicines. They suggested that we rather use a different color icon to show different medicine names. In the next iteration of SignSupport this change was incorporated.

Student pharmacists were adept at using SignSupport after just one session. They suggested a change that was important on two fronts. The first had to do with their code of ethics, which loosely states that before a patient can leave the counter after being handed medication, they have to show/prove that they have understood the instructions. The second had to do with changing the navigation of the system and joining the two interfaces such that one pours into the other seamlessly. In order to make sure that SignSupport is in line with the code of ethics of pharmacists, we had to connect the two interfaces in the next iteration of SignSupport such that immediately when the pharmacist hands the phone back to the patient s/he is confronted with a screen that asks her/him to continue viewing the medical instruction.

TABLE 4.2: **Events that led to the iterations of SignSupport.** Showing a series of events that led to the development of SignSupport. Every row represents an activity that was done either with the participants or with the technical team and results of every process influenced the current version of SignSupport.

Event	Result	Outcome
Focus groups	Find a cellphone solution to break the communication barrier	Decision to develop a Android application with self contained SASL videos
Paper prescription	Paper drawings of different interfaces from Deaf participants	Design engineers design a concept of the UI from user drawings.
Role plays	Collection of conversations	Beginning of conversation script
Extraction of conversation	Conversation script from video recordings	Include the patient background data to the conversation script
Find medicines and illnesses	100 most common illnesses and all medicines	Reduced from 100 to 57 due to language complexities. Only oral medicines included
Prescription review	Add all elements of the paper prescription	Reduced prescription with summary screen
Recording SASL videos	180 videos recorded	35 needed re-recording and and verification
Training and trial	Patients must be forced to watch medicine instructions at counter	Pharmacy navigation and icons changed

4.2 Verification events

This section details the three major events to record and verify the content and position of the videos that are used inside the system. Each subsection details the sample that was involved, procedure, results and analyses the outcomes of each process. Table 4.3 summarizes this section.

4.2.1 Initial video recording

This is where the conversation script (see Appendix I) was converted from English text into SASL videos

4.2.1.1 Sample

An Interpreter, a informed Deaf person (signer), a Deaf education specialist and the author were present during the initial recording of SASL videos.

4.2.1.2 Procedure

We started by going through the conversation script with the interpreter. The interpreter first familiarized herself with the content of the script. The content script is numbered and divided into three sections. These divisions in the script matched the partitions found in the application (background set up, pharmacy-patient interaction and the prescription view). The interpreter read the text on the conversation script and translated it for the Deaf participant who was the signer for the system. The Deaf participant only needed to repeat the information that was shared to them by the pharmacist. When the Deaf participant was ready to sign what was on the script we set record on the video camera. Before she signed, we placed a leaf of paper in front of the video for a few seconds. The paper showed what video was being recorded, as the paper had the same number as the sentence being recorded.

UNIVERSITY of the
WESTERN CAPE

4.2.1.3 Results

At the end of the session we had recorded 180 videos, effectively converting the conversation script into a SASL video library for limited communication exchange at the pharmacy. The videos were still raw at this stage, not yet ready to be uploaded into SignSupport. Editing the SASL videos was the next stage that followed this process.

4.2.1.4 Analysis

Given the length of the conversation script and the time frame which we had to record videos it would have been better to email the conversation script to the interpreter several days in advance. Learning the script during the recording process was not ideal because it confused the Deaf participant signing the videos. It would also have been better for the signer if the conversation script were drafted with the help of the interpreter. In this way, the interpreter would also have had a better understanding of the context of the sentences.

4.2.2 SASL video content verification

To establish sign language video correctness, we were not testing SignSupport itself, but rather using it as a tool to verify the content and position of the sign language videos within the prototype. This section details the events following the procedure (see Chapter 3, Section 3.3.2.2) to test whether the videos on the system gave the correct information about the prescribed medication.

4.2.2.1 Sample

An interpreter (different from the one used in the initial recordings) was present, a Deaf participant (same person who signed the videos on the system), a pharmacist and the author. The interpreter was the one who was being asked to interpret the videos. Whenever there was confusion about a sign, the Deaf participant would then be asked to correct or justify why that particular sign was used.

UNIVERSITY of the
WESTERN CAPE

4.2.2.2 Procedure

The SASL videos were copied to a computer and placed in a randomized manner so that only the researcher knew which video would play next and what it was supposed to mean according to the conversation script and the watermarking placed on it during the initial recording. The interpreter watched the videos one at a time and voiced the meaning of the video. If there was a contradiction, we re-visited that video and let the Deaf participant and the pharmacists discuss it and explain to us why the video is confusing. We did this for all the videos in the system. The following tools were used: a computer, a second monitor, pre-recorded SASL videos, an interpreter and a conversation script.

4.2.2.3 Results

During the content verification procedure, 35 sign language videos were found to be either undecipherable, ambiguous or their content did not match the conversation script (as shown in Figure 4.3). Most of the videos could be understood at first glance. Some were unclear because of the signs that were used. Others were discovered to be unusable because they did not convey the information in the most understandable/desirable format. However, all SASL videos that were stored and used by the system were found to be in the correct position. The video verification test showed that out of 180 videos only 35 could not be used and require re-recording. This translates to 80.6% usable videos. We found that all videos that dealt with a patient consuming one tablet/capsule a day were misleading and thus could not be used. For example, the video saying "take one tablet once a day every 24 hours after meals" was interpreted in sign language as "take one tablet every morning once a day every 24 hours, every 24 hours". Furthermore, "take one tablet every 6 hours four times a day after meals" was interpreted as "take a tablet four times a day after meals, 6 hours after, 6 hours after, 6 hours after, 6 hours after (sic)". One interpretation is that the repetition is for emphasis (there was a disagreement about this between interpreters). However, the lead pharmacist insisted that any confusion about medical instructions must be eliminated since it could lead to patient overdose. This problem of repetition was not true for all videos, but only for the 24 hour videos and some of the 6 hour videos. This is not acceptable for pharmaceutical purposes and all faulty videos were recorded again in the next iteration. The rest of the videos passed the verification procedure and could be understood by the interpreter, and conformed with the corresponding information on the conversation script.

UNIVERSITY of the
WESTERN CAPE

Pharmacists were also asked to perform content verification on SignSupport for the side that deals only with medicine dispensing. Here pharmacy participants were given a randomized list of medicines (414 out of 1179) that are on the system. Pharmacists tested the entire collection of illnesses that SignSupport contains (57 most common illnesses seen in public hospitals). Out of the 414 medicine names that were tested for correctness 8 were found to be incorrect which amounted to less than 2% of medicine names that were tested. Out of the 57 that were tested only 9 illnesses were found to be spelled incorrectly. The 9 illnesses account for 0,2% of the medical conditions that failed the test. Both tests looked at how to spell or represent medical conditions and chemical names for medicines. We chose chemical names because commercial names normally change after several years. During the test pharmacists were also encouraged to comment on the structure/logic/flow of the system during dispensing. Participants were happy with the flow of SignSupport when it came to dispensing medication.

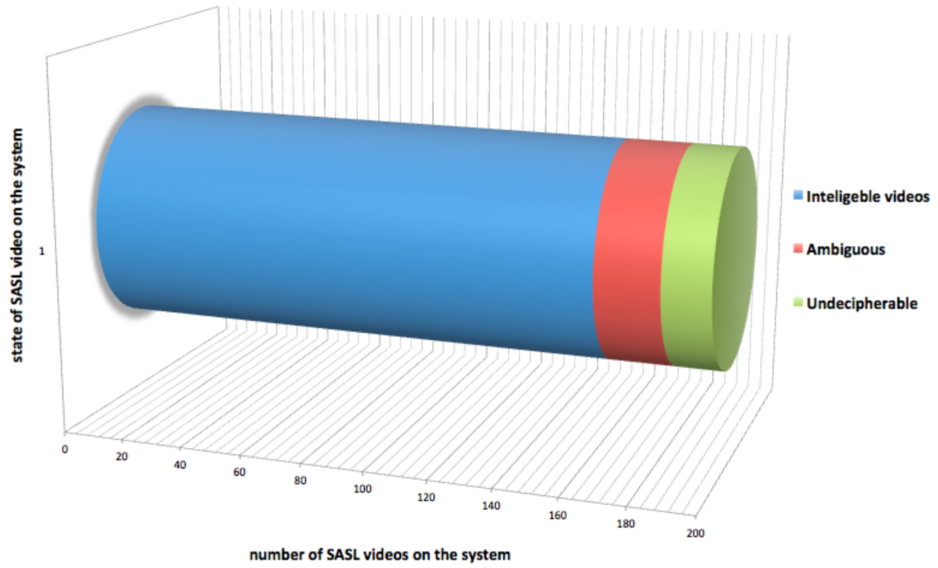

FIGURE 4.3: **Video content correctness results.**
Showing video verification results where all SignSupport SASL videos were tested for content correctness and position. The figure shows different types of errors that were discovered during verification.

UNIVERSITY *of the* WESTERN CAPE

4.2.2.4 Analysis

There were 35 videos that were faulty. Those videos have been re-recorded. They will follow the same procedure before they can be loaded into the system again. The pharmacy side of the application was also tested for content correctness, and here we found spelling errors for some medicines and illnesses. Since these are text, we edited the file that contains the two lists by hand. In the initial recordings, we opted to use a Deaf participant to sign the videos in the system. This was a good idea in that we could capture exactly how lay Deaf people will sign certain signs.

4.2.3 SASL video position verification

Position verification had to do with information appearing at predictable places when the user requests it (see Chapter 3, Section 3.3.2.2). Below we detail the procedure undertaken to test if the position of the SASL videos are found in the correct screen activities.

4.2.3.1 Sample

An interpreter, a pharmacist, the author and SignSupport were used to conduct this test. SignSupport was not used as a communication/dispensing tool here, but rather as a verification tool.

4.2.3.2 Procedure

We verified three parts of SignSupport the pharmacy-dispensing, background set-up and Deaf-dispensing view. For the pharmacy-dispensing side we tested the semantic representation of information, because this side of the interface belongs to the pharmacists and is thus heavily text based. The pharmacy-dispensing side is text based. The most common HCI pitfalls of such design methods are misspellings [35, 41] of text information, in our case information like medicine names, illnesses and dosage times. The background set-up contains 18 SASL videos. These are short sign language videos used to extract personal information from a Deaf user when using SignSupport for the first time. For the Deaf-dispensing view, there are 162 instruction videos that had to be verified for content correctness. These are the videos that are responsible for communicating specific information about the medication that the patient has been prescribed. For this test we systematically went through the whole application and tested every single SASL video that is in the system.

4.2.3.3 Results

All the SASL videos appeared in the correct position. The videos that were deemed unusable were re-recorded and once are loaded into the system will undergo the same procedure for content verification.

4.3 Summary

This section summarizes the results for improving SignSupport's UI and the verification of the video content. We showed results to help answer the research questions raised in Section 3.1. The first question was: how to improve a UI so that it can help a

UNIVERSITY of the WESTERN CAPE

TABLE 4.3: **Events that took place during verification.**
Showing events that took place during video recording, content verification and position verification. We show how each event produced results that influenced the make up of SignSupport. These events are not specific to SignSupport but can be applied to verify content correctness in other applications that use video.

Events	Results	Outcomes
Initial video recording	Conversation script converted to SASL video library	Edit the raw footage
Content verification	Some videos are ambiguous and others do not match the conversation script	Videos for re-recording identified
Position verification	All videos appear in the correct position	—

Deaf person receive pharmaceutical instruction from a pharmacist who cannot use sign language.

To answer this question we had a long series of user interaction events, culminating in a mock pharmacy trial. Some Deaf participants found navigating the system challenging (see Figure 4.1) after the first try but this is mainly because of the new UI that they were not used to (new icons, new keyboard, touch screen UI and application flow). Deaf participants showed interest in SignSupport and said that if it were made available they would use it. Pharmacists were also tested in the same roleplay. Pharmacy participants gave positive feedback about the flow and functionality of the system and all claimed that they would suggest to other pharmacists to use SignSupport to dispense medication to Deaf patients. All pharmacy participants completed every task with fluency. They claimed it was a new experience dispensing medication with a supporting tool. Pharmacists reported that it was easier dispensing medication with SignSupport than it would have been without it (see Table 4.1). They raised the issue of communication i.e. that in a real situation they would have encountered a problem if they could not be understood by a patient during dispensing. Pharmacists reported that SignSupport has a similar flow to the paper prescriptions that they normally used. All participants said that if SignSupport was available they would be happy to use it for communicating pharmaceutical instruction.

UNIVERSITY of the
WESTERN CAPE

The second part of the research question was how to improve content correctness such that English text instructions on the system match the SASL videos in the system and that the information exchange between the two users is always correct. According to classifications listed by the European Health Commission [23] SignSupport is medical software. All medical software that accepts, manipulates and feeds any information that deal with a patient directly or indirectly has to be content-verified before it can be deemed safe for use in the real environment. We used SignSupport as a tool when verifying its content. Content verification was done based on two parameters; 1) to show that the correct video appears at the correct position and time, and 2) the SASL video that appears relays the correct information that was intended. The results discussed above show that 1) we can improve visibility, and 2) improve content correctness of a communication tool with two different interfaces on a mobile device to seamlessly facilitate the transaction of medicine dispensing at a hospital pharmacy between a Deaf person and a hearing pharmacist while ensuring that the information sharing process between the two users is accurate enough to be shared.

UNIVERSITY of the
WESTERN CAPE

Chapter 5

Conclusion

This chapter concludes the thesis. Section 5.1 answers research questions posed in Section 3.1. Section 5.2 discusses the limitations to our methodology. Section 5.3 explains the limitations of the system. Section 5.4 discusses lessons that were learnt during the study. Section 5.5 provides guidelines for working with Deaf based ion our experience. Section 5.6 discusses future work to enhance the functionality of SignSupport.

UNIVERSITY of the
WESTERN CAPE

5.1 Answering the research questions

5.1.1 Improving usability

The system's frontend was improved from previous versions with two main thrusts. We improved the 1) navigation tools (meaningful and personalized icons which participants designed) and, 2) the videos (highest resolution sign language videos on the mobile application) which Deaf participants liked very much. The driving force toward improving our system was the use of iterative development. The pharmacy side of the system was refined over time to provide only the attributes that were important to dispensing. All pharmacists were comfortable using the interface for dispensing and they unanimously agreed that dispensing with SignSupport was more convenient and safe for the patient. Then we ensured constant user feedback was always incorporated into the next iteration of the system. A rigid series of events (see Figure 3.4) were applied in a strategic way such that user feedback flowed into the next event.

To improve usability we noticed that many of the applications Deaf people use for communication are text based. Systems like MobileASL and ASRAR are designed for deaf[1] users and thus incorporated text for navigation. TTYs and ADSs are also text based, VRSs require expensive equipment and TESSA was not mobile, meaning users could only access it in one location. ASRAR and TESSA use avatars which are not popular in the Deaf community.

In the developing world these factors dramatically reduce usability of a system for Deaf users. SignSupport only uses sign language videos and user designed navigation controls and the familiar paper prescription logic flow which has shown to improve usability for pharmacists. In stead of using an avatar we video recorded a member of the community, making SignSupport more relatable to Deaf users. From the results discussed in Chapter 4, Section 4.1 we noticed that user interest in SignSupport was high. Given the events that took place during this research and participant responses we can adequately declare that we have managed to improve SignSupport's usability from previous implementations.

5.1.2 Ensuring content correctness

UNIVERSITY *of the*
WESTERN CAPE

Content correctness involved two aspects, 1) position and, 2) content correctness. ADSs are tested empirically, however the results of their testing protocols are not publicly available (for commercial reasons) so a true comparison with SignSupport cannot be made. To ensure correctness of the two categories we developed a multiple layer testing procedure that involved interaction with an interpreter, a informed Deaf person (signer) and the conversation script. The interpreter, Deaf participant and the conversation script had to all agree that a video communicates what was originally intended and that it appears were it was expected. The procedures described in Section 3.3.2 ensure that every video in the system is where it is supposed to be. Should there be a video that is faulty we also described a method to detect that possibility in Section 3.3.2. We ensured that 80.6% were usable videos in the first iteration and re-recorded the rest (refer to Chapter 4, Section 4.2). Unlike with AI systems (TESSA and ASRAR) where one phrase in the look-up dictionary can be re-used by different avatars increasing the possibility for error, SignSupport uses a one-to-one system. Each instruction has its own

[1]People who are 'deaf' and fluent in reading/writing text.

unique SASL video, meaning that once we tested for correctness we can guarantee that a specific instruction will always provide a specific video.

5.2 Research limitations

This section discusses the limitations of the study. We present challenges that we encountered during interaction with both Deaf participants and pharmacy students. We conclude this section by discussing how these limitations could be lessened and how our procedure can be used in the development of other systems that bridge communication difficulties.

5.2.1 Sample size

Deaf participants

We had a varying number of Deaf participants ranging from 1 to 9 depending on the experiment to be conducted. DCCT has approximately 2000 members. We were interested in members who are semi-computer literate. W chose roleplay because we wanted to test SignSupport at a functional level and this sample was fluent enough to let us do so. The next iteration could possibly include a more realistic and varied sample. We had two interpreters for eight Deaf participants in focus group discussions. Since they could not both sign at the same time they took turns. This was also done so that the interpreters do not get overly fatigued.

UNIVERSITY of the
WESTERN CAPE

Pharmacy students

Senior student pharmacists were chosen because they are allowed to practice dispensing at local pharmacies. They possessed the right amount of dispensing experience. The smallest number of participants used for an experiment was 2 and the highest was 10 student pharmacists. Although is was convenient to use student pharmacists, we always had trouble booking them for sessions because they have a very heavy course load. At some point, qualified pharmacists should be engaged.

5.2.2 Methods

Community-based co-design

At the beginning of this study it was decided that it was best to involve users in the design and development of the system. This was a brilliant idea that soon became increasingly more difficult to implement after the first roleplay and user interface drawings exercise. We wanted a very specific user group of participants, who also happen to be staff members at DCCT. Aside from drawing the initial interface they did not directly influence the application design. A challenge is that co-design principles required that participant communities be present at all critical design meetings. Deaf participants were not present, nor were pharmacy students. Their inputs were captured after major events like roleplay and video recording sessions. However, both participant communities had proxies in the design meetings. Figure 3.3 in Chapter 3 shows an idealized structure of who should be the major players in a community-based co-design driven research project. Since the research communities are so far from one another (30km one way) it was a major problem to get participants in the same meeting every week. Moreover if we had Deaf participants in a meeting we would also need the help of professional interpreters, who are busy and expensive to hire. When it comes to pharmacy students, their course load would not allow such frequent meetings. These were final year students who had to work outside campus as part of their graduation requirements. During office hours they were in class and after office hours they were working at local pharmacies.

UNIVERSITY of the WESTERN CAPE

Multidisciplinary collaboration

The nature of our research is such that it required specialized input from different view points from both pharmacy and Deaf communities. To account for this we introduced a multidisciplinary team. The role of the multidisciplinary design team was to highlight the fine details of their respective communities and not to impose their own ideas on the system. This was particularly challenging for the primary researcher because often he was torn between two or three members of the team. Below are two challenges that were faced using this methodology:

1. Crossover input.

   An example was when one member of the team made a suggestion that attempted to change the logic of the system on the side of another community. Design members were not told from the beginning that they should only contribute based on their expertise. It was assumed that they would be limited to their own field when it came to contributing requirements during design. This led to debates that were useful some times and not very useful sometimes. For example, a Deaf education specialist in the team suggested an interface modification that was not expected in the initial design (system personalization). This created a chain of unexpected events, since the design engineers had already turned in their 'final design sketches' it meant that the computer scientist had to assume the role of designer. The other example was when the lead pharmacist suggested an interface change on the Deaf-participant side of the application. This could have a had negative impact for Deaf participants because we planned to keep the system logic separated in order to minimize confusion. In both the examples given above, the result was eventually positive and the crossover input from the design team worked well enough, but could have easily gone in the other direction.

2. Self appointed proxies.

   This is when a design team member appoints themselves to be their respective community's proxy. Initially this seemed like a good idea and was an easy way for the design team to have meetings that were controlled. Instead of having real members of the communities in our monthly meetings we automatically used members of the design team to represent their respective communities (Deaf community and pharmacy community). This would have been a good idea if those design team members went back to their respective communities and had a discussion about the contents of the design meetings, received feedback and funneled this back into design requirements. However, this did not happen, so we always received the design members' points of view. This was useful, but ultimately not a true reflection of the community itself.

Both issues raised above were a spill-over effect from the community-based co-design method. The fact that these communities were so far away from each other challenged silo-oriented roles of the design team. Had actual participants from both communities attended design meetings it is possible we would have had a different solution to the same problem of communication. The design team was able to take the back seat during training and trial roleplay because the communities were represented in person.

UNIVERSITY of the
WESTERN CAPE

Agile methods in our context

We used an iterative development principle in software engineering that allowed us to consistently feed new requirements into the system. This method was suited for this type of research because we wanted to improve the system as much as we could in a limited timeframe. The problem here was that with each iteration the system became more and more complex. Each iteration was adding more functionality to the previous one. At the beginning of the project our goal was to keep the system as simple and intuitive as possible. A fundamental difference between Agile methods and traditional software methods such as the Waterfall or the V-method is that they assume it is possible to gather all the user requirements at the beginning of the project [19]. Using Agile methods made it difficult to decide what to include and what to exclude because of the rate at which new requirements were brought to our attention. This creates a problem of having more functionality which translated into more things to test, for example, the reminder system. To address this, the design team (not the actual participants) was constantly given demos for each iteration to evaluate and suggest changes. Although it was difficult to keep up with the rate at which requirements were introduced, Agile methods were in principle well suited to our study.

UNIVERSITY of the
WESTERN CAPE

5.2.3 Generality

The methods implemented in this thesis were not specific to our research. Our methods could theoretically be modified to apply to other contexts that deal with multiple communities. One aspect of this study was to concentrate on how to manage and process user requirements from users who have different needs concerning communication. Many different scenarios in everyday life occur where two individuals fail to communicate because of a language barrier. In our research we described a method to study two people struggling to communicate and only extract the most relevant aspects of their conversation. We then designed an ICT UI that binds that conversation to make sense for both parties. Our research methodology applies not only in improving communication between a sign language user and a hearing person, but also could be applied between two hearing people who use different languages like isiZulu and South Sotho, or any combination of spoken and/or signed languages. If there is a limited domain scenario in life were the conversations are predictable and simple enough to follow, then a conversation can be mapped and the same procedures/events (see Figure 3.4 and Figure 3.9) described in this thesis can be applied.

We also describe a generalized strategy to load conversations (see Figure 3.7) onto a system and ensure that it is correct (see Figure 3.8). For our study we implemented loading videos and testing for correctness. In theory it does not matter what type of content is being loaded to a system that accepts limited conversations. So the same strategies are suited for any limited content loading and content correctness testing system. The 8 events that are discussed in Figure 3.4 are only specific to limited content exchange scenarios not exceeding two communities. The more you increase the number of communities the more complex the design space and events leading to conversation mapping become, and the more difficult it becomes to manage the multidisciplinary design team for that project.

5.3 System specifications and limitations

Like any software system SignSupport has limitations under which it must be used in order to get the most benefit from it. Below is a detailed description of the system specification and limitations.

UNIVERSITY of the
WESTERN CAPE

5.3.1 System specifications

SignSupport's was designed to fill the entire length and width of the screen so we edited the video size to be 640x700 (width and length) in MPEG-4 format. We chose 640x700 dimensions because we can programmatically manipulate the video length and width (dimensions) without distorting or introducing black bars on the video when it is being viewed on different sized screens. Should new SASL videos be recorded and loaded into the system, they should possess the attributes that have been mentioned above. Doing this will ensure that when the need to install the SignSupport on a mobile device with a smaller or larger screen, the SASL video will maintain its integrity. Interestingly, the bigger the phone's display the better the sign language video quality [43].

Only having a large video (length and width wise) does not ensure better video quality [9]. A great deal of effort was dedicated to the provision of high video quality to sign language users. The work done by the MobileASL and the ASRAR research teams, respectively, shows the importance of clear legible sign language videos irrespective of the type of sign language [8, 39]. For this reason, we dedicated considerable resources to the development of intelligible SASL videos on mobile devices as shown in Figure 3.10. MobileASL found that at between 10fps and 15fps users could not distinguish the difference in video quality [8]. This meant that users could not tell the difference between the two frame rates but does not suggest that users were happy with a sign language video of 10-15fps. The video quality is still poor at such low rates [9, 22] and unacceptable for sign language communication. A higher frame rate helps with legibility [8, 25] during video compression from MOV to H.246. Since a higher frame rate translates to a higher quality video we decided to record and encode SASL videos on the system with frame rates ranging between 25fps to 30fps. We converted recorded SASL videos from MOV (default camera recording format) because that is the format that our recording camera uses to H.246/MPEG-4 AVC (Advanced Video Coding), which is a standard of video compression that uses open source and also because MPEG-4 is the official video format for the Android OS [16, 41]. We coded the layer where the videos are displayed to be dynamic (see Figure 3.11) in order to correct for many different Android mobile devices with their differently sized displays.

UNIVERSITY of the WESTERN CAPE

A major requirement is that SignSupport must be installed and used on a device that supports a fully touch interactive display (see Chapter 3 Section 3.2.3 for further details). SignSupport cannot be operated from any hard key buttons that are found on the device because we disabled hard key buttons (see Chapter 3 Section 3.4.2). The reason for this is because we wanted SignSupport to work on as many Android devices as possible without having to alter its UI. The other more compelling reason is that of user navigation control. Eliminating the hard key buttons forces the user to interact directly with SignSupport in a predictable manner that we can control to eliminate errors within the system, running Android 2.2.3 to 4.0.1 with at least 2 gigabytes (GB) of external storage space or more. The external memory is used to house the sign language videos and user data. To process in near real time speed consecutive sign language videos and access patient data, a device with a minimum 1GB of Random Access Memory (RAM) and a back-facing camera.

5.3.2 System limitations

5.3.2.1 Context dependence

SignSupport is currently designed to function in one setting, the pharmacy setting. This is a limitation since Deaf and hearing people interact in many other settings everyday like police stations, libraries, air ports and many more public interaction. Should the desire to make SignSupport context free arise, this version of the system cannot be used in those contexts even if the supporting videos to that scenario are loaded. The interface of SignSupport is hardcoded to fit only the pharmacy context. However, the methodology used to design this hardcoded version of SignSupport can be used to develop more context free implementations of SignSupport. Although the actual application can not be plugged into a different context the lessons learnt in the development of our version of SignSupport can be applied in any context of interest to produce a context free solution.

5.3.2.2 Platform dependence

SignSupport is a mobile application that can currently run on many different versions and screen signs of Android devices. Although SignSupport can run on many different Android devices, Android is only one operating system in a pool of many, like iOS X from Apple, Windows Mobile from Microsoft and BlackBerry to name the most popular. The reason we initially chose to develop SignSupport for Android is that the software is Open Source and is available free online. The most important aspect of SignSupport for users is the UI. The UI used for the Android version could easily be adapted to other platforms should the need arise. The disabling of hard key buttons makes the UI hardware independent but not platform independent.

UNIVERSITY of the WESTERN CAPE

5.3.2.3 Physical device limitations

When the design engineer handed over the design sketches to the technical team, she had also designed a cellphone for her version of SignSupport which was initially designed for mid to high-end smart phones (not necessarily Android). SignSupport carries with it a limited set of conversation videos that are used to translate English text to SASL. These videos are stored on the device's external memory card and we consider this a caveat. This limitation meant that only a restricted set of videos can be stored and consequently only a limited set of conversations. Furthermore, SignSupport can only be used on a device that has a minimum of 2 GB memory.

SignSupport can only be installed on a fully touch enabled screen display. Devices with physical keyboards will not work on SignSupport because it has been programmed to set off all physical buttons except the Home or Cancel buttons for reasons discussed in Section 5.3.1. SignSupport was, however not tested on Android devices that had a hard keyboard as their primary keyboard. The space limitations are unbeatable, even if one had a 100 GB or 1 Terabyte (TB) of space it would still not be possible (at least to date) to encode all the videos for all the possibilities, illnesses and questions that could arise in any context including the pharmacy context.

5.4 Lessons learnt

UNIVERSITY of the WESTERN CAPE

In this section we discuss lessons learnt in the past 20 months of interaction with the target communities, interpreters, the multidisciplinary team and the system itself. We emphasize the problems of communication between the research team and the participants during the course of the study, especially during training and testing.

5.4.1 Conducting training/trials and presentations

This research was conducted in as human-centered a way as possible and our target Deaf group's opinions and suggestions were considered as first priority. The first challenge was communication [14]; how does one share information with Deaf users during presentation without spending too much time explaining every detail to the participants? One way to help conduct a PowerPoint-like presentation for Deaf people is that it has to be in SASL. Sign language is a visual language and the presenter has to speak as little as possible about what is on the slide, since Deaf people cannot be watching the interpreter and watching what is on the slideshow at the same time. Another issue was that in order to move to the next slide we had to get an 'OK' signal from all participants, and if something distracted them during a slide transition, then that slide must be repeated. This problem was particularly challenging when dealing with Deaf participants because instruction from the researcher must first go through the interpreter who then relays it

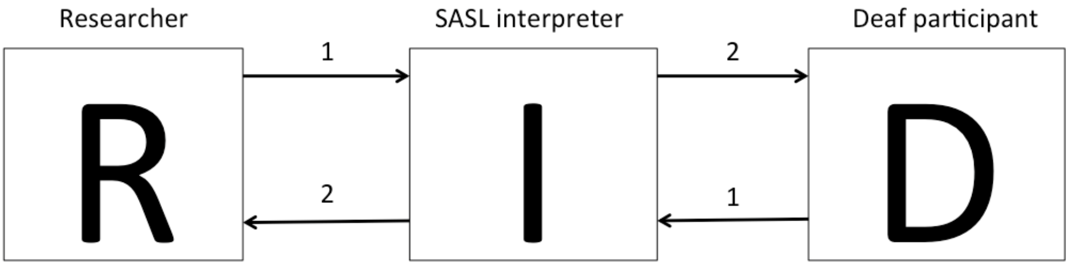

Figure 5.1: **Information exchange between participants.**
Showing how the communication between a researcher, SASL interpreter and a Deaf person transpired. Where the numbers show the amount of steps it takes before their message reaches its target.

to Deaf participants and if the participant has a question, it again passes through the interpreter, who then interprets SASL to English for the presenter (see Figure 5.1). In other words everything has to be repeated twice, making the session twice as long.

Consider this real life scenario experienced by researchers during one training session with Deaf participants. During the planing of the training, it was decided that the best way to conduct a training session with Deaf participants was to do it via a Powerpoint presentation with screenshots of every screen activity that they were expected to interact with in the actual trial. To avoid the to-and-fro exchange shown in Figure 5.1 between the researcher and the sign language interpreter, we opted not to use static screenshots but rather imbedded sign language videos superimposed on the interface [45] of SignSupport screens. Since the videos are in SASL and explain to the participants what needs to be done at every instance, we eliminated the sign language interpreting that would have cost us both time and user interest. SignSupport is a large system with numerous screen activities that need to be explained to Deaf participants. So we essentially planted all the possible screen activities in the presentation and made sure that they appeared in the same order as on the system itself [43]. We also took great care to minimize the text on the presentation as much as possible to keep in line with the suggestions made by Collins [14].

UNIVERSITY of the WESTERN CAPE

To ensure that participants did not lose interest in the training exercise, we divided the presentation into two parts, as it is divided on the system: the background data set up and the medicine review section. Eventually the presentation and training takes a practical turn, and it is at that stage the interpreter facilitates all interaction between the researchers and the participants. In our presentation, we had all eight participants simultaneously try to repeat what they saw in the presentation slides, which meant we had more participants vying for the attention of researchers and the interpreter. For training, we had two interpreters alternating during the course of the session and a Deaf education specialist who also assisted in relaying some information to the research team.

The most important lesson we learnt during the process of conducting training presentations was that it is important to have as many SASL interpreters as possible during the exercise in order to avoid fatigue. This is the most important part of the training especially if the researcher is not fluent in SASL. Also having a one-to-one ratio is essential when the participants are about to sign informed consent forms. Since we had only two interpreters for our training session, if there had been two Deaf participants who did not understand any aspect of the research or training it would mean that we would have to wait for one interpreter to finish interpreting for that participant before we could continue. Many times during the training Deaf participants had to wait for the interpreter while they were helping other participants, and this caused a slight agitation for waiting participants.

Student pharmacists were given a standard text and image driven presentation because these are students who receive presentations on a daily basis in their lectures. We had no communication issues with this target group. The results shown in Chapter 4, Figure 4.3 reveal that communicating with student pharmacists using a PowerPoint presentation was not a difficult task.

UNIVERSITY of the
WESTERN CAPE

5.4.2 Answering questionnaires for Deaf people

One of the ways in which we could elicit user feedback was to use paper based methods, such as issuing a Likert scale questionnaire (see Appendix B). Once again student pharmacists had no issue with understanding the questions and giving appropriate answers. The nature of the student pharmacists' background made it easy for them to answer questions quickly.

On the other hand, Deaf participants were for the most part functionally text illiterate. This meant they could not read and answer the questionnaire reliably on their own (even though some tried because of insufficient number of interpreters). An interpreter was used to interpret the questionnaire for Deaf the participants. The problem again as in the training presentation was with the number of SASL interpreters available for each participant. After participants had completed their section of the roleplay, they had to answer a Likert scale questionnaire with only two registered SASL interpreters at their disposal and eight Deaf participants which meant that if any other Deaf participant completed their roleplay session they could not continue answering the questionnaire but rather had to wait for interpreters to finish helping other participants. The waiting created a bottleneck and agitation in the trial room as waiting participants got distracted.

To solve this problem we suggest that future data gathering events between Deaf participants and hearing researchers be conducted differently. Its not feasible to employ eight, nine or even N number of sign language interpreters because of how rare and expensive they are in South Africa and the rest of the developing world. Information gathering should be done in a group setting where all participants answer the same question at the same time. This could be done by waiting for all the Deaf participants to finish their assigned task. Once all the Deaf participants are done with their given task they should be called to gather in a group (the same way they normally would during a focus group discussion). Each participant should be given a pen and a Likert scale questionnaire and told not to answer it until instructed to do so. Interpreters should also be given copies of the questionnaires beforehand so that they can read it and ask for clarification if there is some part they do not understand. In this way all the participants would be performing the same task at the same time. This method dramatically reduces the number of interpreters that would be needed to interpret for any number[2] of Deaf participants.

UNIVERSITY of the
WESTERN CAPE

The next challenge was how to structure a questionnaire so that we can extract the most relevant information from users? The first hurdle is to choose a Likert scale questionnaire because by its nature it is a rating system. This is particularly helpful when dealing with Deaf participants because the Likert scale questionnaire solves the problem of having Deaf users write out responses. The problem with using a Likert scale questionnaire, though, is that all the participants will reply only with the options that they have been provided and the researcher is possibly prevented from learning the true impressions of the user. To combat this problem, we decided to include a focus group discussion at the end of the questionnaire session. In this way users can provide controlled responses on

[2]We are not suggesting excessive numbers of participants, we mean a reasonable sample of between 5 to 20 participants.

the questionnaire and still get an opportunity to express other issues that were not dealt with in the questionnaire or even expand on the answers they gave in the questionnaire.

5.5 Guidelines for working with Deaf people

Below are a few suggestions to guide new research with Deaf people to ensure that the researcher elicits useful information.

5.5.1 Communication and Deafness

Communication is the most important issue, so hearing researchers interacting with Deaf participants is always a cause for concern. From day one of the research it was in the best interest of the researchers to establish the best way to communicate with Deaf participants. As explained in Chapter 1 being Deaf defines a sense of culture and identity, it is different from text based or spoken languages. The researcher therefore has to respect and be aware of the social norms (especially during a conversation) over the course of the research and incorporate that sense of culture into the research. An example of incorporating Deaf culture into SignSupport is during information sharing between the pharmacists and the patients. In Deaf culture it is considered polite to wait your turn to sign when having a signed conversation with someone. For example, one person signs, finishes then the other responds. SignSupport behaves the same way; whoever has a device has a right of way to share information, and the other has to wait.

UNIVERSITY of the WESTERN CAPE

5.5.2 Learning SASL

While conducting this research two out of five members of the research team did not take any sign language classes. This became a problem in the later stages of the research, for instance in the training and testing phase where more intimate interaction is needed between the participants and the researchers. Is it advised that future researchers learn SASL before they start interacting with Deaf people on research matters. This will help in understanding user needs for the research study. Learning SASL will also help researchers build relationships with Deaf participants.

5.5.3 Weekly DCCT meetings/visits

During the timeframe of this research we visited DCCT once a week to help maintain the network and other technology needs. The primary researcher was also involved in assisting with computer literacy classes that are offered at DCCT every Wednesday. In hindsight, this helped build friendships with the DCCT members of which some were part of the training and testing of SignSupport later in the research. Having been a familiar face at DCCT made Deaf participants more relaxed during the trial/testing phase, which meant they could give us more accurate and honest feedback.

5.5.4 Use of interpreters

Communication with Deaf participants would have been impossible without the help of SASL interpreters. Sign language interpreters are a vital part of any research that is conducted in partnership with Deaf people (even if the researcher can sign). So it is very important to choose an interpreter who understands the content/history/social impact of the research and has some pre-existing relationship with the Deaf participants. Interpreters are a link between researcher and participant, therefore building a good working relationship with interpreters is vital. It is advised that a minimum of two interpreters be booked for any session that involves interaction with Deaf participants. This will allow interpreters to work in sessions and avoid interpreter fatigue.

UNIVERSITY of the
WESTERN CAPE

5.5.5 Good planning

A good amount of time has to be spent on planning should the researcher intend to have any kind of interaction with Deaf participants. A structured procedure of how the researcher plans to conduct their session (whether focus group session, training or testing) must be provided. It will state without any ambiguity what the researcher tools are, including chairs, projectors, number of participants, number of interpreters and session durations. The researcher has to plan the interaction weeks in advance to allow for more experienced people who have been working with DCCT/Deaf participants to approve or make adjustments to that plan. Good planning also includes how the researcher plans to elicit information from participants, for instance the use of a short questionnaire because it is better than a long questionnaire for reasons detailed in Section 5.4. Most researchers are familiar with interacting with hearing participants. However, interacting with Deaf participants is a challenging task and a different experience altogether, not only because of their communication barriers but also because of their different social and cultural background. It is also necessary to manage the interpreter by assigning them shifts so they can rest in between. It is also worth taking the advice of people who have been working in this environment longer than the researcher very seriously as they can warn against common pitfalls that new researchers fall victim to.

5.6 Future work

The reminder system was implemented but not tested with users in this iteration. When the system is ready for use in the real pharmacy then the reminder can be tested. In this research we concentrated on the interaction that happens at the pharmacy during dispensing. Reminders take effect in hours or days, testing them with participants would not have been convenient for the participants since they were not really patients who needed to take any medicines.

The system has shown promise as an effective communication bridge between a hearing pharmacist and a Deaf patient. The following elements of the application and research can be enhanced to ensure its success in a real world situation. SignSupport was tested with student pharmacists, although this gave the researchers an idea of how pharmacists would perceive the system, SignSupport should still be introduced and tested by real practicing pharmacists in real settings. In this case it would be easy to measure the real quality of information exchange between the patient and the pharmacists.

The system is an 'internal sign language translation' system, internal in the sense that it incorporates a closed loop of limited conversations which typically take place between pharmacist and Deaf patient. The system does however not include some conversations that could possibly arise, for example if a Deaf patient had to pose a question, and pharmacist reply with an answer. To solve this problem the system might include functionality that allows for a video relay break-out, which will allow a video conference-type communication, whereby an off-site interpreter can relay SASL to English, for example, and vice versa. SignSupport will need a system of communication with an off-site interpreter should the Deaf patient be confused about the instructions that are

UNIVERSITY of the
WESTERN CAPE

given during dispensing. The technology used by MobileASL could be integrated to allow this breakout on a mobile device. This would make it possible for the pharmacist to explain the instructions to an interpreter who can then have a conversation with the patient. Given the compression techniques and the low bandwidth required, MobileASL could be a plausible breakout solution for SignSupport.

Although the system was designed, implemented and tested in a pharmacy context, the system could also be modified and applied to any context, e.g. a Police Station or Home Affairs. Furthermore, we also realize that this tool could be adapted to use any signed language, and could also be used with audio instead of video to serve the text illiterate in developing regions everywhere. These generalizations would entail building an authoring tool to allow the system to be context and (signed) language independent, and would make an even more valuable contribution to the computing for development community.

In the trial we had two interpreters for eight Deaf participants. This presented challenges because some Deaf participants had to wait for an interpreter while the other two were busy helping other participants with the questionnaires. In future trials it is advised that at interpreters should be half the number of Deaf participants.

UNIVERSITY of the
WESTERN CAPE

Should participants give any information that is personal it should be destroyed at the end (if study deals with medical information). Pictures/drawings and comments dealing with the application usability and design (non personal) information should be kept for future studies. The suggestion is that there should be two sections in the consent form that explains this process clearly.

Bibliography

[1] Y. Anokwa, N. Ribeka, T. Parikh, G. Borriello, and M. Were, "Design of a phone-based clinical decision support system for resource-limited settings," *In Proc. ICTD*, 2012.

[2] F. Banterle, A. Artusi, T. Aydin, P. Didyk, E. Eisemann, D. Gutierrez, R. Mantiuk, and K. Myszkowski, "Multidimensional image retargeting," *SA '11. ACM SIGGRAPH Asian*, vol. 5, 2011.

[3] K. Barker, R. Pearson, C. Hepler, W. Smith, and C. Pappas, "Effect of an automated bedside dispensing machine on medical errors," *Am J Hosp Pharm*, vol. 52, pp. 168–196, 1984.

[4] E. Blake, W. Tucker, M. Glaser, and A. Freudenthal, "Deaf telephony: Community-based co-design," in *Interaction Design: Beyond Human-Computer Interaction.* Wiley, 2011, pp. 412–413.

[5] S. Blankenberger and K. Hainj, "Effects of icon design on human computer interaction," *Int. J. Man-Machine Studies*, vol. 35, pp. 363–377, 1999.

[6] J. Borel and K. Rascati, "Effect of automated, nursing unit-based drug-dispensing device on medication errors," *Am J Health Syst Pharm*, vol. 52, pp. 1875–1897, 1995.

[7] E. Brewer, M. Demmer, B. Du, M. Ho, M. Kam, S. Nedevschi, J. Pal, R. Patra, S. Surana, and K. Fall, "The case for technology in developing regions," *Computer*, vol. 38(6), pp. 25–38, 2005.

[8] A. Cavender, R. Ladner, and E. Riskin, "MobileASL: Intelligibility of sign language video as constrained by mobile phone technology," *In Proc. SIGACCESS*, pp. 71–78, 2006.

UNIVERSITY of the
WESTERN CAPE

[9] A. Cavender, R. Vanam, D. Barney, R. Ladner, and E. Riskin, "MobileASL: Intelligibility of sign language video over mobile phones," *Presented at Disability and Rehabilitation: Assistive technology*, vol. 3, no. 1–2, pp. 93–105, 2008.

[10] N. Cherniavsky, J. Chon, J. O. Wobbrock, R. E. Ladner, and E. A. Riskin, "Activity analysis enabling real-time video communication on mobile phones for deaf users," *In Proc. UIST*, pp. 79–88, 2009.

[11] P. Chininthorn, *Communication Tool Design from Deaf to Hearing in South African*. Unpublished MSc thesis, Delft University of Technology, Netherlands, 2011.

[12] P. Chininthorn, M. Glaser, A. Freudenthal, and W. Tucker, "The design of a Deaf-to-hearing communication aid for South Africa," *In Proc. IST-Africa*, 2012.

[13] J. Chon, N. Cherniavsky, E. Riskin, and R. Ladner, "Enabling access through real-time sign language communication over cell phones," *In Proc. IEEE Signals, Systems and Computers*, 2009.

[14] J. Collins, "Education techniques for lifelong learning," *Presented in the RSNA Faculty Development Workshop*, vol. 24, no. 4, pp. 1177–1183, 2004.

[15] S. Cox, M. Nakisa, and M. Lincoln, "TESSA, a system to aid communication with Deaf people," *In Proc. SIGCAPH*, pp. 205–212, 2002.

[16] Developers, "Supported Media Formats," Android Developers, Tech. Rep., 2013, available online at http://developer.android.com/guide/appendix/media-formats.html (accessed 05 August 2013).

[17] R. Dewar, *Design and evaluation of public information symbols, in Visual Information for Everyday Use*. London: Taylor & Francis, 1999.

[18] J. Doevendans, K. Klugman, L. Mazwai, Y. Seedat, W. Kalk, L. Makubalo, A. Parish, and R. Summers, "Standard Treatment Guidelines and Essential Drug List for South Africa," The Nation Department of Health, Tech. Rep., 1998, Adult Hospital Level.

[19] M. Donnell and I. Richardson, "Problems encountered when implementing agile methods in a very small company," *Communications in Computer and Information Science*, vol. 16, pp. 13–24, 2008.

UNIVERSITY of the
WESTERN CAPE

[20] K. Eilers-Crandall and C. Aidala, "Distance learning opportunities for deaf learners," *In Proc. SSSConference*, p. 139, 2000.

[21] R. Elliott, J. Glauert, J. Kennaway, and I. Marshall, "The development of language processing support for the ViSiCAST project," *In Proc. ASSETS*, pp. 101–108, 2000.

[22] D. Erasmus, *Video quality requirements for South African Sign Language communications over mobile phones.* Unpublished MSc thesis, University of Cape Town, South Africa, 2012.

[23] European Health Commission, "Medical devices: Guideline document, qualification and classification of stand alone software used in healthcare within the regulatory framework of medical devices," DG Health and Consumer, Tech. Rep., 2012.

[24] E. Gamma, R. Helm, R. Johnson, and J. Vlissides, *Design Pattens, Elements of Reusable Object-oriented Software.* Addison-Wesley, 1994.

[25] M. Ghaziasgar and J. Connan, "Investigating the intelligibility of synthetic sign language visualization methods on mobile phones," *In Proc. SAICSIT*, pp. 86–92, 2010.

UNIVERSITY of the
WESTERN CAPE

[26] M. Glaser and D. Aarons, "A Deaf adult literacy collective." *Stellenbosch Papers in Linguistics*, vol. 34, pp. 1–18, 2002.

[27] M. Glaser and W. Tucker, "Telecommunications bridging between Deaf and hearing users in South Africa," *In Proc. CVHI*, 2004.

[28] R. Guerrero, N. Nickman, and J. Jorgenson, "Work activities before and after implementation of an automated dispensing system," *Am J Health Syst Pharm*, vol. 53, pp. 548–554, 1996.

[29] S. Hansen, T. Robertson, L. Wilson, H. Thinyane, and S. Gumbo, "Identifying stakeholder perspectives in a large collaborative project: An ICT4D case study," *In Proc. 23rd OzCHI*, pp. 144–147, 2011.

[30] R. Heeks, "Information systems and developing countries: Failure, success, and local improvisations." *The Information Society*, vol. 18, no. 2, pp. 101–112, 2002.

[31] P. Hekkert and M. van Dijk, *Vision in Design. A Guidebook for Innovators.* BIS, Amsterdam, 2011.

[32] A. Holzinger, "Usability engineering methods for software developers," *Communications of the ACM*, vol. 48, no. 1, pp. 71–74, 2005.

[33] G. Kapuire, G. Koch, H. Theophilus, N. Bidwell, and E. Blake, "A revolution in ICT, the last hope for African rural communities' technology appropriation." *In Proc. IDIA*, p. 8, 2010.

[34] E. Klein, J. Santora, P. Pascale, and J. Kitrenos, "Medication cart-filling time, accuracy and cost with automated dispensing system," *Am J Heath Sys. Pharm*, vol. 51, pp. 1193–1196, 1994.

[35] S. Lauesen, *User Interface Design: A software engineering perspective.* Pearson, Addison Wesley, 2011.

[36] Learn Sign Language, "Non manual features," Learn Sign Language, Tech. Rep., 2013, available online at https://www.http://learnsignlanguage.wordpress.com/2010/05/12/non-manual-features-in-bsl/ (accessed 3 August 2013).

[37] K. Looijesteijn, *The design of a Deaf-to-hearing communication aid for South Africa.* Unpublished MSc thesis, Delft University of Technology, Netherlands, 2009.

[38] Z. Ma and W. Tucker, "Asynchronous video telephony for the Deaf," *In Proc. SATNAC*, pp. 134–139, 2007.

[39] M. Mirzaei, S. Ghorshi, and M. Mortazavi, "Helping Deaf and hard-of-hearing people by combining augmented reality and speech technologies," *In Proc. 9th Intl Conf. Disability, Virtual Reality & Associated Technologies*, pp. 149–158, 2012.

[40] Mobile Telephone Network, "MTN MMS serveices," MTN, Tech. Rep., 2013, available online at https://www.mtn.co.za/MTNSERVICES/MESSAGINGSERVICES/Pages/MMS.aspx (accessed 24 April 2013).

[41] J. Morris, *Android User Interface Development - Beginners Guide.* Packt Publishing, 2011.

UNIVERSITY of the
WESTERN CAPE

[42] M. Motlhabi, M. Glaser, M. Parker, and W. Tucker, "SignSupport: A limited communication domain mobile aid for a Deaf patient at the pharmacy," *In Proc. SATNAC*, pp. 173–178, 2013.

[43] M. Motlhabi, M. Parker, M. Glaser, and W. Tucker, "Improving usability and correctness of a mobile tool to help a Deaf person with pharmaceutical instruction," *In Proc. ACM-DEV 4*, 2013.

[44] M. Mutemwa and W. Tucker, "A mobile Deaf-to-hearing communication aid for medical diagnosis," *In Proc. SATNAC*, pp. 379–384, 2010.

[45] E. Mynatt and G. Weber, "Nonvisual presentation of graphical user interfaces: Contrasting two approaches," *In Proc. CHI Human Factors in Computing Systems*, pp. 166–172, 1994.

[46] B. S. Ngubane, "For the launch of the pilot project: Telephone Interpreting Services for South Africa (TISSA)." Advisory Panel on Language Policy, Tech. Rep., 2002, available online at http://www.dacst.gov.za/speeches/minister/mar2002/tissalaunch.htm (accessed 1 September 2013).

[47] J. Nielsen, "Usability inspection methods," *In Proc. CHI Conference Companion*, pp. 413–414, 1994.

[48] D. Power, M. Power, and B. Rehling., "German deaf people using text communication: Short message service, TTY, relay services, fax, and e-mail," *American Annals of the Deaf*, pp. 291–301, 2007.

[49] M. Power, D. Power, and L. Horstmanshof, "Deaf people communicating via SMS, TTY, Relay service, Fax, and Computers in Australia," *The Journal of Deaf Studies and Deaf Education*, vol. 12, no. 1, pp. 80–92, 2007.

[50] D. Ramachandran, M. Kam, J. Chiu, J. Canny, and J. Frankel, "Social dynamics of early stage co-design in developing regions," *In Proc. CHI*, pp. 1087–1096, 2007.

[51] H. Schwarz and B. Brodowy, "Implementation and evaluation of automated dispensing systems," *Am J Health Syst Pharm*, vol. 52, pp. 823–828, 1995.

[52] B. Shneideman, *Designing the User Interface: Strategies for Effective Human-Computer Interaction.* Taylor & Francis, 1997.

UNIVERSITY of the
WESTERN CAPE

[53] B. Shneiderman, *Designing the User Interface.* Addison-Wesley, 1992.

[54] K. Siau, "Human-computer interaction: The effect of application domain knowledge on icon visualization," *J. of C.I.S*, vol. 45, no. 3, pp. 53–62, 1997.

[55] SignGenius, "Disability Statistics: South Africa," SignGenius Sign Language Software, Tech. Rep., 2013, available online at http://www.signgenius.com/info-statistics.shtml (accessed 04 September 2013).

[56] South African Pharmacy Council, *Good Pharmacy Practice in South Africa.* Printed By S.A Council, 2010.

[57] STATSSA, "Statistics South Africa," Statssa, Tech. Rep., 2013, available online at http://www.statssa.gov.za/keyindicators/keyindicators.asp (accessed 04 September 2013).

[58] K. Thomas. (2002) Glove lends the Deaf a hand. USA Today. [Online]. Available: http://www.usatoday.com/news/science/2002-01-16-deafglove.htm

[59] W. Tucker, M. Glaser, and J. Lewis, "SoftBridge in action: The first deaf telephony pilot," *In Proc. SATNAC*, vol. 2, pp. 293–294, 2003.

[60] Ubiquitous Web Domain, "Extensible Markup Language (XML)," W3C, Tech. Rep., 2012, available online at http://www.w3.org/XML/ (accessed 12 November 2012).

[61] Vodacom, "Vodacom MMS Settings," Vodacom, Tech. Rep., 2013, available online at http://www.vodacom.co.za/personal/services/messaging=true (accessed 24 April 2013).

[62] Y. Wang and W. Tucker, "Browser-based sign language communication," *In Proc. SATNAC*, pp. 71–76, 2010.

[63] J. Watermeyer and C. Penn, "Working across language and culture barriers: Communication skills for pharmacists." Johannesburg, South African, Tech. Rep., Printed in Cape Town 2009.

[64] Z. Zafrulla, J. Etherton, and T. Starner, "TTY phone: direct, equal emergency access for the deaf," *In Proc. 10th Intl. Conf. ACM SIGACCESS*, pp. 277–278, 2008.

Appendix A. Information sheet

The information below is bulleted in English because a professional SASL interpreter will interpret it into SASL for Deaf participants. All Deaf participants speak SASL, and the interpreter is fluent in both SASL and English. Bullets are used instead of prose to ease the interpretation process.

UNIVERSITY of the
WESTERN CAPE

1. **What is this research project about?**

   I am going to tell you about a mobile phone project for Deaf people.

   This project will enable you to communicate independently with a pharmacist and help you to understand clearly the information and instruction about the medication.

2. **Who is running the project?**

   We are Computer Scientists from the University of the Western Cape.

   You might know Bill Tucker. He's the project leader.

   The student responsible for this particular project is Michael Motlhabi (Mike).

   Mariam Parker (Mariam) will also assist.

3. **What do we want to achieve?**

   We want to improve communication between Deaf people and a pharmacist during medicine dispensing.

   All of you use SASL to communicate, and medical personnel like doctors and pharmacists do not.

   This creates a communication barrier between you and the medical personnel, which could have serious health consequences.

   We want to design a system that can make it easier for you and the pharmacist to understand each other.

Most of you carry mobile phone everywhere you go.

So we would like to implement an application for a mobile phone that you can take to a pharmacist.

After the pharmacist provides medication instructions on the phone, you can view them in signed language videos on the phone.

This will not cost anything, to see the video instructions on the phone.

However, if for some reason you do not understand the instructions and want to ask the pharmacist a question; or perhaps the pharmacist wants to ask you something, we will also provide a voice relay to a sign language interpreter with the phone. However, that will cost money.

4. **What will we do?**

   We will design and build an application to run on the mobile phone.

   The system will have pre-recorded SASL videos on the phone which will explain to you the instructions from the pharmacist about taking your medicines and treating your illnesses.

   The application will contain information about you and the medication such as what type of sickness you are currently dealing with, the medication you will be taking, when should you be taking it and also information about where you live, etc.

   We will also provide a simple voice relay system in case clarification is necessary.

5. **Benefits.**

   Once the application developed to the certain stage and implemented on smart android mobile phones, Deaf patients can use it to communicate with pharmacists at public pharmacy hospitals. Thus Deaf patients will understand information and instructions of their medication clearly.

   We plan that the application should handle most dialogs concerning pharmaceutical communication. Also we also plan to provide features which enable a Deaf patient to ask questions regarding his/her prescribe medicine directly.

6. **Risks and difficulties.**

   There is no risk or difficulties in the survey or the experiment. There is no question in the session that will require you to reveal your personal medical history or disease. Please be noticed that there might be some medicines props during the role plays in this study, but you will not be exposed to those medicine.

UNIVERSITY of the
WESTERN CAPE

7. **Withdrawal and confidentiality.**

   All videos recorded during the research session will be kept confidential and will be stored on a computer with password which is known only the responsible researcher. Your identity will not be disclosed in public unless we receive permission from you. Please be informed that you have the right to withdraw from any research session by informing the session leader. As soon as you withdraw from the session, all material about your information will be destroyed.

8. **Dissemination of the study results.**

   All information will be disseminated when the study is completed in the form of several papers at various conferences. Data may be used toward the awarding of higher degrees to the co-researchers involved in the study. Deaf participants will be kept informed via several presentations at DCCT at strategic times of the project life.

For further information, please do not hesitate to contact:

Michael Motlhabi & Bill Tucker

Dept. of Computer Science

University of the Western Cape

Private Bag X17

Bellville 7535

Email: diablonuva@gmail.com / wdtucker@gmail.com

UNIVERSITY of the
WESTERN CAPE

Name (Participant): ________________________

Signature (Participant):________________________

Appendix B. Interpreter consent form

I, ____, fully understand the mobile health communication aid for Deaf people project and agree to interpret. I understand South African Sign Language and will provide sign language translation. I am bound by Deaf South Africa's (DEAFSA) code of ethics for SASL interpreter to adhere all aspects of the Code of Ethics at all times during and after assignments; keep all assignment-related information strictly confidential and adhere to professional standards of confidentiality; and render the message faithfully, always conveying the content, intent and spirit of the speaker using the language most readily understood by the person(s)whom they serve.

I also pledge that I have explained all the aspects of the research to the participants.

For further information, please do not hesitate to contact:
Michael Motlhabi & Bill Tucker
Dept. of Computer Science
University of the Western Cape
Private Bag X17
Bellville 7535
Email: diablonuva@gmail.com / wdtucker@gmail.com

Signature (Participant):______________________

UNIVERSITY of the
WESTERN CAPE

Appendix C. Pharmacy participant consent form

I, ____, fully understand the mobile health communication aid for Deaf people project and agree to participate. I understand that I can withdraw from the study at any time, and any information collected pertaining my contribution will be destroyed at once. I also understand that all information that I provide will be kept confidential, and that my identity will not be revealed in any publication resulting from the research unless I choose to give permission. I acknowledge that all information attained in this study or test will be stored on a computer that has a password that is only known by the researcher. Furthermore, all recorded interview media and transcripts will be destroyed after the project is completed. I am also free to withdraw from the project at any time. I understand that an interpreter will be used for this trial to translate the research methods to the Deaf participant and the information he/she translates will be kept confidential and not repeated.

UNIVERSITY of the
WESTERN CAPE

For further information, please do not hesitate to contact:

Michael Motlhabi & Bill Tucker
Dept. of Computer Science
University of the Western Cape
Private Bag X17
Bellville 7535
Email: diablonuva@gmail.com / wdtucker@gmail.com

Signature (Participant):________________________

UNIVERSITY of the
WESTERN CAPE

Appendix D. Deaf participant consent form

I, ____, fully understand the mobile health communication aid for Deaf people project and agree to participate. I understand that I can withdraw from the study at any time, and any information collected pertaining my contribution will be destroyed at once. I also understand that all information that I provide will be kept confidential, and that my identity will not be revealed in any publication resulting from the research unless I choose to give permission. I acknowledge that all information attained in this study or test will be stored on a computer that has a password that is only known by the researcher. Furthermore, all recorded interview media and transcripts will be destroyed after the project is completed. I am also free to withdraw from the project at any time. I understand that an interpreter will be used for this trial and the information he/she translates will be kept confidential and not repeated.

For further information, please do not hesitate to contact:

Michael Motlhabi & Bill Tucker
Dept. of Computer Science
University of the Western Cape
Private Bag X17
Bellville 7535
Email: diablonuva@gmail.com / wdtucker@gmail.com

Signature (Participant):________________________

UNIVERSITY of the
WESTERN CAPE

Appendix E. Consent form for use of participant likeness

I, ____, hereby grant the University of the Western Cape (UWC) permission to record and photograph me. I understand that the term "photograph" as used herein encompasses both still photographs and video recordings. I further grant the University of the Western Cape full unrestricted rights to the use of my photographs and likeness in any form, including edited versions, in audio/video presentations, streaming audio and/or video over the Internet, broadcast, cable, satellite transmissions, and media that are unknown at this time, worldwide for educational purposes.

UNIVERSITY of the
WESTERN CAPE

For further information, please do not hesitate to contact:

Michael Motlhabi & Bill Tucker

Dept. of Computer Science

University of the Western Cape

Private Bag X17

Bellville 7535

Email: diablonuva@gmail.com / wdtucker@gmail.com

Signature (Participant):________________________

UNIVERSITY of the
WESTERN CAPE

Appendix F. List of illnesses in SignSupport

Below is a list of 57 medical conditions that were programmed into SignSupport for the purpose of training users and running trials for with the system. Pharmacists chose this list because they claim in their professional opinion these conditions are the most commonly felt with in South African public hospitals.

Medical Conditions 1	Medical Conditions 2	Medical Conditions 3
heartburn	Helminthic infestation	Helminthic infestation
HIV prophylaxis (PEP)	Hormone replacement therapy	Human immunodeficiency virus
Hypertension	Immunisation	Impetigo
Injuries	Insomnia	Itching (pruritus)
Jaundice	Chronic renal problems	Lice (pediculosis)
Lice, pubic	Malaria	Measles
Meningitis	Meningitis meningococcal	Mood disorders
Mumps	Napkin rash	Nausea and vomiting
Nose bleed (epistaxis)	Prophylaxis in adults	Prophylaxis in children
Osteoarthrosis	Otitis (ear infections)	Pain control
Periodontitis	Pneumonia	Poisoning
Child transmission of HIV	Psychosis, acute	Rheumatic fever, acute
Ringworm	Rubella (German measles)	Scabies
STI	Shock	Sinusitis, acute
Snakebite	Sprains and strains	Tick-bite fever
Tonsillitis and pharyngitis	Tonsillitis, bacterial	Tuberculosis
Ulcers, mouth	Urinary tract infection	Urticaria
Visual problems	Vitamin deficiencies	Warts, genital
Wheezing in children	Diabetes mellitus type 2	

UNIVERSITY of the
WESTERN CAPE

Appendix G. Pharmacy participant questionnaire

Questions	No	Yes	Comment
Do you think SignSupport would be a useful dispensing tool?			
Are there any icons you did not understand?			
Have you dispensed medicine using similar type of technology?			
Were the displayed error messages helpful?			
Was the information well organized?			
Did you find the support information useful?			
Is there any functionality you would like to add?			
Questions	Easy	Hard	Total
How easy was it to learn SignSupport?			
How easy was it to complete the task of dispensing SignSupport?			
How easy was it to understand the instructions on the screen?			
Questions	No	Yes	Total
Would you consider using SignSupport at the pharmacy?			
Are you with happy with the flow/logic of SignSupport?			
Did you get lost/confused while using SignSupport?			
Is SignSupport useful in dealing with Deaf patients?			
Would you recommend SignSupport to your colleagues?			
Do you think that SignSupport would improve patient adherence?			

UNIVERSITY of the
WESTERN CAPE

UNIVERSITY of the
WESTERN CAPE

Appendix H. Deaf participant questionnaire

Questions	No	Yes	Comment
Do you think that this software is useful?			
Have you used other software similar to this one?			
Were error messages displayed at the right place?			
Was the information well organized?			
Did you find the support information useful?			
Is there any functionality you would like to add?			
Are there any icons you did not understand?			
Questions	Easy	Hard	Total
How easy was it to learn SignSupport?			
How easy was it to complete the tasks ?			
How easy was it to understand what was said in the video?			
Questions	Not clear	Clear	Total
How clear were the hand gestures?			
How clear were facial expressions in the videos?			
Questions	No	Yes	Total
Would you consider using SignSupport in real life?			
Would you be happy using SASL videos of this quality?			
Did you get lost/confused while using SignSupport?			

UNIVERSITY of the WESTERN CAPE

Appendix I. Conversation script

Conflict resolution screens with Deaf-Pharmacist interaction

Screen activities	Resulting conversion text
A	The pharmacist would like to see you hospital card. Please show it to him/her together with the phone.
B	Your name does not match the name on the prescription. It is not yet your turn to collect medication. Please sit back in the waiting room until you are called again. Press the Home button and take a sit.
C	The pharmacist has found a conflict in your prescription. Please wait here at the counter while we sort out the problem. Wait until the pharmacist get back and press the Next button.
D	The pharmacist has found a conflict in your prescription. Please wait at the waiting area while we sort out the problem. Wait until the pharmacist get back and press the Home button.
E	The pharmacist has found a conflict in your prescription. Please return to the doctor for more consultation. Please press the Next button.
F	Thank you for your patience. Your medication interactions have been recorded successfully.

UNIVERSITY of the
WESTERN CAPE

Background information set up script

Screen activities	Resulting conversion text
G	You are about to set/update your personal information. Ready?
H	Please tap on the box and type your name in full then press OK.
I	Please tap on the box and enter a 4 digit passcode then press OK.
J	Are you Male or Female?
K	Please enter your weight in Kilograms.
L	Do you have any food allergies? If yes then press the button to the right. If no then press the button to the left. If you don't know then press the button in the center.
M	If middle button pressed Define allergy in SASL the press Back button.
N	Do you have any medicine allergies? If yes then press the button to the right. If no then press the button to the left. If you don't know then press the button in the center.
O	Are you currently on any medication?. If no then press left button If yes then press right button.
P	Do you smoke cigarets?
Q	Do you drink any alcohol?
R	Do you eat regularly?
S	Do you have access to clean water?
T	Are you suffering from any other sickness?
U	If you are female, are you pregnant? If yes then press the button to the right. If no then press the button to the left. If you don't know then press the button in the center.
V	Thank you for setting up your background information. Please press the Home button to start the system.

UNIVERSITY of the WESTERN CAPE

Dispensing, warnings and recommendations script

Screen activities	Resulting conversion text
W	The pharmacist would like to see you hospital card. Please show it to him/her together with the phone.
X	Your name does not match the name on the prescription. It is not yet your turn to collect medication. Please sit back in the waiting room until you are called again. Press the Home button and take a sit.
Y	The pharmacist has found a conflict in your prescription. Please wait here at the counter while we sort out the problem. Wait until the pharmacist get back and press the Next button.
Z	The pharmacist has found a conflict in your prescription. Please wait at the waiting area while we sort out the problem. Wait until the pharmacist get back and press the Home button.
AA	The pharmacist has found a conflict in your prescription. Please return to the doctor for more consultation. Please press the Next button.
BB	Thank you for your patience. Your medication interactions have been recorded successfully.
CC	Do you smoke cigarets?
DD	Do you drink any alcohol?
EE	Do you eat regularly?
FF	Do you have access to clean water?

UNIVERSITY of the
WESTERN CAPE