UNIVERSITY OF THE WESTERN CAPE

A Mobile Deaf–to–hearing Communication Aid for Medical Diagnosis

By

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Lookup dictionary
Medical doctor
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South Africa Sign Language
Pre–recorded sign language video

Abstract

Many South African Deaf people use their mobile phones for communication with SMSs yet they would prefer to converse in South African Sign Language. Deaf people with a capital 'D' are different from deaf or hard of hearing as they primarily use sign language to communicate. This study explores how to design and evaluate a prototype that will allow a Deaf person using SASL to tell a hearing doctor how s/he is feeling and provide a way for the doctor to respond. A computer–based prototype was designed and evaluated with the Deaf people in a previous study. Results from the user trial of the computer–based mock–up indicated that Deaf users would like to see the prototype on a cell phone. Those user trial results, combined with our own user survey results conducted with Deaf people, are used as requirements. We built a prototype for a mobile phone browser by embedding SASL videos inside XHTML pages using Adobe Flash. The prototype asks medical questions using SASL videos. These questions are arranged in an organized way that helps in identifying a medical problem. The answers to the questions are then displayed in English and shown to the doctor on the phone. A content authoring tool was also designed and implemented. The content authoring tool is used for populating the prototype in a context free manner allowing for plug and play scenarios such as a doctor's office, Department of Home Affairs or police station. A focus group consisting of Deaf people was conducted to help in the design and pilot trial of the system. A final user trial was conducted with more than thirty Deaf people and the results are presented and analyzed. Data is collected with questionnaires, semi-structured interviews and video recordings. The results indicate that most of the Deaf people found the system easy to learn, easy to navigate through, did not get lost and understood the sign language in the videos on the mobile phone. The hand gestures and facial expressions on the sign language videos were clear. Most of them indicated they would like to use the system for free, and that the system did not ask too many questions. Most of them were happy with the quality of the sign language videos on the mobile phone and would consider using the system in real life. Finally they felt their private information was safe while using the system.

Declaration of authorship

I declare that *A Mobile Deaf–to–hearing Communication Aid for Medical Diagnosis* is my own work, that it has not been submitted before for any degree or examination in any other university, and that all the sources I have used or quoted have been indicated and acknowledged as complete references.

Muyowa Mutemwa

August 2011

Signed: ________________________

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Glossary

3G	**T**hird **G**eneration or **N**etwork
3GGP	**T**hird **G**eneration **P**artnership **P**roject
AI	**A**rtificial **I**ntelligence
ADSL	**A**symmetric **D**igital **S**ubscriber **L**ine
API	**A**pplication **P**rogramming **I**nterface
ASL	**A**merican **S**ign **L**anguage
ASR	**A**utomatic **S**peech **R**ecognition
BANG	**B**ridging **A**pplications and **N**etworks **G**roup
BSL	**B**ritish **S**ign **L**anguage
Codec	encoding and/or decoding a digital data stream
CSS	**C**ascading **S**tyle **S**heets
DeafSA	**D**eaf **S**outh **A**frica
DCCT	**D**eaf **C**ommunity of **C**ape **T**own
DSS	**D**ecision **S**upport **S**ystems
FLV	**F**lash **L**ive **V**ideo
GPRS	**G**eneral **P**acket **R**adio **S**ervice
H.264	A standard for video compression
HCI	**H**uman–**C**omputer **I**nteraction
HTML	**H**yper**T**ext **M**ark–up **L**anguage
HTTP	**H**yper**T**ext **T**ransfer **P**rotocol
ICT	**I**nformation and **C**ommunication **T**echnology
ICT4D	**I**nformation and **C**ommunication **T**echnology for **D**evelopment
ISDN	**I**ntegrated **S**ervice **D**igital **N**etwork
IM	**I**nstant **M**essenger
JPEG	**J**oint **P**hotographic **E**xperts **G**roup

KBPS	KilobbitsPer Second
MB	Mega Bytes
MMS	Multimedia Messaging Service
MMSSign	Multimedia Messaging Service Sign
MobileASL	Mobile America Sign Language
MPEG	Moving Picture Experts Group
MySQL	My Structured Query Language
MXit	Mobile eXchange
NGO	Non–Governmental Organization
NMF	Non Manual Features
OS	Operating System
Open C	A set of industrial–standard POSIX and middleware C libraries for S60 for Symbian OS phones
PAMP	Personal Apache MySQL PHP
PHP	Hypertext Preprocessor
PSTN	Public Switched Telephone Network
ROI	Region–of–Interest
SASL	South African Sign Language
SDLC	Software Development Life Cycle users' acceptance.
SIP	Session Initiation Protocol
SL	Sign Language
SLED	Sign Language Education and Development
SMS	Short Messaging Service
STEM	Science Technology Engineering and Math
SVRS	Sorenson Video Relay Service
SWF	Small Web Format or ShockWave Flash
Symbian OS	A mobile phone operating system designed for smart phones by Symbian Limited with a libraries, framework, a user interface, and an SDK for developing common tools.
Telkom	A wireline and wireless telecommunications provider in South Africa
Teldem	A text telephone for the Deaf

TESSA	**TE**xt and **S**ign **S**upport **A**ssistant
TISSA	**T**elephone **I**nterpreting **S**ervice for **S**outh **A**frica
TRS	**T**elecommunications **R**elay **S**ervice
TTS	**T**ext–**t**o–**S**peech
TTY	**T**elephone **T**ypewriter or **T**ele**T**ypewriter
UCT	**U**niversity of **C**ape **T**own
UI	**U**ser **I**nterface
URL	**U**niform **R**esource **L**ocator
UWC	**U**niversity of the **W**estern **C**ape
VI	**V**ideo **I**nterpreter
VRS	**V**ideo **R**elay **S**ervice
VIS	**V**ideo **I**nterpreting **S**ervice
WAP	**W**ireless **A**pplication **P**rotocol
Wi–Fi	**W**ireless **F**idelity
WebMD	**W**eb **M**edical **D**octor
WMV	**W**indows **M**edia **V**ideo
WWW	**W**orld **W**ide **W**eb
X264	A free software library for encoding video streams into the H.264/MPEG–4 AVC format
XHTML	e**X**tensible **H**yper**T**ext **M**arkup **L**anguage
XML	e**X**tensible **M**arkup **L**anguage

Chapter 1

Introduction

This thesis describes the implementation and evaluation of a Deaf-to-hearing communication aid on a mobile phone. Suppose that a Deaf person wakes up one morning with a runny nose, coughing and feeling too weak to get out of bed. This person wishes to seek medical advice from a doctor who does not understand sign language. The system described herein allows a Deaf person to tell a hearing doctor about symptoms they are feeling. The Deaf person does this by answering questions presented in South African Sign Language (SASL) using videos, and choosing an answer also presented with a SASL video. Once the Deaf person has completed answering the questions, s/he hands the mobile phone over to the doctor who can read the symptoms in English. The doctor can then make a diagnosis. The system will then play a SASL video diagnosis given by the doctor. The system also allows the doctor to ask more questions. In this way, a hearing doctor who cannot sign can assist a Deaf person that cannot hear or speak.

1.1 Deaf with a capital 'D'

According to Deaf South Africa (DeafSA) there are between 500 000 and 600 000 South Africans that use SASL for communication [4, 16]. This is about 20% of the disabled people in South Africa. The Deaf community in South Africa (SA) has a 70% unemployment rate and 75% of the community is functionally illiterate [60]. A Deaf person with a capital D is a person who uses SASL as his/her primary language to communicate. Their cultural identity is defined by the use of SASL. They tend to have low levels of basic education and literacy [1]. Most Deaf people in SA are illiterate and have basic levels of education, which, combined with their inability to speak and hear places them at a disadvantage when it comes to socializing with other people or economic matters such as getting a job [37]. The combination of poor literacy levels and the communication barriers between Deaf and hearing people causes a high unemployment rate in the Deaf community [37]. Services in sign language are limited in South Africa, but there have been attempts to bridge the gap by including sign language interpretation during news bulletins on television and telephonic interpretation such as the Telephone Interpreting Service for South Africa (TISSA) (see Section 2.2.2 for more on TISSA). There is also a service that converts English into a SASL video equivalent [60]. In communication, it is essential to get straight to the point, and this can be difficult to achieve if the language used is not the preferred language for either one or both people involved [39]. When both people use the same language that they are comfortable with, it then becomes easier to express ideas, and more ground can be covered in terms of information shared on a specific subject.

1.2 Previous design

The design of the system described by this thesis follows on a previous study by Looijesteijn [37]. He used a focus group to design a mock–up such of the interfaces and the diagrams depicted the flow of the system using sketches drawn on paper. Paper prototypes were used during the design stages to simulate user interaction with the proposed system by the focus group members. The focus group members told stories of their experiences with medical doctors. These were used to understand some of the problems that Deaf people experience when they visit a hearing doctor. A Deaf person's visit to a medical doctor illustrates the need for a communication aid to provide clear and intelligible communication between a Deaf person and a hearing person. An incorrect comprehension of symptoms could lead to an incorrect diagnosis. The concept, overall shape of the system and the user requirements were derived from the analysis of results obtained during the focus group sessions. Looijesteijn designed a mock–up that allowed Deaf people and hearing people to communicate with each other using pre-recorded SASL videos. This mock–up is called SignSupport. The mock–up asks a Deaf person questions using SASL pre-recorded videos. After the Deaf person has answered the questions, the answers are presented to a hearing person in plain English. The hearing person reads the answers and responds using an English lookup dictionary. The Deaf person then watches the SASL video of the response. Looijesteijn's mock–up system ran on a computer browser and simulated a conversation for a Deaf person's visit at the doctor's office [37]. Each page displays a question, an answer or a response using a pre-recorded SASL video and English text. The page also provides navigation to the next and previous pages. Other pages in the system display the English summary of the answers and lookup dictionary.

A SASL interpreter was used to facilitate communication between the Deaf participants and the researcher. Four participants were put into pairs to allow for discussion while testing the prototype. The testing sessions were recorded on video, and screen capture software was used to capture user interaction with the prototype. There was an interview at the end of the user trials. The users evaluated the icons, navigation arrows, the videos, and look-and-feel of the system. The Deaf users did not immediately understand what the system was about, yet after playing with the system a while they came to understand it. The users felt the system would be useful in real life and that they would want to see the system on a mobile phone.

The next step in the evolutionary design of the Deaf to hearing communicating aid is to implement the system on a mobile phone, and also to implement the system in such a way that new scenarios can be created by typing in questions and uploading SASL videos. The work herein describes how such a system was implemented for mobile phones and tested with Deaf people. This work also describes a content authoring tool that is used to create new scenarios using an authoring tool wizard. The scenario used in Looijesteijn's design was a Deaf person's visit at a hearing doctor's office who cannot understand sign language. In this work the scenario used is still the same.

1.3 The Deaf Community of Cape Town

Most Deaf Non-Governmental Organizations (NGOs) promote the use of sign language and sign language education. One such organization that we worked with is the Deaf Community of Cape Town (DCCT) which helps the overall Cape Town Deaf population with social services. The community offices are located at the Bastion of the Deaf (herein referred to as the Bastion) in Newlands, Cape Town. The NGO has more than a thousand members who are mostly Deaf. Looijesteijn [37] conducted his work with DCCT staff members. The target group for the work described by this thesis remains the Deaf people at DCCT with whom our research group has a long history [24]. Since 2001, various Deaf telephony prototypes have been tested out with DCCT staff members [62]. The prototypes are aimed at allowing Deaf people to communicate with each other and bridging the gap between Deaf people and hearing people to enable them to communicate with each other (see Section 2.2.4 for more details). These gaps can be social or economic, or both, and further complicate communication barriers [62]. Designing software that bridge this gap is not simple. Some of the software designed to bridge this gap have not always been successful. We as the Bridging Applications and Networks Group (BANG) not only to develop such systems but also to understand why the software we build succeeds or fails [1]. Since 2001, one positive result has been an increase in computer usage and literacy amongst DCCT members, mainly due to the establishment of a small computer lab at the Bastion. When the Information and Communication Technology for Development (ICT4D) projects began, few Deaf users had cell phones. Currently, most Deaf users have at least a low-end mobile phone. All of these phones support SMS and can vibrate to alert a Deaf user of an incoming SMS. DCCT staff members help trial ICT4D prototypes. The NGO pays for its own Asymmetric Digital Subscriber Line (ADSL) with Telkom. Their download cap for the month is normally consumed by the middle of each month, due to Deaf people watching videos on the Internet. A Deaf person manages the small Internet cafe at the Bastion.

1.4 Mobile phone usage of DCCT members

Deaf people cannot communicate by speaking so voice aspects of computer and mobile technologies cannot be used [24]. Even though they can use SMSes and e-mails, their level of English literacy is poor compared to hearing people, and they feel shy or scared to communicate with hearing people using these technologies [62]. Deaf people prefer to communicate in sign language and not text. DCCT members tend to own low-end mobile phones with low-resolution cameras and narrow bandwidth data connectivity. Previous work has also indicated that DCCT Deaf users do not take advantage of low cost text messaging like Mobile exchange (MXit) [62]. They might be more inclined to use data services and own smart phones if content was available in SASL on these phones, and if the phones and data costs were cheaper Deaf people at DCCT exchange text messages with both hearing and Deaf people [25]. In South Africa SMS is one of the primary methods Deaf people use to communicate [30]. Deaf people pay their own SMS bills. In both developed and developing countries using SMSes can be cost effective [63]. SMSes are not a synchronous communication and hence cannot replace a synchronous communication. SMSes are cheaper than making calls in South Africa and SMSes

[1]The research group is described later in Section 2.2.4

have been successful for Deaf South Africans who are both literate and illiterate [62].

1.5 Motivation

Deaf people struggle to communicate with hearing people. There are limited methods in South Africa to aid Deaf people communicate with hearing people. Hiring an interpreter needs to be done ahead of time, is expensive and there are not enough interpreters anyway. Even though interpreters are bound by a code of conduct to maintain confidentiality, privacy is still a concern such as in medical situations. Although there are communication methods such as SMS, relay services, video over Internet, and TISSA that Deaf people can use, these systems are either text based and hence not ideal for Deaf people, are expensive or are simply not available in South Africa. We have noticed that Deaf people choose to use sign language communication systems because sign language is their preferred language. The motivation for this study is to improve communication for Deaf people of South Africa. In so doing, Deaf people can use sign language to communicate with a hearing person for public services such as a doctor's visit without needing an interpreter. DCCT people have mostly low levels of English literacy, they are mostly unemployed and thus cannot afford interpreters and afford systems that are usable by Deaf people [62]. Looijesteijn's results obtained from user trials were that Deaf people in our community would like to use his system when communicating with a hearing doctor [37]. They also indicated that they would like to see the system running on a mobile phone.

1.6 Research question and approach

The research question is how to design and evaluate a prototype that will allow a Deaf person to use SASL to tell a hearing doctor how s/he is feeling and provide a way for the doctor to respond.

- how to design and implement SignSupport for a mobile phone browser in a context free manner which allows for other scenarios to added easily?
- how to evaluate SignSupport to determine if the Deaf users can understand the sign language in the videos and if they find the system easy to use?

This thesis describes the design of such a system and its evaluation with DCCT members to determine the ease of use and the ability to understand the SASL videos by the Deaf users. The technique used for the design is to embed the SASL videos inside eXtensible HyperText Markup Language (XHTML) code for online streaming within a browser. The system also stores everything in a database, the overriding goal being to save the user money by storing everything locally on the phone's memory. The first step taken was to understand the user requirements from Looijesteijn's results [37]. Secondly, a user survey was performed to add onto the user requirements and to further understand the Deaf community. Thirdly, a pilot trial was conducted with a focus group of four Deaf people to involve the Deaf users in the design of the system. The User Interfaces (UI) of the prototype should be user friendly and resemble that of the Looijesteijn's computer based prototype. Finally, a larger scale user trial was set up and conducted to obtain user feedback from the Deaf community.

1.7 Thesis outline

This thesis describes how to design and evaluate a system that can help Deaf people communicate with hearing people using a mobile phone when they require the services of a public worker such a doctor, pharmacist, policeman and so on. Aside from the technical challenges to implement such a system on a mobile phone, we also found that Deaf people's literacy and their perception towards technology have a significant influence on user trial results. This thesis presents the technical details of the system, collection of data and analysis of user behavior data with the system.

Chapter 2 presents related work. Medical expert systems are discussed first. Then text and video relay systems are discussed. Relay systems relay communication between text and voice, or sign language and voice. Mobile sign language communication tools such as mobile support, and video calling are then discussed and four phases of BANG projects are listed. Internet systems such as Allan eC, SignForum, WinkBall, Skype, and GoogleTalk that can be used for sign language communication are discussed. Online sign language dictionaries are also discussed. A sign language translation system is also discussed.

Chapter 3 presents the research methods and the experimental design. The challenges arising from the related work with respect to our Deaf community are presented. Then the research question is presented and explored. The research method used to answer the research question is discussed, namely how the system is designed and evaluated. The experimental design is presented. The methods used to design the prototype are also discussed. We detail how Deaf participants were asked to participate in the research and how sign language interpretation was organized to assist in communication between the researcher and the Deaf participants. Ethical considerations are also discussed.

Chapter 4 presents the system design of SignSupport and the content authoring tool used to make the interface. The technologies which make up the system are presented. Two systems are presented and discussed. The first is SignSupport – the user interface and the classes are discussed. The second is the content authoring system – the user interfaces and the classes are discussed. Specifications for recording the SASL videos are presented.

Chapter 5 presents the data and analysis of Deaf people's experiences with our SignSupport implementation. First, the user survey data is presented and discussed. Then the focus group data is presented and discussed. Lastly, the user trial data is presented and discussed. The results from the final user trial are then analyzed and compared with the results from some of the related work discussed in Chapter 2.

Chapter 6 concludes the thesis. Chapters 1–to–5 are summarized and a conclusion is drawn. Suggestions are made for conducting future projects involving Deaf people, in particular DCCT. Limitations of this research are presented. Future work is also suggested.

Chapter 2

Related work

The work presented consists of research projects and software that relates to our implementation of SignSupport on a mobile phone, and its subsequent evaluation with Deaf end–users. Section 2.1 presents and discusses medical expert systems. Section 2.2 presents text and video relay systems, semi-automated relay and some projects done by the BANG group over the years. Section 2.3 presents of–the–shelf software that Deaf people can use. Section 2.4 presents online sign language dictionaries where a user enters text and receives a sign language video or animation of the text entered. Section 2.5 presents a translation system that captures sign language and converts it into text.

2.1 Medical expert systems

Section 2.1.1 describes how medical expert systems work. Medical expert systems provide a diagnosis which is used as addition information to that offered by a medical doctor. Section 2.1.2 provides an example of a medical expert system, Wireless Medical Doctor (WebMD) a symptom checker.

2.1.1 Expert systems

A medical expert system is software that is programmed using Artificial Intelligence (AI). A medical expert system uses huge libraries to phrase questions and based on the answers from the questions, calculates the likelihood of a disease [52]. Expert systems have to evaluate all possible diseases listed in the database from the user's response to the phrased questions. Personal information supplied by the user such as age and gender help an expert system to compile a list of potential diseases which the user may be classified under based on his/her symptoms [61]. Some expert systems use decision trees in automated knowledge acquisition from databases [29]. The results of this approach have shown the method as appropriate. Well-defined medical expert systems contain two knowledge types: firstly, the objective knowledge which can be found in textbooks, and secondly, subjective knowledge which changes frequently and is limited. The main criteria for the determination of the success or failure of a medical expert system are the accuracy and the rate of the diagnosis. The number of diseases that can be diagnosed by the system should also be high enough so that it can be distinguished between the common symptoms. A medical expert system can be used from the patient's side to diagnose the disease s/he is suffering from. The individual can then monitor the status of his/her health from the system, which can help in early diagnosis of the disease. A medical expert system can get the symptom and laboratory results from the user and suggest appropriate treatment options after the diagnosis has been made. Thus initial diagnosis and treatment can be made at home rather than at the hospital [17].

2.1.2 An example: WebMD

WebMD's symptom checker is an online advanced Decision Support Systems (DSS) used to provide information while awaiting evaluation with a doctor or provide a user with additional information after consulting with one [34, 68]. Symptom checkers do not replace face–to–face communication but they provide additional diagnosis on the most common diseases. The diagnosis is not exhaustive and there can exist many diagnoses that the system missed. The system interface begins by showing a full image of a human body. A user can then click on the body part they wish to know more about. The system will then ask questions related to the clicked body part, which are presented one at a time in simple English. The symptom checker ends by presenting the user with an overview summary of the body part selected, possible ways the disease might have occurred and a possible diagnosis (see Figure 2.1).

2.2 Relay systems

A medical expert system is a system that phrases questions to a user in order to give a diagnosis without requiring a medical doctor, but such systems lack a sign language user interface for Deaf people. Deaf people would prefer to communicate

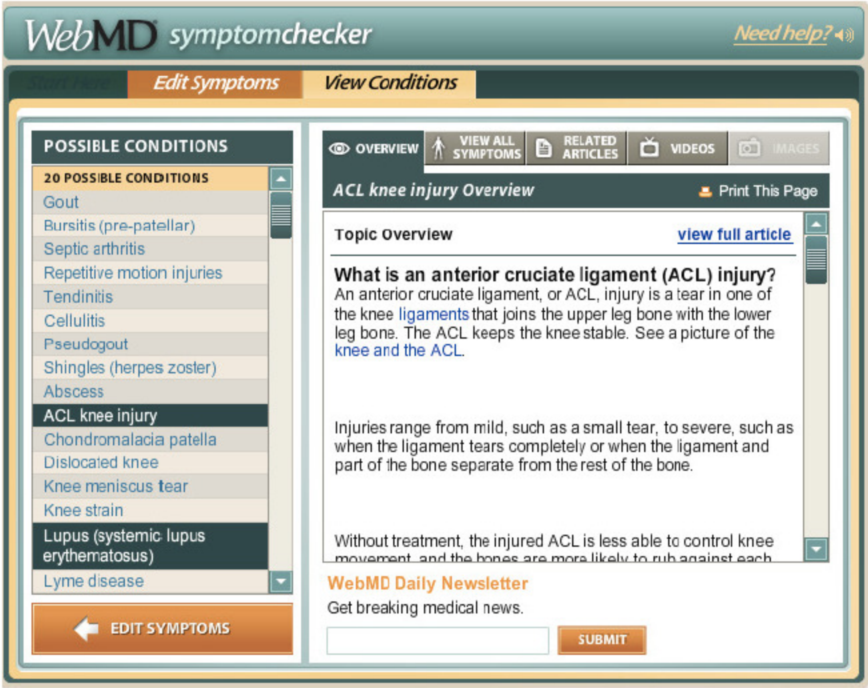

FIGURE 2.1: **Interface for webMD's symptom checker**
The system provides all possible diagnoses on the Left–hand–side. The user can read the overview of the diagnosis and possible other symptoms, read related articles, and watch videos about symptoms or conditions.

in SASL rather than English text [23, 24]. The following systems, called relay systems, are created for receiving and passing on information from a Deaf person to a hearing person, and vice versa. These systems are directed at helping Deaf people communicate with hearing people who cannot sign.

2.2.1 Text relay service

Telecommunication Relay Service (TRS) is a service that allows for communication between Deaf and hearing people using text and voice in real time via an interpreter. This communication is done with the hearing person using a standard telephone and a Deaf person using a standard telephone line with an assistive device such as a Telephone Typewriter or Tele Typewriter (TTY) [73]. To use a TRS the Deaf person should be able to read and write in a spoken language[1]. TRS systems are common in developed countries such as the United States, New Zealand and England, where the government often subsidizes them. In a text relay system the Deaf person types messages into the TTY and the TRS operator relays the messages in voice to the hearing person (see Figure 2.2). The hearing person responds by saying the words and the TRS operator types the spoken words for

[1] Such systems maybe be more suitable for deaf people rather than Deaf people.

the Deaf person to receive on the TTY system. Currently South Africa has no active TRS services.

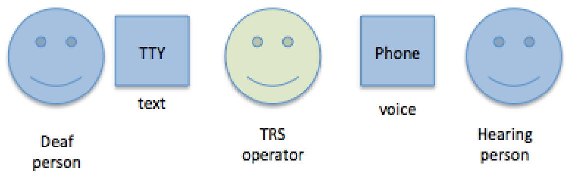

FIGURE 2.2: **Telecommunications relay service.**
A relay service where one person uses text to communicate with another person using a voice telephone, with the help of an interpreter.

2.2.2 Video relay service

Video relay is preferred by Deaf people because it allows them to communicate using sign language, whereas text relay forces Deaf people to use a written language such as English [24]. A Video Relay Service (VRS) or a Video Interpreting Service (VIS) facilitates communication between a Deaf person and a hearing person. This communication is done with the help of a sign language interpreter [49]. In a video relay system, a Deaf person picks up a video device such as a videophone that has an Internet connection to a VRS. The call is picked up by a Video Interpreter (VI) who is seated in front of a video camera. The Deaf person then asks the VI to dial the number of a hearing person. Once the hearing person answers the phone, the VI will sign anything the hearing person says into the camera in front of him/her for the Deaf person, and anything the Deaf person signs the VI will speak into the phone for the hearing person to hear (see Figure 2.3).

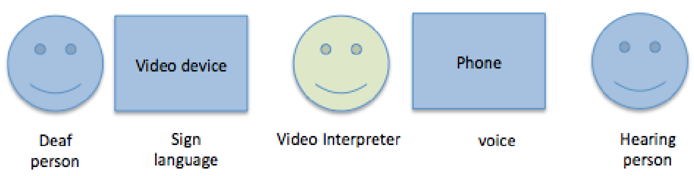

FIGURE 2.3: **Video relay service.**
A Deaf person sits in front of a video device, and dials the VRS line. A VI answers the call, the Deaf person asks the VI to dial the hearing persons number. The Deaf person communicates with the VI in sign language and the VI communicates with the hearing person through speech or voice. Thus a Deaf person can communicate with a hearing person using a VRS.

In the United States, and several European countries the governments compensate companies who provide telephone lines and similar technologies to bring VRSes to their citizens. The availability of video calling and Third Generation (3G) technologies on mobile phones allows Deaf people to have access to such systems although the use of such systems is expensive.

Telephone Interpreting Service for South Africa (TISSA) is a video interpretation to provide people with assistance in South Africa's 11 official languages, when they visit service providers such as doctors, the Department of Home Affairs and the Police Station [42]. The main aim of the TISSA project was to bridge language barriers between members of the public and public service officials via a telephone in South Africa. SASL interpretation on TISSA was at one time provided, and worked as follows. The SASL interpreter was located in a remote location. A Deaf person would go to a public service official and interpretation would be required. SASL relay communication was established using Integrated Service Digital Network (ISDN) video phones so that the public service official and the Deaf person could communicate. TISSA with SASL was piloted in 2002. It was later relaunched without SASL interpretation.

The VP-200 is a next generation videophone that is designed to use the Sorenson Video Relay Service (SVRS) to allow Deaf people and hard–of–hearing to effectively communicate with hearing people [56]. Deaf people can use the SVRS software and hardware to call hearing people and other Deaf people who use the VP-200 telephone (see Figure 2.4). The TExt and Sign Support Assistant (TESSA) is a project where speech is converted into text and the text is then converted into a sign language animation [14]. The TESSA project aims to aid communication between a Deaf person and a clerk in a Post office, by translating the clerk's speech into British sign language (BSL) for the Deaf person to understand. This is an interactive system but contains a very limited domain of communication between a hearing person and a Deaf person. The main objective in the TESSA project is to provide a system that converts speech-to-sign language with a limited generality but could be used to accomplish communication between a hearing person and a Deaf person thus aiding the Deaf person. Furthermore facial expression (see Figure 2.5 for the avatar) and the appearance of the avatar need to be improved. All the Deaf users said that a combination of BSL and text are better than BSL alone. Finally that the delay between phrases needs to be reduced.

2.2.3 Sign language communication

Sections 2.2.1 and 2.2.2 described communication methods that Deaf people can use, and some of these require the use of a relay operator. This section describes

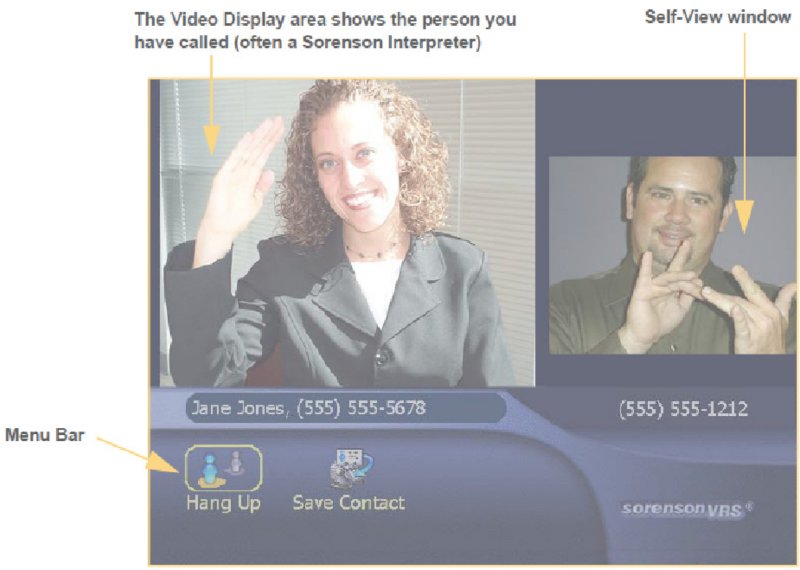

FIGURE 2.4: **VP–200 SVRS user interface.**
The SVRS system allows Deaf people and hearing people to communicate with each other over telephone lines using a video interpreter. A Deaf person using the VP-200 telephone appears on the right hand side, the SVRS interpreter appears on the left. Below the Deaf persons window and the video interpreters window is a menu bar.

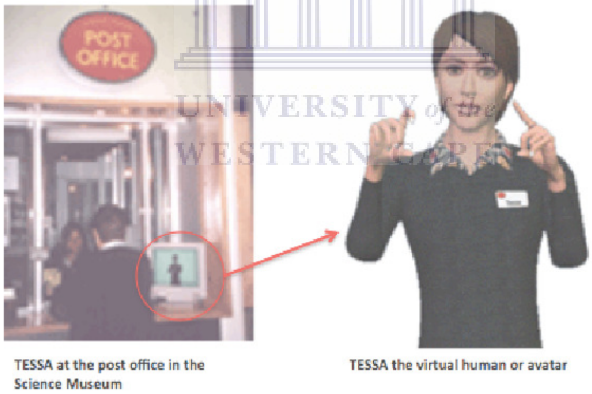

FIGURE 2.5: **TESSA interface.**
A hearing person speaks into a microphone, the system does some processing, and a BSL animation of the spoken words is displayed on the screen.

other communication methods for Deaf people using videos for sign language communication. Thus, Deaf people can communicate with other Deaf people using video technology systems which utilize their very own sign language.

The first example is a mobile system to facilitate communication between the medical responders and the Deaf patients [6]. The system allows the medical respondent to browse a collection of medically related sentences and the corresponding sign language video is played for the Deaf person (see Figure 2.6). The system runs only on Windows mobile OS. The questions on this system are formatted to allow for ‘yes/no’ answers because the hearing person might not understand and the system cannot translate the elaborate answers given by the Deaf person in sign language. The system is only used by the medical respondent and no interaction is expected from the Deaf person. The Deaf person answers the ‘yes/no’ without the system. The filming of the videos required a high-definition camera (1280x720, 16:9, 50fps, H.264/MPEG-4) which were then encoded to a lower quality (640x480, 4:3, 12fps, WMV) to allow for smooth play on the mobile phone. For additional feedback for the medical respondent, a corresponding English translation audio is played at the same time as the sign language video. Distinctive sounds are used at the beginning and the end of the video to notify the medical respondent that the video is starting or ending. The sounds are played because the phone is facing the Deaf person (see Figure 2.7).

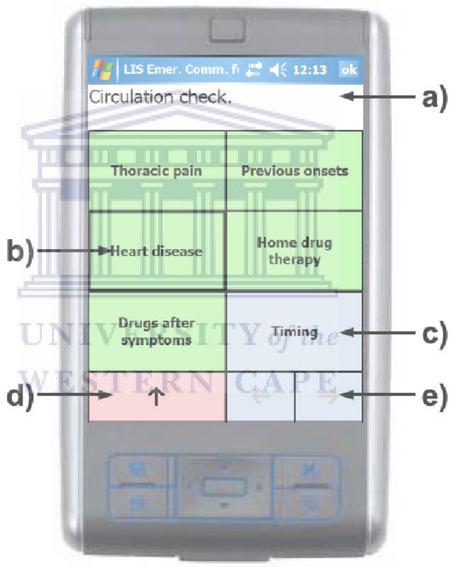

FIGURE 2.6: **Mobile support user interface.**
(a) Current menu. (b) Green buttons to select a sentence. (c) Pale–green button to enter a sub menu. (d) Pale–red button to go one level up in the tree. (e) Pale–blue button to navigate menu pages.

The next example is video calling, which is available in South Africa and the cost of using it during peak and off–peak hours is the same as a voice call during peak-hours, which can be expensive. Any mobile phone with a front–side video camera and 3G network capability can handle video calling. Video calling uses the camera in front of the phone, typically a low–resolution camera that allows users to see themselves (see Figure 2.8). The high-resolution camera at the back of the phone can be used, but the user cannot see the other person because the screen is turned away from them. The resolution from the front–end camera is typically poor and unacceptable for sign language communication. The videos

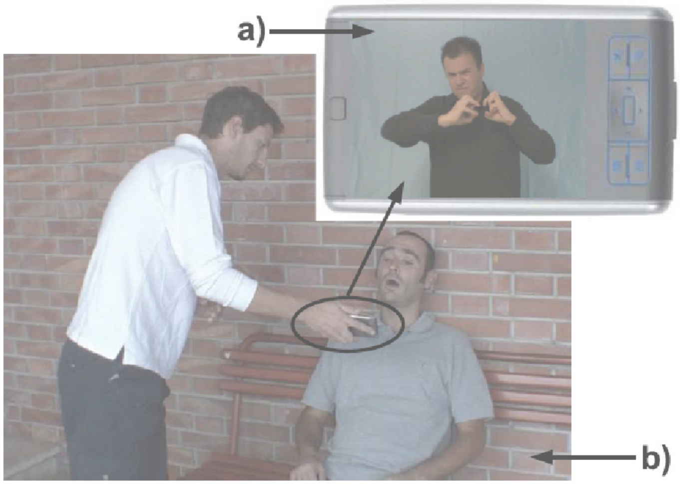

FIGURE 2.7: **Deaf people using mobile support**
A hearing person speaks into a microphone then the system does some processing and a BSL animation of the spoken words is display on the screen.

captured by the front–end camera have low–resolution and this does not support sign language communication well due to the low frames per second. This service is not intended for Deaf people because voice communication is still prioritized. The cost of making a video call is between R0.90 and R2.90 depending on whether their tariffs are on contract, prepaid or to–pup [66].

FIGURE 2.8: **Video calling user interface.**
The big video window shows the other person while the small video window shows the person using the phone.

The last example is for American Sign Language (ASL) in a project called Mobile American Sign Language (MobileASL) project. This was developed at the University of Washington and aimed to advance the Deaf and hard–of–hearing in the field of Science Technology Engineering and Math (STEM) [10, 11]. The MobileASL system allows two Deaf people to communicate with each other in ASL over the United States cellular network using video cell phones (see Figure 2.9). Some of the motivation behind the project includes a need within the Deaf community for mobile ASL conversations, limited cellular network bandwidth, and limited processing power on the cell phones. The two cellular networks taken into consideration are the General Packet Radio Service (GPRS) network and the

3G networks. The encoding and decoding of the videos on the target devices is done with an open source implementation standard, the X264 codec, from the well-known H.264 codec. The limited phone network bandwidth presents video compression with a challenge: the simultaneous delivery of clear video while expending the least possible amount of bandwidth.

FIGURE 2.9: **MobileASl user interface.**
The big video window shows the other Deaf person, while the small video window in the bottom right corner shows the person using the phone.

In their project they define the Region-of-Interest (ROI) to be the face, hands and arms of a person signing in a the sign language video (see Figure 2.10). The resolution is dropped around the other areas of the video which are not required for sign language communication, such as the background. This is achieved by using a skin detection algorithm. They also determine if a person is signing or not by using active recognition, that is if the person is not signing then the video is not sent.

2.2.4 BANG projects

BANG has been developing systems for Deaf people since 2001 and began working with DCCT in 2004 [24]. BANG's fieldwork with Deaf related projects fall into different phases (see Figure 2.11). The first phase is the Telgo phase, with text relay [46, 62]. In this phase, a Deaf person uses a Teldem and a hearing person uses a phone. Sometimes the relay systems converted text–to–speech automatically which made the text relay semi-automatic. An example is the Telgo323: An H.323 bridge for Deaf telephony [47]. The second phase is the Softbridge phase, which provides fully automated text relay [62]. On Softbridge prototypes a Deaf person uses an Instant Messaging (IM) client on a computer to type and the hearing person uses a similar IM client that converts Text–to–Speech (TTS) and uses Automatic Speech Recognition (ASR). An example is the multimodal

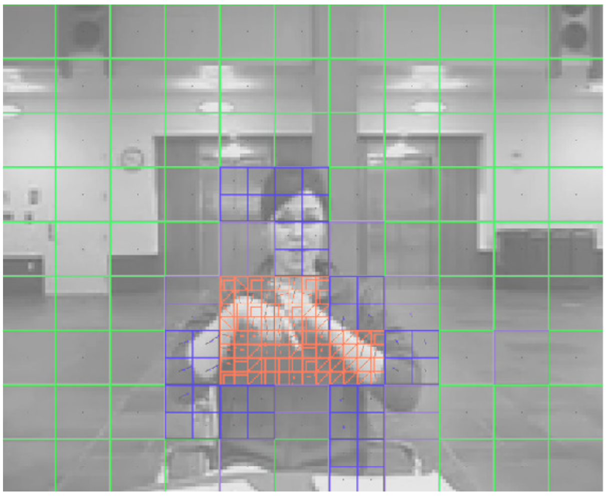

FIGURE 2.10: **Video processing in the MobileASL project.**
The blue region presents the main part of the person signing and in most cases that would be the hands, face and body. The red region represents the only part of the persons signing which is moving or different from the previous frame and is important in the conversation. Anything that is green, is deemed as irrelevant to be transmitted to the next user.

instant messaging bridging system [35]. The third phase is the Softbridge Instant Messaging Bridging Architecture (SIMBA) phase, which involves semi-automated text relay because it requires a human operator to convert the hearing person's speech into text [23]. Two examples are the web–based telephony bridges for the Deaf and semi–synchronous Internet Protocol–based communication [31, 59]. The fourth phase is the Deaf–to–Deaf communication phase with synchronous prototypes and semi-synchronous video sign language communication [62]. Two examples are a asynchronous video telephony for the Deaf and browser–based video communication for Deaf people [38, 72].

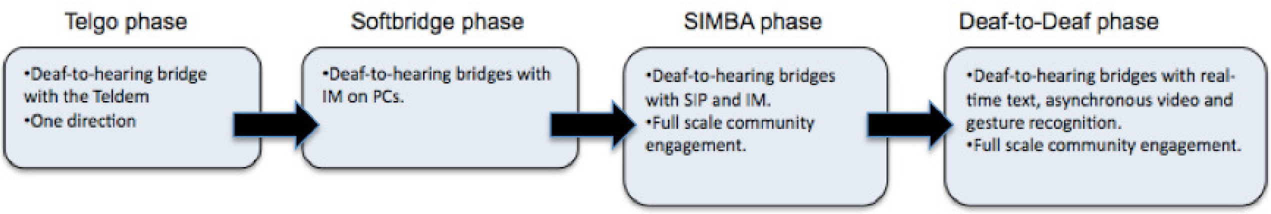

FIGURE 2.11: **BANG projects.**
BANG projects fall into four phases. The first is the Telgo. The second is the Softbridge phase. The third is the SIMBA phase and the final one is the Deaf-to-Deaf phase.

2.3 Other video systems

Other than the conventional research project systems, there are many free and commercial types of software that Deaf people can use for both Deaf-to-Deaf and Deaf-to-hearing communication. Some online sites where both Deaf and hearing people can exchange sign language videos are WinkBall [69], [55], Camfrog [7], GoogleTalk [26] and many others. The following two examples are systems that Deaf people can use to communicate using sign language. The first is a stand–alone application that runs on Windows OS and the other is an online forum. These two examples are mentioned here because of good video quality they transmit which can support sign language communication [44, 71]. Both are products from the company, Omnitor. The Allan eC (All languages electronic Conversation communication) platform that gives a person the possibility to communicate in a way that suites their specific communication technique [71]. The Allan eC platform is added to a computer running Microsoft Windows OS. The Allan eC comes with, amongst other things, a camera and a PCI–card for video capture. It requires support for DirectX v 8.0 or later. It offers the possibility to use text and video in the same conversation. Deaf people can communicate with each other using the Deaf video part of the platform (see Figure 2.12). Video communication has good quality for sign language and lip reading. It is compatible with other Session Initiation Protocol (SIP) and H.323 video conferencing systems.

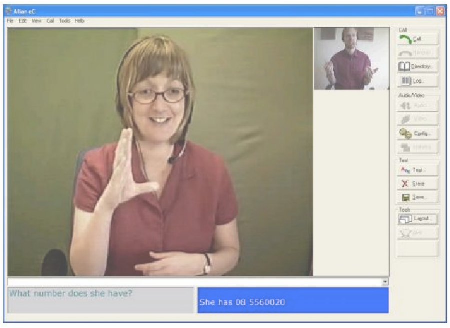

FIGURE 2.12: **Allan eC user interface**
Two Deaf people using the Allan eC application and typing simultaneously.

SignForum is a meeting point discussion forum on the Internet for Deaf people [44]. Instead of the usual typed text message, a Deaf person records a video message with optional text. The video is recorded using client software to record a message. The message is then sent to the Signforum server. As the user reviews it, a message is played automatically. SignForum runs inside a browser and allows for sign language communication (see Figure 2.13).

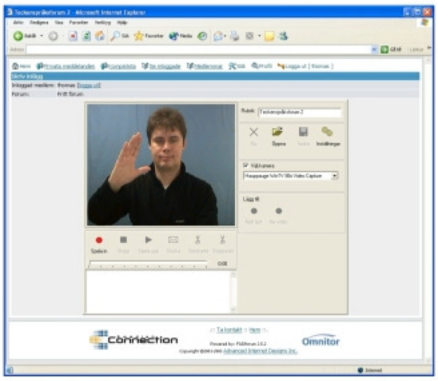

FIGURE 2.13: **SignForum user interface**
User interface of SignForum with sign language video playing inside an Internet browser.

2.4 Mobile sign language dictionaries

Mobile sign language dictionaries are systems where text is entered on a website or sent to a web server and sign language video or animation is sent back or displayed respectively. Online dictionaries can be used to aid communication between Deaf and hearing people. In the United Kingdom, there is a site where a Deaf person can logon and use the sign dictionary online, which has more than 5 000 British Sign Language videos of signed words (see Figure 2.14) [64]. The user downloads the videos and plays them locally on his/her phone.

FIGURE 2.14: **MobileSign browser project.**
A user types an English word and downloads a pre-recorded BSL video. The pre-recorded BSL video is an equivalent of the typed text.

Multimedia Messaging Service Sign (MMSSign) is a project that converts a text message into a sign language video equivalent and then puts the sign language video into a Multimedia Messaging Service (MMS) [28]. The Project aims to enable communication between Deaf people and hearing people using sign language animation (see Figure 2.15). The system was developed to translate text-to-MMS containing the video of the text in sign language. A user creates a text message and sends it to the MMSSign server to process it. The text is converted into a sign language animation video equivalent. The animation is then converted into a video format called Third Generation Partnership Project (3GPP) video. Finally a 3GPP video is then put into an MMS and MMSSign server sends back an MMS to the user. The cost of the MMS is paid for by the user, through the telecommunication's operator who delivers the MMS. The automatic translation of text-to-sign is not a word for word translation, because sign language is an independent language on its own and not a dialect of a spoken language. Translating the text-into-sign language requires a variety of procedures such as lexical, grammatical, translational equivalences and semantic analyses. It requires time and sophisticated programming skills. The system allows for high usability of cell phones by Deaf people, and a hearing person can also communicate with a Deaf person. A similar system in South Africa is the Thibologa System which can be used by Deaf people in South Africa [60]. A Deaf person sends the word dictionary followed by the word they want (i.e. dictionary hello) to a number. The system sends back an SMS with a link to the SASL video. Accessing the link allows the Deaf person to download the SASL video signed by an avatar to the mobile phone. If the word is not available in the dictionary, the word sorry is sent back.

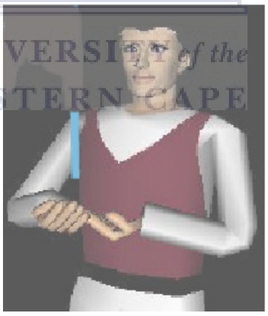

FIGURE 2.15: **MMSSign avatar.**
The MMSSign avatar in an animation video MMS that is sent back to the user in the form of an MMS.

2.5 Translation systems

Some researchers attempt to convert sign language signing into text using AI [2]. These systems are meant to detect various hand shapes, hand positioning and hand movements to identify them from a user in real time. These systems require fast matching algorithms. Using the dot product of the new image being tested and the stored eigen values it is possible to obtain recognition that can determine whether a matching gesture falls within the matching threshold. If the new image being tested does not fall within the threshold then this new image is either not in the training or it is not a hand. These systems require the use of large mathematical libraries as evidence. The more images the system has, the longer it takes for the system to finish, and the more memory required. Data gloves and colored gloves can be used to identify hand gestures. When a user wears these input devices, the system uses them to capture the position, rotation, and formation of the hand and uses a computer camera to capture the hand gestures and image manipulation algorithms to interpret signs or gestures. The Pose-Movement Model incorporates the static (Pose elements) and dynamic (movement elements) subclasses of manual gestures. This system also uses the Hidden Markov Models (HMM) for classification of gestures.

Local South African systems examples can be found in projects such as gesture recognition using feature vectors [41, 51]. This system is still in the process of being developed; it converts SASL into English and vice versa. The English–to–SASL conversion is presented using a 3 Dimensional humanoid Avatar, and the SASL–to–English conversion is presented as speech in English. This system makes use of a client–server model with the mobile phone being the client, the server being a computer, and the two are connected through Wireless Fidelity (Wi-Fi). A recognition rate of more than 65% was achieved from all the methods they used (see Fig 2.16). This rate was sometimes affected by the different SASL dialects that exist in South Africa. Once the SASL dialects were not taken into consideration, a recognition rate of more than 85% was archived from all the methods they used. Deaf users recognized the pre–recorded SASL video with ease, followed by the Man avatar with high detail, followed by the Man avatar with low detail, and then the low–detail Avatar Phlank. This shows that the SASL video equivalent of English is better than animation or the use of avatar [21]. The system achieves an acceptable level of accuracy [2].

2.6 Summary

SignSupport is a mobile system that will allow a Deaf person tell a hearing doctor how they are feeling so that the doctor can give them a diagnosis (see Section 1.2). The Deaf user answers questions presented in SASL. The answers are presented in English for the hearing doctor to read and diagnose. The hearing doctor uses a look–up dictionary to respond to the Deaf person. This chapter discussed related work, similar to our system. Medical expert systems use huge libraries to ask people questions about their symptoms and based on their answers diagnoses them

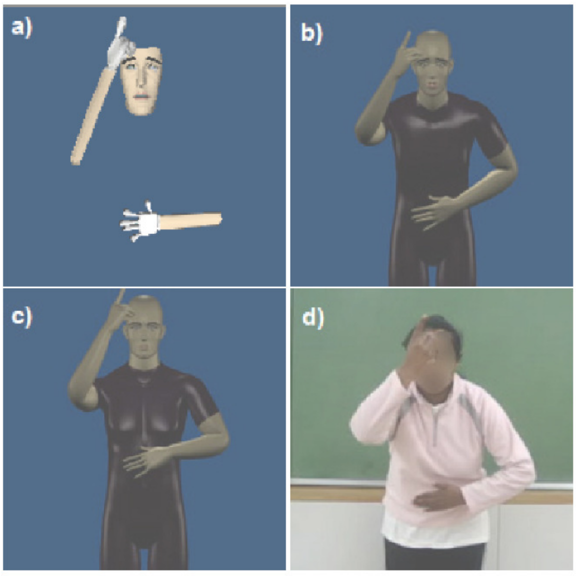

FIGURE 2.16: [21] **The Machine Translation system using four methods** (a) the avatar called Phlank a low–detail avatar, (b) the avatar Man with high–detail with non–manual features such as facial expressions, (c) the avatar Man with low–detail with non–manual features such as facial expressions (d) a pre–recorded sign language video

[29, 52, 61]. Our system will ask Deaf people questions and the answers to these questions the doctor will diagnose. Both text and video relay system take what a Deaf person types or signs and relays it to a hearing person vocally [62]. The TESSA project converts speech–to–sign language with the use of an avatar, but with limited vocabulary [14]. Our system is a form of automated relay. It takes a Deaf person's sign language answers and presents English text and from English phrases to sign language. Our system also uses a limited vocabulary. Some project likes mobile support, video calling, mobileASL online dictionaries, MMSSign and the translation system mentioned herein allow for sign language communication and display sign language on a mobile phone [6, 10, 11, 28, 64] (see Section 2.2.3). Some of these systems use real sign language videos to present the sign language while other use avatars. Our system uses SASL videos play back on a mobile phone to ask Deaf people questions and to display SASL video responses from a hearing doctor. Our intention is to use SASL videos not avatars, on a mobile phone. BANG projects have been tested with DCCT Deaf people since 2004 [62]. Our system will also be tested with the same Deaf community (see Sections 1.3 and 1.2). Computer based video communications such Omnitor's Allan eC and SignForum can be used by Deaf people for sign language communication because their video quality is good [44, 71]. SignSupport should be able to present SASL video with good quality enough for Deaf people to understand manual features and non–manual features. In this chapter we looked at the related work, similar to our system. In the next chapter, we look at methods used in the related work to design systems and also how these systems were evaluated.

Chapter 3

Methods

This chapter presents the research question and methods used in answering the research question. The research question is how to design and evaluate a prototype that will allow a Deaf person to use SASL to tell a hearing doctor how s/he is feeling and provide a way for the doctor to respond. The overall approach is to design and evaluate the system for a mobile phone browser in a context free manner to allow for new scenarios to be created using a content authoring tool. Section 3.1 identifies the challenges arising from the related work. Section 3.2 presents the research question. Section 3.3 presents the design and evaluation methods used in answering the research question. Section 3.4 outlines the experimental procedures for designing the prototype on the phone and the way in which the prototype was evaluated. Section 3.5 presents ethical considerations. Section 3.6 summarizes this chapter.

3.1 Challenges emerging from the related work

In this section both the design and evaluation challenges arising from the related work are discussed. The questions Looijesteijn used for his prototype were obtained from three medical doctors [37]. For his design, he used a focus group consisting of Deaf people and he also used a survey to elicit the Deaf community's characteristics. Looijesteijn's mock–up runs inside a computer browser using video streaming, uses SASL videos and English text, has a user interface made for Deaf people, and uses a limited vocabulary. Looijesteijn tested his system with four DCCT Deaf staff members at the Bastion with the help of an interpreter. The Deaf people navigated through the system in pairs, they filled in a questionnaire and were interviewed. From the results obtained from Looijesteijn's design, the Deaf users at DCCT were happy with the proposed system.

Medical expert systems are limited for our Deaf community because they have a text interface suited for a hearing person and not a SASL interface [29, 52, 61]. Our Deaf community has basic levels of English literacy, and prefers SASL communication [62]. Many people in our Deaf community have mobile phones however, they are mostly low–end. Medical expert systems phrase question for their users, the answers to which are then used to diagnose the user [29, 52, 61]. The AI in a medical expert system also requires a dedicated server on which to run the system and mobile phones do not have the capacity of handling such a system. However a mobile phone can offer a front–end to such a system. Some medical expert systems are web–based and are easily accessible for people to use, e.g. WebMD a symptom checker [68]. WebMD is text–based and not available in SASL.

A few Deaf people who are literate have an option of using text relay which can help improve their English literacy [37]. Deaf people in our community do not have well paying jobs due to their low–levels of English literacy so they cannot afford relay systems even if they were available. Other relay systems are not available in South Africa [62]. Members of our Deaf community are not confident using text in the form of SMSes with hearing people. This is because sign language and English have different sentence constructions [30]. With SMS one never knows if the other party has actually read a message or not. SMS may be useful in some Deaf Telephony situations, but it is not applicable to all situations, particularly where synchronous, acknowledged communication is required. In practice, relay systems need the government to subsidize companies to provide telephone lines [49]. For this reason, relay systems have not been available in South Africa and they are only available in developed countries [14].

TESSA has a limited vocabulary and is semi–automatic converting speech–to–SASL animation. A limited vocabulary makes a system easier to build, yet does not offer a Deaf person full exibility with sign language. The MobileASL project allows Deaf people to use sign language to communicate. It runs on a mobile phone which makes it portable and cheap [8, 9]. A focus group was used as user input for the design of mobileASL, and the system was tested by Deaf people. After evaluating the system, the Deaf participants had to answer a subjective questionnaire consisting of part multiple choice questions and questions with a likert scale ranging from 1–to–5. The TESSA project was evaluated by Deaf people and post office clerks. The Deaf people determined if the sign language rendered by the avatar was acceptable or understandable. At the end of the user trial both the post office clerks and the Deaf people filled in a questionnaire. Sign language dictionary sites are limited for Deaf people in our community be cause they have to download the videos off the site, the cost of which in South Africa is about R0.02–R1.50 per MegaByte (MB) [27]. Deaf people in our community do not have sufficient means to pay for internet downloads [62]. Sign language dictionary sites are uni–directional communication, that is, a Deaf person in our community cannot upload a sign language video recording for English text.

In video calling, voice communication is still a priority. This means poor video quality. On a mobile phone, the camera with high–resolution is at the back. It is also expensive because a user pays between R0.90–R2.90 per minute depending on whether their tariffs are on contract, pre–paid or top–up [66]. Video calling and SMS are portable because they are available on a mobile phone. Video calling also uses pre–existing technologies found on most smart phones. Synchronous communication on a computer is not ideal because such systems require the person to have a computer and be online. In our experience, few Deaf people in our community are simultaneously online. Therefore if a Deaf person wants to use such a system, there are not many other Deaf people who would simultaneously be online at the same time.

Omnitor's Allan eC and SignForum have good video quality sufficient for sign language communication [44, 71]. One drawback of translation systems is that they take too much time. A local translation machine project's results indicated that Deaf users prefer real SASL videos for displaying sign language as opposed to using avatars [21, 41, 51]. Online dictionaries are made for mobile phone browsers and have limited vocabulary [64]. Medical respondents and Deaf people were involved in the design of the mobile support system [6]. The questions asked by the system were obtained from medical respondents. Each medical respondent gave 10–15 sentences they used in an emergency, and ambiguous ones were removed. The questions were formulated to only receive 'yes/no' answers. The questions used in the mobile support were stored in a tree–like structure in eXtensible Markup Language (XML). The sign language videos were recorded using a high–definition camera. Deaf people described means by which they communicated with hearing medical respondents such as read and writing. Their interview results with Deaf people indicated that, Deaf would like to use sign language to communicate with hearing people. They used touch screen smart phones to run their prototype on. Their design is inspired by simple user interface. The medical respondents selects a sentence and a SASL video is played in full view. The Deaf person does not touch the phone but responds with a 'yes/no' answer. Ten medical respondents and Deaf people tested the system in pairs. At the end of the user trial both the medical respondents and the Deaf people filled in a questionnaire and were interviewed.

3.2 Research question

The research question emerges as: How to design and evaluate a prototype that will allow a Deaf person using SASL to tell a hearing doctor how s/he is feeling and provide a way for the doctor to respond. This research question can be split into two.

- how to design and implement SignSupport for a mobile phone browser in a context free manner which allows for other scenarios to added easily?
- how to evaluate SignSupport to determine if the Deaf users can understand the sign language in the videos and if they find the system easy to use?

The first part of the first research question is how to design SignSupport on a mobile phone. Looijesteijn's results forms the core of the user requirements [37]. Our system is an implementation, not a mock–up, and runs on mobile phone's browser. Similar to Looijesteijn's SignSupport design and MobileASL, Deaf people's input was obtained from a focus group consisting of Deaf people [8, 9, 37]. Nurses at University of the Western Cape (UWC) were asked to list questions they would ask a person they suspect to have flu [5, 37] (See Section 3.4.1 for why nurses were used instead of doctors). SignSupport is a web–based system [68] that will run on a mobile phone [5, 8, 9, 37, 64]. The system will use SASL videos for the questions, answers and responses [5, 8, 9, 21, 37, 56]. The system will phrase questions that have 'yes/no' and multiple choice answers [5, 37]. A look–up dictionary similar to the online dictionaries is used to allow a hearing doctor to respond [64]. The system will have a simple user interface [5]. The system will have a Deaf interface using SASL videos and a hearing interface using text [37, 62]. The SASL videos is converted into Adobe Flash to allow for video streaming in the mobile phone browser [37]. The entire system is stored on the mobile phone's memory to cut data costs to 0 and also to make the system portable [5, 37].

The second part of the first research question is how to implement the system to allow for multiple context free scenarios to be created easily. An authoring tool is built to create the pages of SignSupport. The authoring tool allows for easy creation of other scenarios that Deaf people could use at a police station, Department of Home Affairs, pharmacy, etc. The authoring tool allows a user to upload SASL videos and equivalent English text without editing low–level code. After the scenario is created, SignSupport is ready for use once the SASL videos and the pages are coped to the mobile phone's memory.

The second question is how to evaluate the system within the target community to determine if they understand what is signed in the SASL videos and if they find the system easy to use. Deaf people in our community are familiar with evaluating the SignSupport prototype [37]. A plot trial was conducted with a focus group to obtain preliminary user feedback before a final user trial is scheduled. The final user trial will consist of more Deaf people from DCCT. Consent was obtained from the Deaf participants. They were given an example of the doctor's visit scenario [6, 37]. They were informed how to use the system in the scenario. The system will then be tested by the Deaf people. At the end of the user trial the Deaf users filled in questionnaires and after that they will engage in a semi–structured interview [5, 8, 9, 14, 37]. An interpreter was used to facilitate communication between the Deaf participants and the researcher. We want to know if Deaf people can understand the sign language videos on the SignSupport prototype. Did they found the system easy to learn and use? Did the system increase their level of privacy when exchanging information with a doctor? Would they use the system in real life?

3.3 Methods

This section presents the methods used in answering the research question. Section 3.3.1 is used to answer the design part of the research question. This is the method used to design the prototype in a context free way for a mobile phone browser. Section 3.3.2 is used to answer the evaluation part of the research question. This includes the methods used to collect data from the Deaf users to evaluate ease of use and video quality on the mobile phone.

3.3.1 Design

Iterative prototyping can be used within a Software Development Life Cycle (SDLC) where a system's functionality and interface are designed, implemented and tested in a repetitive manner each time the results contribute to the design [15]. Our first design was a mock–up prototype, which ran on a computer, and the design mentioned herein is the mobile implementation thereof which runs on a mobile phone. Feedback from the computer-based prototype forms the heart of the mobile system's user requirements. Iterative prototyping allows the addition of features or changes to be made to the existing features on the prototype. In this way the prototype evolves through user feedback obtained from user testing [5]. The iterative steps are user input and design, implementation of design, user testing and user feedback analysis. Testing is important in iterative prototyping because as users test the system, functional and non-functional errors can be detected [5]. New features, which were suggested by the users, were analyzed to further develop the prototype.

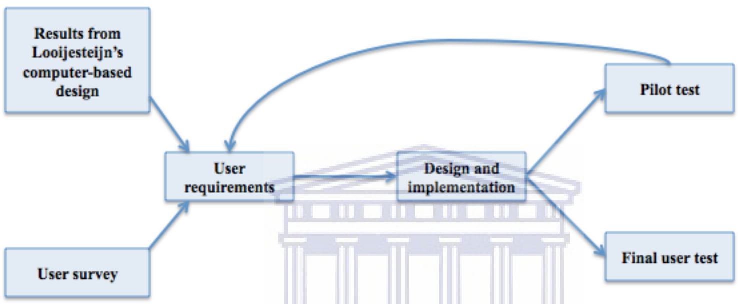

FIGURE 3.1: **Iterative prototyping.**
The initial prototype ran on a computer, made by Looijesteijn [37]. The prototype evolved from running inside a computer browser to run inside a mobile phone browser in this research. The user requirements were obtained from the Looijesteijn computer–based results and the survey. The design was then implemented on for a mobile phone browser. After the first implementation a pilot test was conducted. The results from the pilot test were added to the requirements, the prototype was then re–implemented. After this implementation a final user test was schedule and user testing was conducted. This figure also shows how the results in Chapter 5 are organized.

The user feedback from the testing of the computer-based prototype by Looijesteijn [37] was used as initial input for the prototype described in this thesis (see Figure 3.1). Looijesteijn's computer–based prototype, webMD's symptom checker and mobilesign are online systems that run in browsers whether on a mobile phone or a computer [37, 64, 68]. The system is implemented to run in a mobile browser following user input and design. Looijesteijn's system and the MobileASL project used focus groups consisting of Deaf people in the design of their systems [8, 9, 37]. These projects' design also follow iterative design, where the systems are improved over time based on user feedback. A focus group was used for Deaf user input on the design and also to test a preliminary prototype. After the system was completed, user testing was done with the focus group. The results obtained from the focus group testing were used as input for the second iteration (see Section 5.2 for the focus group results). The system was then implemented again based on the users' input. The prototype was then used for the final user test.

3.3.2 Evaluation

Qualitative methods are used to describe how people experience a given research project from a human side such as their personal opinions about a system [18]. Subjective methods are also used to understand feelings and perceptions that influence a behavior. These help to identify a user target group's needs and generate ideas for improvement [19]. Qualitative methods offer advantages in that some aspects of the study are flexible and can follow an iterative design, which is affected by the participant's input [18]. The participant's response affects what question the researcher asks next. The data collected contains rich explanatory information. Weaver et al. tested their sign language video on 3 resolution levels (low, medium and high) [67]. Their results indicated that despite the Deaf users watching the videos on 3 resolution levels, this did not affect their ability to replicate the signs they saw. For our evaluation, we only tested the videos on our system on one resolution, the resolution with which the videos were captured. Based on Weaver et al.'s results the Deaf people in our community should be able to understand the signs in the videos [67].

The qualitative research methods reported in this thesis consists of surveys, questionnaires, participant observation and a focus group. The user survey was performed in the beginning of the process to help understand the community and to add onto the user requirements from Looijesteijn's results [37]. Questionnaires were used to collect data from the focus group during the pilot trials and the final user testing. The questionnaires employ Likert scales for the users to answer questions (see Appendix B). A focus group was used to evaluate the mobile-based prototype in the first iteration. The focus group was used to draw out cultural norms of Deaf people and a general overview of issues that are common to them. The SASL videos used in the prototype were recorded with the members of the focus group. Only one member of the focus group signed in the videos while the other helped in deciding which signs to use based on how well the signs were known and used often by most Deaf people who come to DCCT. Participant observation was used for collecting data on natural occurrences, i.e. things that come up or are taking place during the user trial of the prototype. The type of data obtained from the qualitative research methods were field notes and completed questionnaires. The relationship between the researcher and the participants was less formal, allowing participants to be more elaborative, giving more detail.

3.4 Experimentation design

This section details how the design and evaluation methods described in Section 3.3 were implemented. Section 3.4.1 describes how the user survey was organized, how the questions used for SignSupport were gathered and how SignSupport is made. Section 3.4.2 describes how the focus group and the final user evaluations were conducted, what happened when the research met the participants and how data was collected.

3.4.1 Prototyping design

User survey

A user survey was arranged with some of the Deaf people who go to DCCT. It was held on a Wednesday and we organized lunch for the Deaf people who were involved. The survey was held at the Bastion. We made use of an interpreter. We had to ask permission to interview the Deaf people from one of the DCCT staff members and she also provided us with a venue. There were 33 Deaf people at the beginning of the survey but some of them had to leave towards the end. Not all of them answered all the questions. The Deaf participants were told about the research. This survey was conducted with two other Masters' students in the BANG group from the UWC. The Deaf people were asked to fill in a questionnaire (see Appendix E).

Questions

The mobile prototype asks a Deaf person medical questions. These questions were obtained from UWC fourth year nursing students. The students are practicing nursing at Tygerberg Hospital in Bellville. Nurses were used because they were easily accessible because the UWC has a nursing department and no medicine department. That means more people could be used to formulated the questions in a short amount of time. Also the use of doctors would have been ideal but that means several appointments had to be arranged with different doctors to obtain different questions. Perhaps the use of actual doctors (more than 1) can be used in the next iteration of SignSupport by the next person. A meeting was arranged with 12 students at their department on UWC premises (They were informed about the project). Consent was obtained from each one of them (i.e. they signed consent forms (see Appendix F)). Each nursing student was asked to write down questions that they would ask a patient who they suspect has flu and also write down the possible answers. The number of questions obtained from each student ranges from 8 to 12 questions with answers. Some of the questions were similar. When all the questions were added together and similar ones were removed, they were 38 in total (see Appendix D). The questions were then arranged in chronological order. A meeting was arranged with the focus group to arrange the questions and their answers into a structure that is usable for SASL. After that the questions and their answers were recorded as SASL video with the focus group. The SASL videos were then inserted into the SignSupport prototype. A pilot trial was conducted with the focus and an interpreter was used (see Section 5.2). After the feedback from the pilot trial, the main result that emerged was that there were too many questions and they had to be cut down for the final user testing. A second meeting was arranged with two of the 12 nurses to cut the number of questions to 11 questions for the final user trial. The nurses choose 11 questions that they felt were the most important. The questions were cut down because pilot trial results indicated user fatigue. The pilot test results were used to determine the suitable number of questions for the final user trial. This appears here because the results from the user trial were re-inserted into the design in order to produce the design for the final user trial. The sample questions and the map of how each question follows the other can be seen in Appendix C. As the questions are added using the content authoring tool, a tree–like structure can be achieved by controlling the link to the next question page (see Section 4.3 for more details).

SignSupport

To answer the research question a prototype was designed and implemented for a mobile browser that is Adobe Flash enabled using Looijesteijn's results [37] and results obtained from the survey (see Appendix E). This prototype is called SignSupport (see Section 4.2). The SASL videos are played inside the browser for better user interaction and for this to happen the SASL videos are embedded into XHTML pages. To create the pages of SignSupport an authoring tool was designed and implemented to generate context free scenarios (see Section 4.3). Context free scenarios are simply a set of SignSupport SASL video questions for a Deaf person's visit at a doctor, a pharmacy visit, at the department of home affairs, police station, etc. For this project, I choose to implement a small number of questions. A more complete system can be implemented by someone else (see Section 6.4 for more details). The authoring tool allows an administrator (admin) user to create a context free scenario by only uploading pre–recorded SASL videos and adding the

SASL video equivalent in English text. The target user of the authoring tool is an Admin user at this stage, this is someone that understands how the system is made and understand the Deaf community. This person is responsible for recording new SASL videos, adding them to the system and deploying them on Deaf people's phones. This person should update the system's questions whenever most of the Deaf people experience the same problem in communicating with a hearing person who cannot sign. An example is when everyone goes to the a hearing doctor with flu symptoms. Before recording a new SASL video upon Deaf people or doctor's request, the Admin user needs to bring both the Deaf people and the hearing doctor together and arrange for interpretation if needed. The problem is then clearly noted and understood then a solution is suggested before the new questions and answers are added to the system. When creating a scenario or adding new questions to the system, the admin user does not have to deal with any low–level editing when using . When creating a SignSupport page, which contains a video, the following happens. The user uploads a SASL video and types in the English text equivalent. The video name and the text are the only difference between two questions, two answers or two response pages (see Figure 3.2). There is only one introduction page, which is also generated in the same way as the other pages that contain a SASL video. In this way the presentation of the SASL video, text, and the page format remain constant but the video name and text differ (see Figure 3.2). The other pages of SignSupport do not change from one scenario to the next, except in title of the scenario displayed on each page.

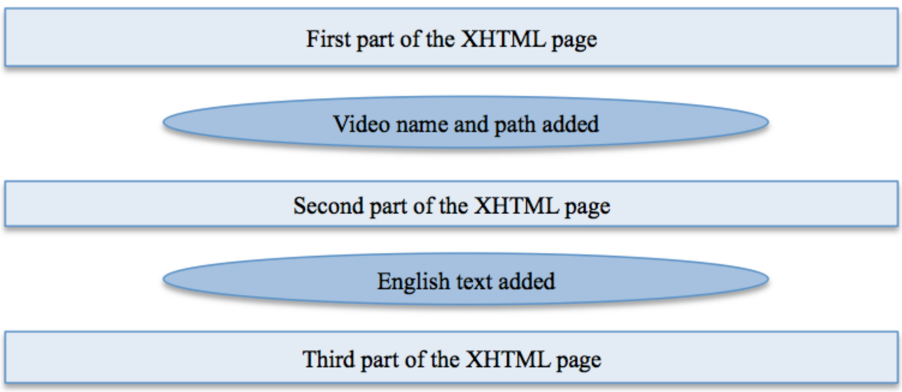

FIGURE 3.2: **Design of a SignSupport page with a video.** SignSupport pages that contain a video such as an introduction, question, answer or response pages. The first, second and third parts of the XHTML page do not change. The difference between two questions, two answers or two responses is in the video name and the English text. This makes it easy to generate a SignSupport video page.

3.4.2 Prototype evaluation

In Section 1.5 the target community was introduced. This community was chosen because since 2004, UWC has tested ICT4D prototypes with them and that is also the community used by Looijesteijn [37]. There were two user tests carried out with the Deaf community. The first was a pilot test that was conducted with members of a focus group. The second was the final user test. In both, an interpreter was made use of to ease communication between the researcher and the Deaf participants. The researcher conducted the focus group and final user testing alone, unlike the user survey, which was conducted with other other MSc students from BANG.

Focus group evaluation

Four Deaf people, an interpreter and the researcher met at the Bastion, to have focus group meetings, record SASL videos, go through SASL video questions, and to test the prototype. The focus group was chosen from DCCT staff members (see Section 5.2 for more details on the focus group). Arrangements for user testing were done as follows: firstly the researcher had to check for a day when the Deaf staff members were free, preferably on a Wednesday because that is the day of the week set aside for BANG prototype testing. Secondly the interpreter's availability was checked against the date. When the focus group members and the interpreter were available, the focus group meeting was arranged. Three of the focus group members were chosen because they participated in Looijesteijn's [37] evaluation of the computer-based prototype and one other Deaf user was asked to be part of the focus group because he was free whenever the focus group met. When the focus group met, we changed the structure of the questions and answers, recorded SASL videos used in the system, discussed the design of the system and conducted a preliminary test of the system. A SASL interpreter was used to facilitate the conversation between the researcher and the Deaf members of the focus group (see Section 4.4 for more details on the pre-recorded SASL video recordings). The data collection methods used were; observations, video recording, field notes and questionnaires. Observations were made during the session and noted down in a book. The pilot trial was recorded with a video camera. Field notes consisted of observations, and any other notable points that had or would have had an impact on the session (see Section 6.2 for information). A questionnaire was used to collect data in a more formal way. The results are shown in Appendix F, and discussed in Section 5.2.

Final user evaluation

The final user testing was done over three days. The first two days were on Mondays and the final day was on the third Sunday of the month. That Sunday was used because many Deaf people come to the Bastion of the Deaf on the third Sunday of every month for a large meeting. We had to ask for permission from one of the Deaf people at the Bastion who is in charge of the Deaf staff there. Then we had to book an interpreter for each day. We also asked for a venue from the person in charge of the staff members at the Bastion of the Deaf. The final user testing consisted of 31 Deaf members who had to have used a mobile phone before. The Deaf users were informed briefly about the project. Consent was obtained from them. The storyboard was shown to them telling what role they played in an example of a visit to the doctor. They were also shown how they would interact with the system, how to answer the questions and when to hand the mobile phone over to the hearing doctor. The Deaf participants then tested the system. After testing was complete, they were asked to fill in a questionnaire and then a semi–structured interview was held with them. The data collection methods used were observations, field notes and questionnaires. Field notes consisted of observations, and any other notable points that had or would have had an impact on the session (see Section 6.2 for information). A questionnaire was used to collect data in a more formal way. The results are in Appendix B, and discussed in Section 5.3.

3.5 Ethical considerations

Ethical approval was obtained from the UWC Science Faculty Ethics Committee. For the user survey and the focus group sessions, the Deaf people signed consent forms (see Appendix F). For the final user trial, verbal signal consent was used. For the user survey, focus group sessions and the final user trial, Deaf people were told about the project. After which they were asked for the consent to participate. They were told what the consent was for, how their identities were would be kept private, and the use of an interpreter.

Consent

A Deaf person was not allowed to participate in the research until informed of the project and consent obtained. Each participant was informed about the project and exactly what their role would be, stipulating in detail how the gathered information would be used. The researcher read the consent one sentence at a time and the interpreter translated what the researcher read into sign language for the Deaf people to understand. When the researcher was done reading consent, each of the participants agreed voluntarily and they were free to withdraw at anytime from the research. For the user survey and the focus group the Deaf people who participated were asked to sign consent forms (see Appendix F). The pilot test was conducted during one of the focus group sessions and the Deaf people in that session were asked to also sign consent forms. For the final user trial verbal consent was used. The verbal consent was noted on paper.

Confidentiality

Data collected from user survey in the form of answered questionnaires on paper were stored in a safe place. The identities of the participants are not revealed on the survey questionnaires. Data collected from the focus group sessions were field notes, answered questionnaires and video recordings. The field notes are digital and stored on the researcher's computer. The video recordings from the pilot user trial held with the focus group are also stored on the researcher's computer. The researcher's computer has a password, which prevents unwanted parties from using the machine. The answered user test questionnaires were stored in the BANG laboratory cupboard. Data collected from the final user trial were in the form of field notes and answered questionnaires. The field notes are stored on the researcher's computer. The answered questionnaires are stored in a safe place. The identities of the participants can only be seen on the video recordings, which are stored on the researcher computer. Elsewhere in the field notes and answered questionnaires the Deaf participants' identities are not revealed.

Interpreter

A sign language interpreter was used to facilitate communication between researcher and the Deaf participants during the user survey, focus group sessions, and user trial. The interpreter was notified that the information he or she is about to hear was confidential and that he or she could not make use of it and that the participant's privacy must be preserved. The interpreter had to able to sign in SASL, and speak English fluently to ease communication between the researcher and the participants. We hired professional interpreters who are bound by a code of conduct not to reveal personal communication made during the interpretation process.

Disclosure of researcher's role in research group

The research group is composed of the postgraduate students and their supervisors from the University of the Western Cape, (i.e. BANG). Other students in the extended research group study at the University of Cape Town (UCT). The Bastion of the Deaf building is the research site. DCCT staff members are our research participants. They tested the prototypes we present and gave us feedback. BANG's aim is building and evaluating bridges over digital divides centered around the realm of ICT4D. BANG's research is based on Internet Protocol, related protocols and networks [www.coe.uwc.ac.za]. The author is a postgraduate student and a member of the BANG research group at the University of the Western Cape and is responsible for the work reported in this thesis. At the Bastion there is a computer lab with Internet that Deaf people in our community use. On a weekly basis members of the BANG group repair hardware and software problems on the computers and the network at the Bastion. There was a course to teach some DCCT Deaf staff about computers and networks. DCCT's website is designed and maintained by a member of the BANG group. Other members of the BANG research group both at UWC and UCT carry out projects with the Deaf community. BANG and DCCT have a good working relationship that allows teaching of new technologies to Deaf people and the evaluation of projects.

3.6 Summary

SignSupport is a communication aid that allows a Deaf person to use sign language to view and answer questions, the answers of which are then presented in English for a doctor to diagnose. The system has a look–up dictionary the doctor can use to respond to the Deaf person with a SASL video. We examined relate work to address the challenges of such systems. These challenges lead to the research question: 1) how to design and implement SignSupport for a mobile phone browser in a context free manner which will allow for other scenarios to be added easily and 2) how to evaluate SignSupport to determine if the Deaf users can understand the sign language in the videos and if they find the system easy to use. The related work was then used to help with the design and implementation of SignSupport. SignSupport runs inside a browser on a mobile phone, allows for video streaming, is stored locally on a mobile phone's memory to reduce cost, uses SASL videos, has a simple interface, phrases questions, where the answers are either 'yes/no' or multiple choice, uses a look–up dictionary to respond to a Deaf person, and has SASL questions about health obtained from UWC nurses. A focus group and user survey were used together as Deaf people's input for the design. SignSupport mentioned herein is not a mock–up but an implementation with respect to Looijesteijn's design [37]. Methods we used for our evaluation and data collection were also drawn from the related work. SignSupport was tested as a pilot trial by focus group users, and also in the final user trial concluded the user tests. Data was collected by observations, field notes, video recording during the focus group sessions and questionnaires. The experimental design also comes from the related work. The arrangements of meetings for the user survey, focus group sessions and the final user trial were discussed. Consent was obtained from Deaf people who participated in the user survey, focus group and final user trial.

Chapter 4

System design

This chapter discusses how SignSupport and the authoring tool were developed. The user interfaces and high–level designs of both SignSupport and the authoring tool systems are presented. In Looijesteijn's design [37], SignSupport should be implemented to be stored both on and off the mobile phone. Herein this research, only the implementation where the SignSupport content is stored on the mobile phone is developed. Implementing SignSupport this way means that no network structure is required and Deaf people in our community do not have to pay for data downloads when using SignSupport. The authoring tool is used to generate the SignSupport prototype. The XHTML pages generated by the authoring tool and the SASL videos are stored on the mobile phone's memory. The prototype design is used to answer the first part of the research question which is how to design and implement SignSupport for a mobile phone browser in a context free manner which will allow for other scenarios to added easily. Section 4.1 presents the technologies that are available on Nokia S60 phones required to run SignSupport. Section 4.2 presents SignSupport's user interfaces and the high–level design for classes. Section 4.3 presents the authoring tool's user interfaces and the high–level design for classes. Section 4.4 presents the guidelines that should be considered when recording SASL videos. Section 4.5 presents the summary to the chapter.

4.1 Implementation technologies

This section identifies the technologies required to build the system on a mobile phone, and Symbian S60 in particular. Section 4.1.1 presents how Adobe Flash enables video streaming in mobile phone bowsers. Section 4.1.2 presents some popular mobile browsers, the platforms they run on and lastly indicates if they are

Adobe Flash enabled or not. Section 4.1.3 presents Personal Apache MySQL and PHP (PAMP) which is used to display SignSupport pages in the mobile browser.

4.1.1 Adobe Flash on mobile phones

Most video playback on mobile devices comes in the form of third party media players, e.g. Real Player on Symbian OS phones. Many vendor browsers, including cross-platform browsers like Opera Mini, still struggle to render Adobe Flash Video (FLV) playback. The use of Adobe Flash remains significant to obtain generalized access to sites like YouTube on a mobile phone. Currently, a cross platform browser called Skyfire [54] enables a user to view almost any web page that can be viewed with a desktop browser, including those with JavaScript and Adobe Flash content, such as videos on YouTube [48]. The new release of Adobe Flash Lite 3 by Adobe has increased video streaming on mobile phones experiences. Flash Lite 3 enables support of web content and video streaming with FLV and Adobe ShockWave Format (SWF). FLV and SWF file formats are Adobe products that render video for streaming in a browser, including mobile phone browsers. FLV and SWF support the H.264 video codec. Multi-platform Application Programmatic Interfaces (APIs) are available for smart phone developers. Flash Lite 3 has recently been included in the latest Nokia phone browsers. FLV and SWF files can be embedded into a Wireless Application Protocol (WAP) page though other more technical features, such as third-party enhancements are required to view various rich content types [32]. We tested the prototype implemented mentioned herein on the Nokia N82 and N78 phones. The OS on both phones is Symbian Series 60 OS 9.2 and their browser has Flash Lite 3, which supports video streaming.

SWF files can be used to control all other Flash content [53]. SWF files contain graphics, audio, programming and data in a single package that is delivered over a web connection to most browsers. SWF files are made for streaming. They are intended to be played back as they are being delivered over a network. As soon as the browser has enough information to play a frame, whether on a computer or a phone, the browser starts playing the file, while the remainder continues to be downloaded in the background. This is known as progressive downloading or streaming. Flash in SWF was designed to deliver live animation and audio over a network connection. For the playback to happen without the complete file, SWF files have a very specific sequence structure so that the first frame of the animation is not added to the end of the file. Furthermore, SWF files are stored sequentially, meaning that, if the end of the file is damaged then the last frames will also be damaged. Due to bandwidth limitations, the SWF files are compressed to deliver small data. The compression system used allows for the tightest possible package without any loss of content. This compression remains in the same order as the frames. Before any SWF file starts playing in a Flash player, certain file information has to be taken into consideration such as frame rate, animation times, and dimensions. Video can be embedded into SWF files in two ways. The first is simply placing bitmap images compressed into Joint Photographic Experts Group (JPEG) on the timeline along with the audio track. The second is Flash video with H.264/MP4 compression. Not all the streaming content is necessarily embedded into an SWF file. Flash can also load graphics, video, audio, data, and other SWF files.

4.1.2 Mobile phone browser

Mobile phone browsers are often developed for a specific mobile phone [65]. They are optimized to display web content on small portable screens. Initially they begin by trimming down web content, but more recently can display content such as Cascading Style Sheets (CSS), JavaScript, Ajax, Flash content, etc. Smart mobile phones have browsers that resemble smaller versions of desktop web browsers [50]. As a result, desktop browser companies also provide mobile browsers that are similar to the desktop computer OS [45]. Mobile browsers are smaller to accommodate smaller amounts of memory found on the mobile device. These browsers display WAP, HyperText Mark–up Language (HTML) and XHTML but greatly compressed in size with zoom functionality. The interface on the mobile phone can be similar to that of a desktop computer but in a scaled down mode. Video streaming is currently in development. Certain browsers currently have limited functional capability but with poor video quality. However, video streaming is promising to be a positive achievement for the future. A disadvantage of running Flash content in a mobile browser is that it is often not compatible across mobile phones. This can be problematic as not everyone is comfortable with using a browser on the mobile phone, and data plans are expensive. There are many browsers out there that allow for video streaming within the browser itself but the Nokia Series S60 browser was the only browser used for this project (see Table 4.1 for popular browsers that are Adobe Flash enabled). This particular browser was chosen because it comes standard with the phone and no additional plugins need to be installed. In addition, according to our survey results most Deaf people at the Bastion have Nokia phones (see Section 5.1).

Table 4.1: **Popular mobile phone browsers.**

Browser	**Mobile phone**	**Adobe support in the browser**
Nokia S60	Nokia S60	Yes
Dolphin	Android	Yes
Skyfire	All smart phones	Yes
IE mobile	Windows OS phones	Yes
BlackBerry	BlackBerry	Yes
Safari mobile	iPhone	No
FireFox mobile	Android	No
Opera mobile	All smart phones	Yes
Opera Mini	All smart phones	No

The Firefox browser Fennec does not support Flash yet [13]. Internet Explorer (IE) mobile has support for Flash Lite 3.1 which allows for Flash content streaming [46]. Skyfire allows for Flash content to be streamed [54]. Opera Mini does not support flash but Opera Mobile supports Flash Lite 3.1 on Windows mobile and Symbian S60 phones only [3, 12]. Android mobile phones that have Android OS 2.0–2.1 support Flash Lite 3.1 and while Android 2.2 support Adobe Flash 10.1 [58]. Opera Mini and Nokia S60 are common mobile browsers. Our prototype was tested with the community using the Nokia S60 because most Deaf people with phones have Nokia phones, although not high–end but low–end. Opera Mini could not be used because it does not support Flash streaming within the browser. The Nokia S60 browser can handle local sites stored on the phone's memory and works well with open source tools, as described in the next section.

4.1.3 Personal Apache MySQL and PHP

PAMP is a lite version of Apache MySQL and PHP [22, 40]. It is used to create dynamic web pages on the Symbian OS on the Nokia Series 60 phones. PAMP is only available on the Nokia S60 OS phones (see Figure 4.1). This software allows for resources stored on the mobile phone to be accessible by using relevant calls over HTTP and for mobile phones to be used as web servers. Although PAMP is used to run a web server on a mobile phone, in this project we used PAMP to store users accounts, the English summaries as cookies and diagnoses in MySQL tables. PAMP is also used to display the pages in the browser - not as PHP, but as XHTML.

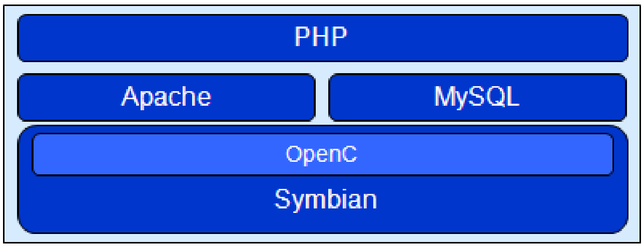

FIGURE 4.1: **PAMP stack.**
In the Symbian Series 60 environment the Apache, MySQL and PHP stack is built over the Open C. The requirement for running PAMP is a S60 mobile phone with at least 128MB RAM.

4.2 SignSupport

SignSupport runs in a Symbian browser from XHTML pages embedded with SASL videos, without the use of a third party media. The screen size of the SASL videos have nothing to do with the phone's memory but its display resolution only. The SASL videos are small because the phone screens on which SignSupport was tested are small. That means the use of bigger screens will result in bigger SASL videos. Also the SASL videos are small because the videos need to appear on the same screen as the navigation buttons to allow the Deaf user ease of use and the user does not have to scroll around the screen looking for buttons. This makes the system consistent, easy to learn how to use, easy to use, and easy to navigate. SignSupport is displayed in the mobile browser using PAMP over HTTP protocol. SignSupport displays the SASL questions and answers used to provide an English summary for the doctor. The system also provides a way for the hearing doctor to respond to the Deaf person. Section 4.2.1 presents the user interfaces for both the hearing and Deaf users. Section 4.2.2 presents the high–level design of the classes and their interaction.

4.2.1 User interfaces

The Login interface is used by the Deaf user to logon onto the system (see Figure 4.2 (a)). The password is encrypted and is stored in the MySQL database on the phone and accessed using PAMP. We use authentication on SignSupport because the mobile phone can be shared with other Deaf people. Each mobile phone could hold several profiles of Deaf people, which allows for sharing of resources and accommodating people who cannot afford the required mobile phones. This is important because it was on of the questions the users asked during the user testing. The introduction page appears all the time because different people can use the same mobile phone and also on the design, it is simpler to design the system this way. If a user does not have an account, when they login an account is created automatically.

The Introduction interface is the first screen the Deaf user sees once they logon. The introduction page contains a SASL video and the English equivalent of the SASL video that tells the Deaf user what the system is about and how to navigate the system (see Figure 4.2 (b)).

FIGURE 4.2: **Introduction screen and login screen.**
(a) The Deaf user's login screen, after entering in the username and password the Deaf user continues to the next page by clicking on the smiling image. (b) The introduction page displays a SASL video and its English equivalent which describes to the Deaf user what the system is all about and how he/she can use it.

The Question interface displays the questions the system asks. A question is presented in a SASL video and its English equivalent as text on the same page, because this is in Looijesteijn's computer mock–up [37]. The Deaf user watches the SASL video or reads the English, and proceeds to the answers by clicking the navigation arrow to the right between the SASL video and the English equivalent text (see Figure 4.3 (a)).

The Answer interface appears after a question page. This page also has a SASL video. The left navigation button is designed to access previous pages and a right navigation button is designed to access the following page. The English equivalent text of the SASL video appears below the navigation buttons (see Figure 4.3 (b)).

To select an answer to a question, the Deaf user clicks on the smiling image, and the system will then proceed to the next question and corresponding answers.

The Doctor's desk interface is the first screen displayed after the Deaf user has completed answering the questions. This is when the Deaf user hands the phone over to the hearing doctor. The doctor's desk appears, from here the hearing doctor can then read the summary of the answers using the 'English summary' button. The doctor can also use the phrase book look–up dictionary to either ask further questions or give a diagnosis using the 'Respond' button (see Figure 4.4 (a)). The doctor can also ask the Deaf user to restart the whole process using the 'Home' button. The doctor clicks on the button 'English summary' button.

FIGURE 4.3: **Question screen, video embedded in an XHTML** (a. i). Video embedded into an xhtml page playing inside a mobile browser using Adobe Flash player. (a. ii). An example of a question presented in a SASL video, the English text equivalent bellow the video and the navigation arrow between the SASL video and the English text. (b) A page displaying an answer has a SASL video and its English equivalent describing the answer. The Deaf user can navigate to the previous page using the left arrow and to the next page using the right arrow, or accept the answer by clicking on the smiling image.

The English summary interface is used by the doctor to view the Deaf person's answers to the questions posed in SASL. The doctor can read the summary as plain English (see Figure 4.4 (b)).

The Response interface is used by the hearing doctor to respond to the Deaf patient. This interface displays a look–up dictionary containing diseases and questions that are arranged alphabetically. If the doctor wishes to ask the Deaf patient a question with a key word in the question, he then clicks on the letter the key word starts with. For example to ask the Deaf patient for a 'stool sample' the doctor clicks on the letter 'S' (see Figure 4.5). The next screen shows some of the questions or diseases translated into SASL videos that begin with that letter. For example, Figure 4.5 (b) shows some sample diseases and questions that start with the letter 'S'. When the doctor clicks on a keyword that contains a question or diagnosis, a SASL video is played and this can be shown to the Deaf patient. In the case of a question (see Figure 4.3 (a)) the Deaf patient can respond to the questions using pre–recorded answers as in Figure 4.3(b). A diagnosis button is different to a question button: a questions button has a question mark at the end while a diagnosis button does not. Once the question is answered, the English is added to the English summary (see Figure 4.5 (b)) and the doctor can read the English summary to see the Deaf person's answer.

Figure 4.4: **Doctor's desk and English summary page.**
(a) The doctor's desk allows him to view the SASL–to–text summary using the 'SASL–to–text' button; use the phrase book to give a diagnosis using the 'Respond' button; or ask the Deaf person to start over by clicking on the 'Home' button. (b) A example of the SASL–to–text summary, obtained after a Deaf person has completed the questions, the doctor reads.

FIGURE 4.5: **Phrase Book example of phrases that start with the letter 'S'**
(a) The Deaf users login screen, after entering in the username and password the Deaf user continues to the next page by clicking on the smiling image. (b) The introduction page displays a SASL video and its English equivalent which describes to the Deaf user what the system is all about and how he/she can use it.

4.2.2 High–level design

SignSupport has 7 classes: Login, Introduction, Question, Answer, English summary, Lookup dictionary and Response (see Figure 4.6). The Login class is used to create an interface for the user to login. Once the user logs on, the next page is displayed by the Introduction class. The Introduction class plays the introduction SASL video and displays a link for the Questions class. The Question class presents a question in the form of a SASL video and English text, with a link to the answers. The Answer class displays the answers one at a time in the form of a SASL video and the equivalent text. After the user has answered all the questions, the English summary class is called to display the answers in plain English text for the doctor to read. It also provides a link for the Lookup dictionary class which in–turn calls the Response class to present the response in the form of a SASL video, or the Question class, to ask the Deaf person more questions.

The SASL videos for the questions, answers or responses are stored in the mobile phone's memory. The related English texts are stored in each question, answer or response page in XHTML together with a reference to the related SASL video from the mobile phone's memory. When a page is displayed it loads the video from the mobile phone's memory and displays the video together with the English text. The video is displayed playing continuously. Each question, answer and response page has settings to display the SASL video the mobile phone screen. These settings are organized using CSS. Each question, answer and response has its own page, with a reference to the SASL video name and the related English text.

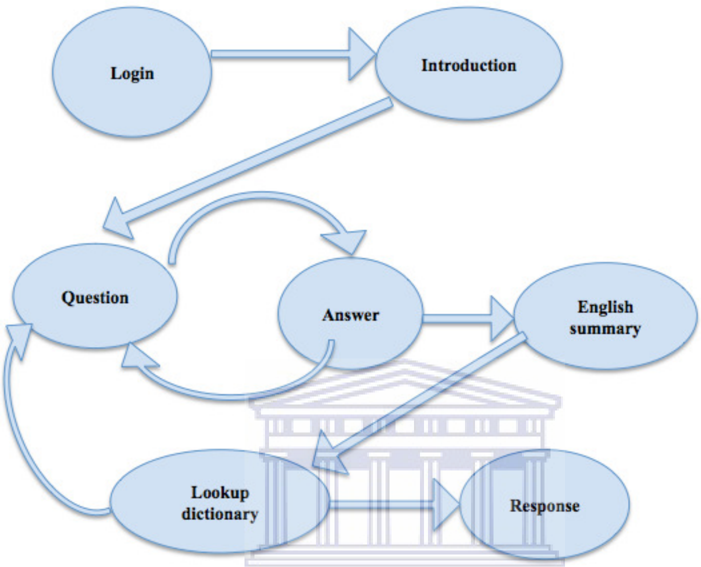

FIGURE 4.6: **System classes interaction.**

The Login class handles the user authentication data (see Figure 4.7). The user can create a user profile using this class. If the user already has a profile on the system, s/he can log on. Once the user logs on and begins answering the questions, his/her profile history is updated with the answers. In this way the doctor can check previous symptoms or conditions from user's use of the system. The get–username and the get–password methods are used to obtain the username and password as the user types them in. The set–username and the set–password methods are used to save the username and password of a user after the person types them in. Once this is done, the user is authenticated utilizing the login–correct(string username, string password) method.

The Introduction class is used to play the introduction SASL video which tell the Deaf user what they system is about and how to use it (see Figure 4.8). In this class, the user is only supposed to watch the SASL video and once they have understood what the SASL video says then they can continue. The videoObject method displays the SASL video on the introduction page; the textObject method displays the textual equivalent of the displayed SASL video and the navigation

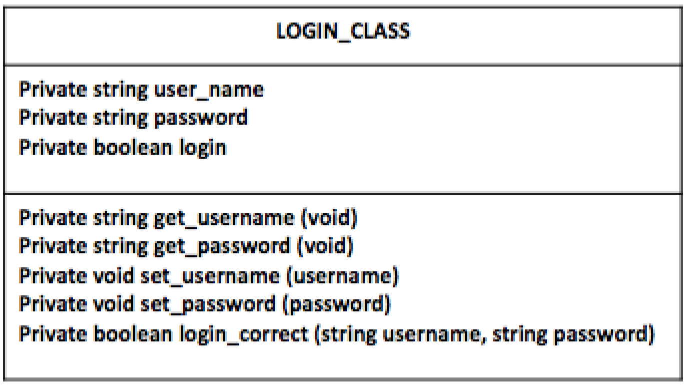

FIGURE 4.7: **Login class.**

method then provides the link to the question page or the method provides the user with the option to continue.

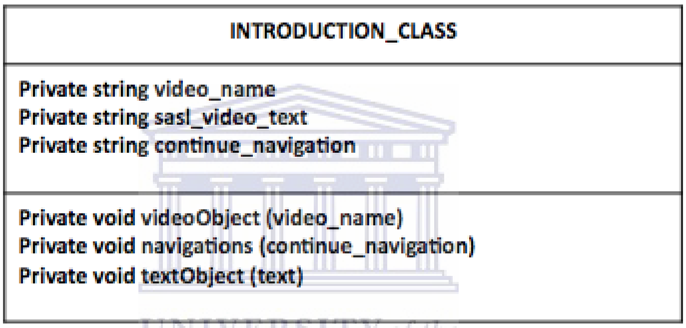

FIGURE 4.8: **Introduction class.**

This Question class displays questions with a SASL video and English text. Each time the class is called a new question is displayed and this question is stored using cookies (see Figure 4.9). The setCookie stores the question with the username from the login page. The checkCookie method is used to check if the question is already stored. The getCookie method is used to obtain the stored cookies. The videoObject method displays the SASL video on the question page, the textObject method displays the textual equivalent of the displayed SASL video and the navigation method then provides the link to the answer page.

This Answer class displays a set of answers with an SASL video and English text (see Figure 4.10). All the answers that deal with a specific question are linked to each other, so that the user can navigate through the answers and choose the appropriate one. The answer chosen by the user is then stored in the cookie next to the related question under the username provided from the Login class. The setCookie stores the answer with the username from the login page. The checkCookie method is used to check if the answer is already stored. The getCookie method is used to obtain the stored cookies. The videoObject method displays

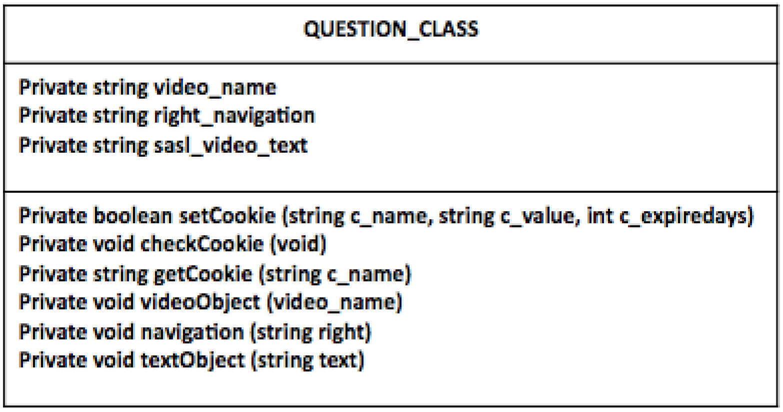

FIGURE 4.9: **Question class.**

the SASL video on an answer page, the textObject method displays the textual equivalent of the displayed SASL video, the navigation method then provides the link to the previous answer pages, the navigation method then provides the link to the next answer pages and the accept–answer method is used to define which answer was chosen and show the next question page.

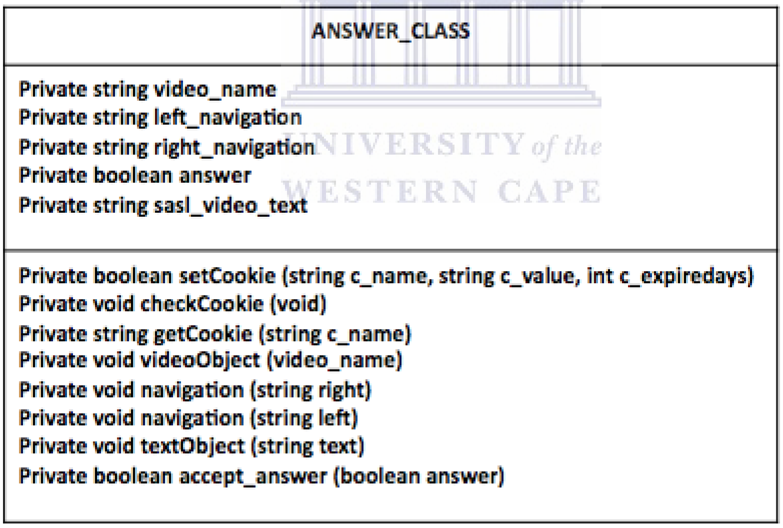

FIGURE 4.10: **Answer class.**

This English summary class retrieves and displays the cookies under the current username from the Login class. A small amount of processing is done on the cookies so that they are displayed correctly (see Figure 4.11). The getCookie method us used to obtain the cookies stored.

This Lookup dictionary class allows the hearing doctor who cannot sign to communicate with a Deaf person. The doctor chooses a diagnosis and the system then plays the sign language video equivalent of the English diagnosis. This class also makes use of cookies to store a Deaf patient's symptoms and the diagnosis gave

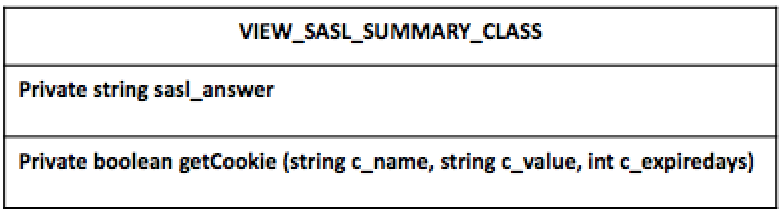

Figure 4.11: **SASL–summary class.**

for future clinical visits (see Figure 4.13). The setCookie stores the answer with the username from the login page. The checkCookie method is used to check if the answer is already stored. The getCookie method is used to obtain the stored cookies. The videoObject method displays the SASL video on an answer page, the textObject method displays the textual equivalent of the displayed SASL video, the navigation method then provides the link to the previous answer pages, and the navigation method then provides the link to the doctor's desk for more questions or diagnosis.

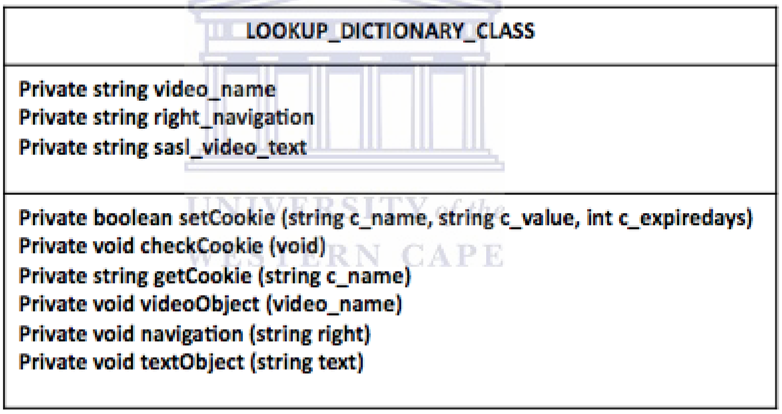

Figure 4.12: **Lookup dictionary class.**

The Response class is used by the doctor to respond this class displays the look–up dictionary. The doctor clicks on a word and a response is displayed with a SASL video and the equivalent text on the response (see Figure 4.13). Each time a response is required the class is called and it plays the relevant video. The videoObject method displays the SASL video on an answer page, the textObject method displays the textual equivalent of the displayed SASL video, and the navigation method then provides the link more follow–up questions and responses. Note this class was implemented and added to SignSupport but its functionality was not tested with the Deaf community because no response SASL videos were recorded.

RESPONSE_CLASS
Private string video_name Private string sasl_video_text Private string continue_navigation
Private void videoObject (video_name) Private void navigations (continue_navigation) Private void textObject (text)

FIGURE 4.13: **Response class.**

4.3 Content authoring

SignSupport authoring tool runs on a computer browser – from a database into the user's browser on HTTP localhost. This system is used to create the SignSupport pages. An Administrator (Admin) user can create SignSupport pages by uploading SASL videos, typing in English text and clicking buttons without editing lowlevel code. To arrange the questions in a tree–like structure (see Appendix C for a tree–like structure of the questions used for SignSupport), the Admin user can edit a generated answer page's link to the next page question page manually. Each answer page does not contain links to the previous question pages or their respective answers but only contains the links the question it is answering and the other answers under its question. Question pages do not have a previous links only links to their answers. In this way an Admin user can control which question page comes next by manually adding children question pages to a specific answer page's next question page link. An answer page's next question page link is edited to a specific question page, when a user answers a questions using this answer then the next question page that was manually edited is called. Section 4.3.1 presents the user interfaces for the authoring tools. Section 4.3.2 presents the high–level design of the classes and their interaction.

4.3.1 User interfaces

The Registration screen is used to create an account. To create a new scenario a user must first login. If they do not have an account they are required to create one. The user enters a unique username and email address, while the password can be common. The submit button is pressed and to create the user account and then the system proceeds to the login screen. The password is encrypted using standard HTML input type password encryption. The details entered are sent to the MySQL table where the user's account details are stored. User accounts are created for the authoring tool because it allows the created scenario to have an author name.

Login screen is used to logon onto the authoring tool. Each account has a username and password registered in the database. Once the details are entered they are sent to the MySQL database to compare with the users stored in a table. When there is a match, the user logs into the home page.

The Home screen is displayed upon successful login, and a new context free scenario can be created. A scenario can also be deleted and the option exists for the user to logout. The home screen also displays other details such as the name of the current user and the last login data.

The New scenario creation screen is used to create a new scenario. The options in this screen are to be followed sequentially from 1 to 4 or the system will not operate (see Figure 4.14). Option 1 is to create the questions linked to their answers. Once the questions and answers are entered, option 2 creates the doctor's desk which means that no more questions and answers can be added to the scenario. The response for the hearing person is created now using option 3. Option 4 creates the English summary of the scenario. The screen also displays the username, last login date and logout option.

FIGURE 4.14: **New scenario creation screen.**

The Uploading a question video screen is used to create a question video page. To add a question, an SASL video with a ".swf" file extension is uploaded (see Figure 4.15). The user searches for the video and clicks on the 'upload' button. The correct file format is uploaded and the system proceeds to the page that allows for the English equivalent question to be typed.

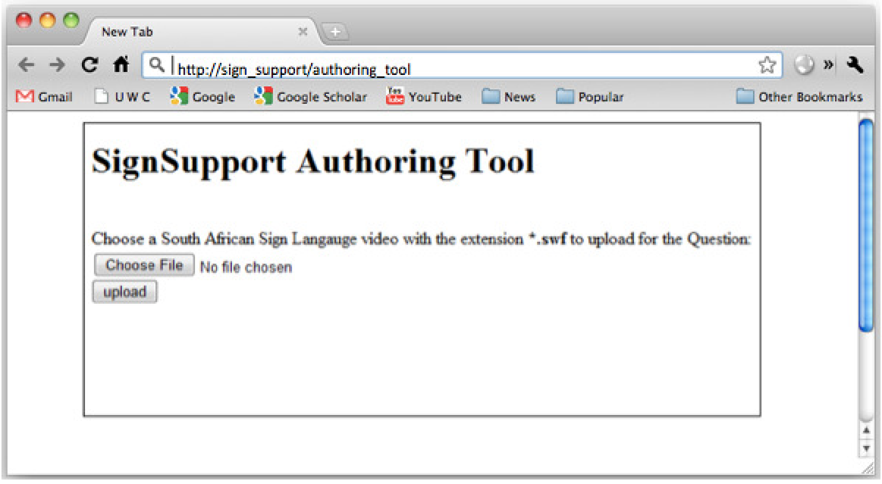

FIGURE 4.15: **Uploading a question video.**

The English equivalent of the answer video screen is used to type in the English equivalent of the answer video uploaded. The English equivalent screen is used. The English words typed in must be the same as those in the uploaded video. The "add answer" button is used to complete the addition of a single answer. To indicate that this is the last answer so that the authoring tool can proceed to the next question, the check box next to the words "This is the last answer to the question" is checked. To proceed to the next screen the button "Add answer" is clicked. After uploading an SASL answer video and its English equivalent the system proceeds to allow the users to add another answer.

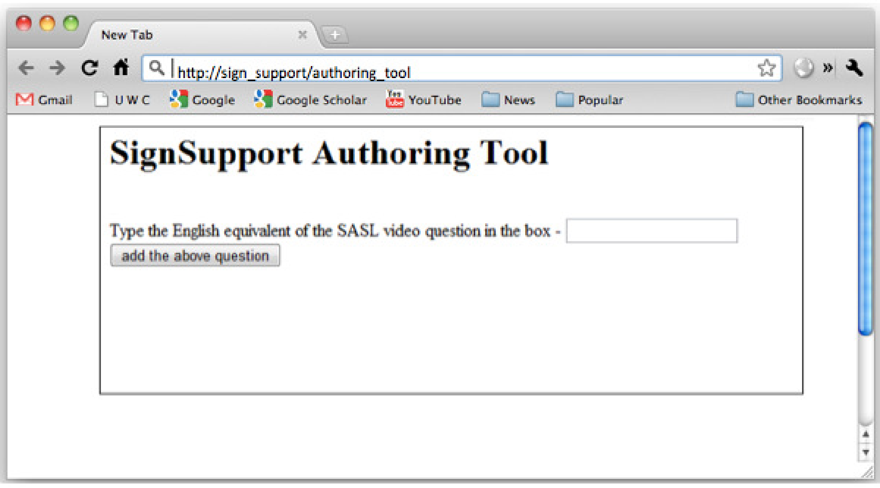

FIGURE 4.16: **English equivalent of a question video.**

The Hearing person's screen is used to create the doctor's desk. After the SASL video questions and answers have been uploaded and added to the scenario together with their respective English equivalent words, the doctor's desk is created.

This is the screen the hearing person uses as his/her home page. The hearing person's desk allows him/her to view the English summary and to give a response.

The Response creation using for a specific letter screen is used to create a response. The user chooses the first letter of the condition in the first form option. In the second form option the user chooses how many conditions from the letter chosen from the first form. The user then clicks on the 'Start condition creation' button to move to the uploading of the SASL response videos and the typing of their English equivalent. S/he then clicks on the button to move to the next screen where each response video is uploaded and the English equivalent is typed in.

Adding an SASL video and English text for a response. The user types in the key word, types in the English equivalent and uploads the video for each response under the specified letter (see Figure 4.17). After adding a response corresponding to a letter the system allows the user to navigate back to the scenario creation screen where the user can create other responses that begin with different letters.

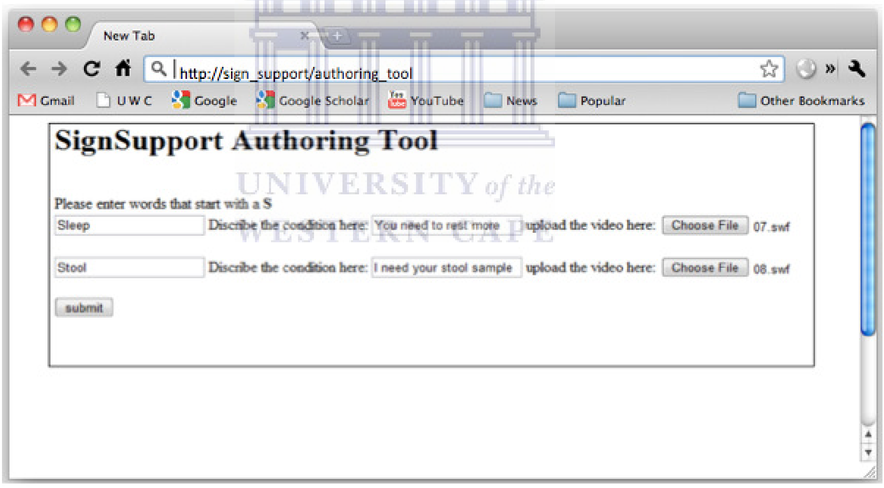

FIGURE 4.17: **Adding a SASL video and English text for a response.**

The English summary page creation screen is used to create the English summary page. After the English summary page is created the authoring tool proceeding back to the scenario creation screen. This means SignSupport is completed and can be sent to a mobile phone.

The Deleting a scenario screen is used to delete a scenario. A confirmation screen is displayed after the last scenario is deleted from the SignSupport folder. The scenario's subfolders and files are deleted with one click on a link on the home page.

4.3.2 High–level design

SignSupport authoring tool has 13 classes: Register, Login, Home–page, Scenario–create, Scenario–delete, Introduction, Question, Answer, Hearing–person–screen, Response, English–summary, Video and the Text classes (see Figure 4.18). The Register class can be used to create a user account. The Login class displays the login page. The Home–page class displays the main page, on this page the user is able to create a scenario and delete a scenario. The Scenario–create class allows the user access the Introduction, Question, Answers, Hearing–person–desk, Response and English–summary classes. Using these classes the user can create the various parts of SignSupport. The Video–class is used to upload SASL videos in form of SWF files into the video folder on the SignSupport system. The Text class is used to add the English text equivalent of the SASL videos. The Introduction, Question, the Answer and Response classes upload the SASL introduction, question, answer and response videos respectively using the Video class. These classes then add the video Uniform Resource Locator (URL) and text using the Text class to the introduction, question, answer and response pages for SignSupport. The Hearing–person–screen class is used to create the hearing person's desk for SignSupport. The English–summary class is used to create the English summary page for SignSupport. The Scenario–delete class is used to delete the last created scenario.

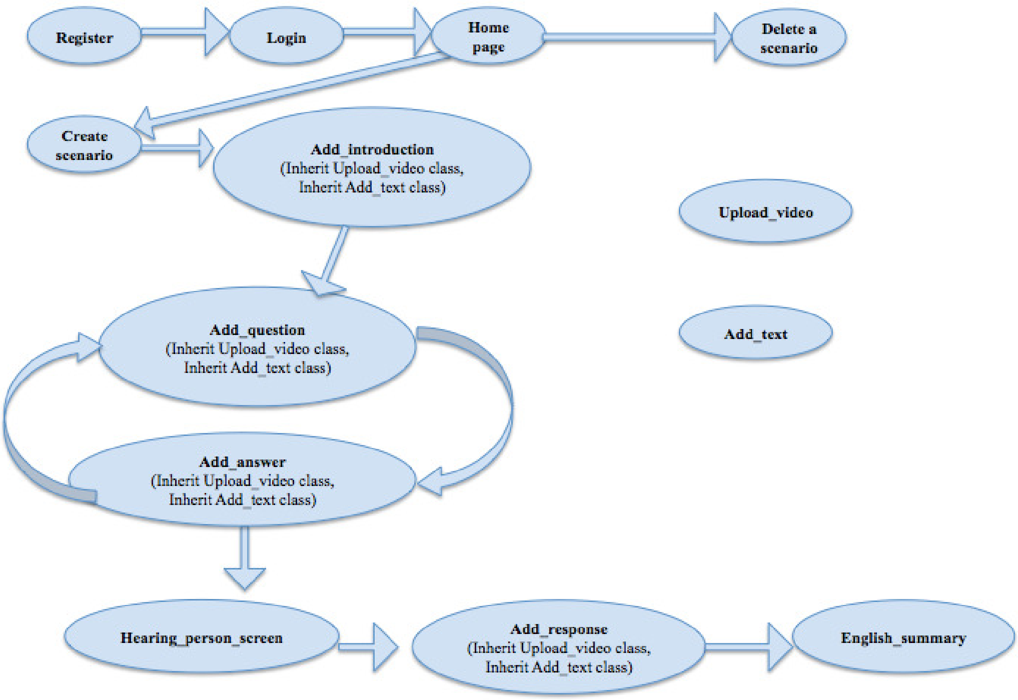

FIGURE 4.18: **Authoring tool classes interaction.**

The Introduction, Question, the Answer and Response classes have CSS and XHTML lines that are printed into the introduction, question, answer and response pages for SignSupport. When an introduction, question, answer and response page is created for SignSupport the CSS code, XHTML, video name and path, English text, the required links, and the pictures are hardcoded by the authoring tool into each page as it is created. That means that after the page is created nothing changes. Each question, answer and response has its own page. After the scenario is created the folder containing that scenario has many XHTML pages and each one of them are linked to each other using links inserted into the pages. The creation of a scenario does not require the user to edit any code, but only using the wizard.

The Register class is used to create users for the authoring tool (see Figure 4.19). To create an account the user must enter a username, password and email address. Once the username and email have been checked for uniqueness with the usernames and emails addresses in the MySQL database, the user account is created. The get–username, get–password and get–email methods are used to obtain the username, password and email address of the user. The set–username, set–password and set–email methods are used to save the username, password and email address of a user. The isAccount method is used to check if an account with the same username and email has been created. The create–account method is used to create the account once the username and email are unique.

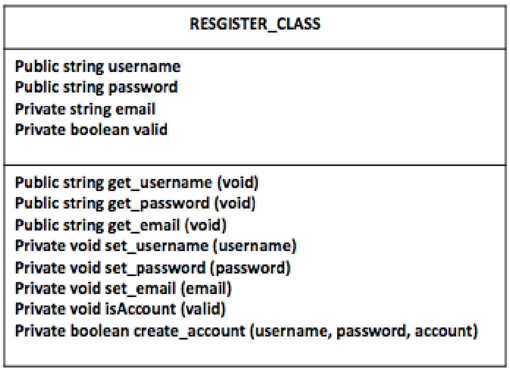

FIGURE 4.19: **Register class.**

The Login class displays the login page for the authoring tool (see Figure 4.20). To log in the user enters a username and password that are on the MySQL database table. The encryption on the password is from HTML. When the user enters the password the characters are not revealed. The get–username and get–password methods are used to obtain the username and password the user types in. The login–correct is used to verify if that the username and password are found in the

MySQL database. Once the login is correct the login–correct method calls the Home–page class.

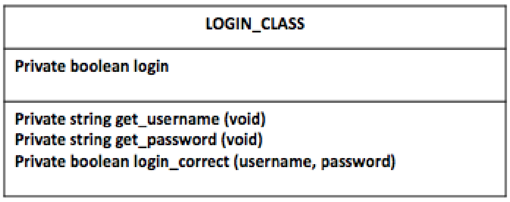

FIGURE 4.20: **Login class**

The Home–page class displays the home page for the authoring tool. Here the user can create and delete a scenario (see Figure 4.21). The Scenario–create method is used to call the Scenario–create class. The Scenario–delete method is used to call the Scenario–create class.

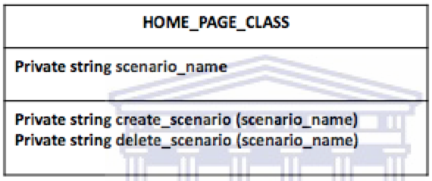

FIGURE 4.21: **Home–page class.**

The Scenario–create class has 9 methods used to create a scenario (see Figure 4.22). The get–scenario–name, get–scenario–directory, get–video–directory and get–picture–directory methods are used to obtain the scenario name, scenario directory, video directory and the picture directory from the database. The set–scenario–name, set–scenario–directory, set–video–directory and set–picture–directory methods are used to set the scenario name, scenario directory, video directory and the picture directory to the database. The create–login–page method is used to create the login page for SignSupport with the current user account and a link to the next known page which is the introduction page.

The Video class has 5 methods used to upload a video (see Figure 4.23). The set–video–directory method is used to keep the path to where the SASL video is uploaded. The get–video–directory method is used to get the path to where the last uploaded video is stored. The isSize methods checks if and ensures that the uploaded video size is not greater than 15MB. The Video method is used to upload the video by setting where the video is stored and its name. The Upload method checks if the video upload is of the format SWF and that it is uploaded into the correct folder.

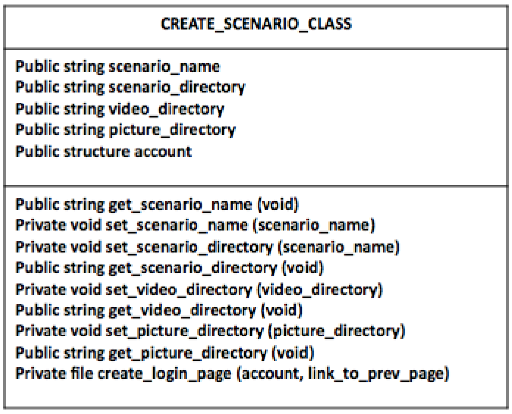

FIGURE 4.22: **Create–scenario class.**

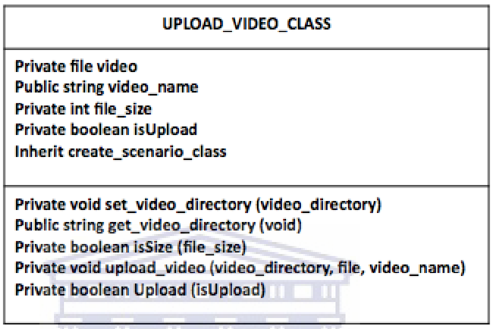

FIGURE 4.23: **Upload–video class.**

The Text class has 3 methods used to add English text (see Figure 4.24). The set–text method is used to enter English text for the SignSupport pages. The Get–text method is used to get the English text entered. The isAnswer method is used to check if the answer entered is the last answer, if the answer entered is the last answer then the Answer class is not called.

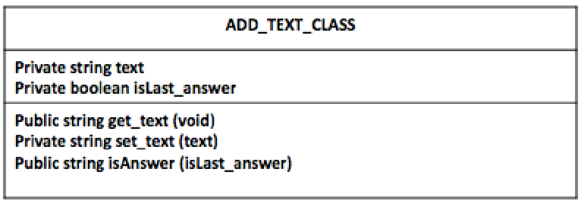

FIGURE 4.24: **Add–text class**

The Question class has 3 methods used to add a question page to SignSupport (see Figure 4.25). The get–video–directory method is used to obtain the path of the last uploaded video and its name. The get–text method is to get the last added English text. The create–page is used to create the question page for SignSupport. A link to the first answer page is created while the page is generated.

The Answer class has 5 methods used to add an answer page to SignSupport (see Figure 4.26). The get–video–directory method is used to obtain the path of the last

ADD_QUESTION_CLASS
Private file page Private boolean isPage Public string link_to_next_page Inherit upload_video_class Inherit add_text_class
Public string get_video_directory (void) Public string get_text (void) Private file create_page (text, video_name)

FIGURE 4.25: **Add–question class.**

uploaded video and its name. The get–text method is to get the last added English text. The create–page is used to create the question page for SignSupport. A link to the previous and the next answer pages is added while the page is generated using the get–link–to–prev–page and link–to–next–page methods respectively.

ADD_ANSWER_CLASS
Private file page Private boolean isPage Public string link_to_prev_page Public string link_to_next_page Private string picture Inherit upload_video_class Inherit add_text_class
Public string get_video_directory (void) Public string get_text (void) Private string get_link_to_prev_page (Page.prev) Private string get_link_to_next_page (Page.next) Private file create_page (text, video_name, picture, link_to_prev_page, link_to_next_page)

FIGURE 4.26: **Add–answer class**

The Response class has 4 methods used to add a response page to SignSupport (see Figure 4.26). The get–video–directory method is used to obtain the path of the last uploaded video and its name. The get–text method is to get the last added English text. The create–page is used to create the question page for SignSupport. A link to the hearing person's screen page is added while the page is generated using the get–link–to–prev–page method.

ADD_RESPONSE_CLASS
Private file page Private boolean isPage Public string link_to_prev_page Inherit upload_video_class Inherit add_text_class
Public string get_video_directory (void) Public string get_text (void) Private void get_link_to_prev_page (prev->Page) Private file create_page (text, video_name, link_to_prev_page)

FIGURE 4.27: **Add–response class**

The Introduction class has 4 methods used to add an introduction page to SignSupport (see Figure 4.28). The get–video–directory method is used to obtain the path of the last uploaded video and its name. The get–text method is to get the last added English text. The create–page is used to create the introduction page for SignSupport. A link to the first question page is added while the page is generated using the get–link–to–next–page method.

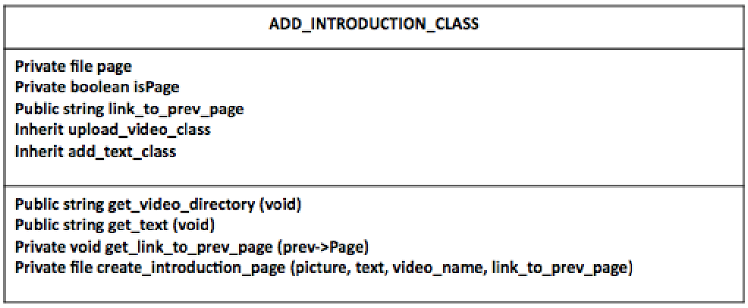

FIGURE 4.28: **Introduction class**

The Hearing–person–screen class has 2 methods used to add the hearing person's screen and the screen with all the alphabets that lead to keywords on SignSupport (see Figure 4.29). The set–alphabet method created a page with all the alphabets listed from 'A' to 'Z'. Each letter is a link to the keywords of a responses and questions that starts with that letter. The create–page create the SignSupport lookup page with all the letters of the alphabet with their links and the hearing person's screen page.

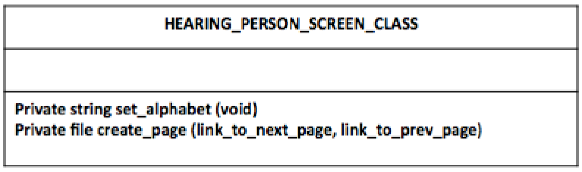

FIGURE 4.29: **Hearing–person–screen class**

The English–summary class has 3 methods used to add the English summary page to SignSupport (see Figure 4.30). This class is used to add the English summary screen to SignSupport. The gettext method is to get the last added English text. The createpage is used to create the introduction page for SignSupport. Note the videoname variable is set to null, because there is no video. A link to the first question page is added while the page is generated using the getlinktonextpage method.

The Scenario–delete class has 4 methods used to delete the last created scenario (see Figure 4.31). The get–scenario–name method is used to get the name of

DELETE_SCENARIO_CLASS
Private file page Private boolean isPage Public string link_to_prev_page
Public string get_scenario_name (void) Public string get_scenario_directory (void) Public string get_video_directory (void) Public string get_picture_directory (void)

Figure 4.30: **English_summary class**

the scenario to be deleted. The getscenariodirectory method is used to get the directory of the scenario to be deleted. The Scenario–delete method is used to delete the scenario and the whole entire folder containing the scenario.

DELETE_SCENARIO_CLASS
Private file page Private boolean isPage Public string link_to_prev_page
Public string get_scenario_name (void) Public string get_scenario_directory (void) Public string get_video_directory (void) Public string get_picture_directory (void)

Figure 4.31: **Delete–scenario class**

4.4 Video specifications

When recording the SASL videos the following have to be taken into consideration: only SASL can be used, the signing should be clearly visible, cropping to fit a required width and height, viewing the video in the browser should be done without a third-party media player, and the size of the videos should not be bigger than 15MB. A larger video size will not play on the phone at all because the phone memory is too small to play such a file. The mobile phone screen size on which the prototype is tested herein this research is 240 x 320 pixels or 2.4 inches. In more detail the things that need to be taken into consideration are:

- The person signing in the videos must only use SASL to sign, as this is the language for all Deaf people living in South Africa,
- The sign language gestures can be made more visible by:
  - Making the background darker than the person who is signing, and clear any objects from the background such as posters.

  - The person who is signing should wear one color or similar colors, and this should be different to the background.
  - Have full control of the lights in the recording room cause this may affect the person signing, i.e. too much light can be a distraction when Deaf person is watching the sign language video.
  - Only one person should sign the videos, for consistency and user familiarity.
  - No accessories such as earrings or too much makeup, to avoid distracting the person viewing the video.

- After the recording of the videos was completed, the original video had to be cropped to remove unnecessary width and height, to resize the video into a useable video for 240 x 320 pixels screen,

- A usable video height should be 660 and its width 440 for embedding the video, because its comes out clearly on the 240 x 320 pixels screen,

- The videos embedded into the HTML or XHTML should be in the SWF file format, as this allows for streaming inside the current Nokia S60 browser without using a third-party media player,

- The videos were embedded at a square ratio of 190 by 190 into the XHTML as this is suitable for the mobile screens with 240 x 320 pixels and still maintains visibility. The square ratio is used because the N82 and N78 screen is portrait and is good for the height of the mobile screen because the video leaves enough space on the same page below the video for the navigation arrows and the English text without a much need to for scrolling up and down. The square ratio is also good for the width of the mobile screen -the video fits well, and the user does not need to scroll left and right,

- Deaf people should clearly be able to see the elements of sign language, i.e. hand shapes, palm orientation, location, movement, use of classifiers, high–degree of infection and topic-comment syntax [36] from the end product of SASL video height and width reductions and conversions to the SWF file format size.

4.5 Summary

This chapter answers the first part of the research question which is how to design and implement SignSupport for a mobile phone browser in a context free manner which will allow for other scenarios to added easily. This chapter presented the implementation of the system design of SignSupport. The results obtained from Looijesteijn's design [37], related work and the user survey are used as input for the design. SignSupport is implemented using XHTML pages. The SASL videos used in the prototype are stored as SWF format which is easy for video streaming. The user interface design is made for Deaf people and is simple. Each page question, answer and response page has a SASL video, English text, and navigation buttons. SignSupport's high–level class interaction is also describe. According to Looijesteijn, a content authoring tool should be designed and implemented to create new SignSupport scenarios such as a Deaf person's visit to a police station or library. The design of the authoring tool is also described in this chapter. This chapter also discussed the authoring tool's user interfaces and the high–level design of its classes. The SignSupport implementation mentioned herein was evaluated with the Deaf community. The next chapter presents and discusses the results of the evaluation of SignSupport with the Deaf community.

Chapter 5

Results

This chapter provides the results from the user survey, focus group and the user tests. For each, the sample size, procedures used to arrange interaction with Deaf people at the Bastion, questions and the results are presented and discussed. The results in this chapter follow the flow of Figure 3.1. The results from Looijesteijn's user trial were used as input. Figure 3.1 also shows that the user survey results were also used as input together with Looijesteijn's results. After both the Looijesteijn's results and the user survey results were used as input, the system was implemented. A pilot trial was conducted with the focus group members to test the implementation and the results were also added into the final design of the system which was then tested. The final design produced an implementation of the system which was tested with the Deaf users. Section 5.1 presents the results of the user survey. Section 5.2 presents the results of the focus group. Section 5.3 presents the results of the final user trial. Section 5.4 presents an analysis of the overall results. Section 5.5 is a summary for the chapter.

5.1 Deaf user survey

A user survey was conducted to added to the requirements obtained from Looijesteijn's results [37]. The Deaf user trial was conducted by the researcher and the results belong to this work and not Looijesteijn's (see Section 1.2 for Looijesteijn's results). Section 5.1.1 presents the user survey's sample size and characteristics. Section 5.1.2 presents the procedures used to obtain an interpreter and participants for the user survey. Section 5.1.3 presents the format of the questionnaire used in the user survey. Section 5.1.4 presents the results of the user survey.

5.1.1 Sample

At the beginning of the user survey there were 33 Deaf people, but as the survey progressed some of the Deaf people left. The number that remained was 20. Their ages mainly ranged between 26–35 and 41–50. They have the same characteristics as the target group mentioned in section 1.5. There were no selection criteria. Any Deaf person was allowed to participate in the user survey. For information about the members of the survey group (see Section 5.1.4).

5.1.2 Procedure

The interpreter was the first person to be asked for availability because it is essential to have an interpreter present. The interpreter's availability was checked for Wednesdays only. Communication between the researcher and the interpreter was done using SMS and voice calls on a mobile phone. Once the interpreter confirmed a date where she was available, communication with one of the staff members of DCCT was established. This was done because she would organize Deaf people to be available at the Bastion on the user survey day. She also organized us a venue. Communication between the researcher and the DCCT staff member was done in person and where it was not possible to go the Bastion we used e-mail. The Deaf people participating in the survey, the interpreter and the researcher met at the Bastion building.

On the user survey day, we had a venue which housed all the Deaf participants in the survey. The Deaf people were told about the BANG projects for which the user survey was used for. Then we went through each question on the user survey questionnaire one–by–one for SASL interpretation. Breaks were taken between sections. At the end of the user survey we offered the Deaf participants lunch as an incentive.

5.1.3 Questions

In Section 3.4.1 it was mentioned that the user survey was conducted with two other Masters' students in the BANG group from UWC. A Likert scale questionnaire was used to obtain information from the Deaf users. The questionnaire had four sections (refer to Appendix E for the questions and answers from the first and the third sections of the questionnaire only). The first section in the questionnaire was used to obtain general information about Deaf people which was used by all the three researchers. The second and fourth sections in the questionnaire were used by other Masters' students to obtain information concerning their researches. The third section in the questionnaire was used to obtain information on how Deaf people communicate when they visit a hearing doctor.

5.1.4 Results

According to Appendix E, more than half of the Deaf participants were female 55%. The age group of the Deaf participants were as follows: 26–35 61,%, 41–50 21%, 36–40 9%, 51–older 6% and 15–25 3%. The primary language that the Deaf Chapter 5. Results 67 participants use is as follows: SASL 61%, written English 27%, written Afrikaans 3% and the other 9% did not answers the question. The Deaf participants written English level were as follows: good 49%, average 36%, poor 12% and excellent 3%. The Deaf participants grew up in the following areas: rural areas 42%, city 30%, town 24% and informal settlement 4%. They now live in: a city 40%, informal settlement 27%, town 18% and rural area 6%. Most of the Deaf participants know how to use a mobile phone 88% and a computer 56%. Their Internet usage on computers is as follows: daily 18%, weekly 27% monthly 9% and rarely 33%. Most of the Deaf participants use written English on the computer and the phone 76% as compared to face– to–face sign language 55%. Most of them have Nokia phones 68% and Samsung 16%. The communication tools used are Facebook 40%, MSN 25%, Gtalk 10%, Camfrog 10%, Skype 10% and Tokbox 5%.

The hearing public workers that our Deaf participants most commonly interacted with were pharmacists 27%, shop keepers 27%, and doctors 24%. The language that the Deaf participants use to communicate with the hearing public worker is as follows: written English 44%, interpreter 24%, sign language 16%. The public workers in turn used written English 56%, interpreter 33% and sign language 8%. Half of the Deaf participants have used an interpreter for a doctor's visit. Most of the Deaf participants 89% felt uncomfortable with the use of an interpreter during their doctor visit. Most of the Deaf participants who had used an interpreter felt that their privacy was not compromised (67%) yet some did feel that it was compromised (22%). Most of the Deaf participants had used a family member 65% to help them communicate during a doctor's visits and some did not 35%. Those that had used a family member felt their privacy was not compromised 36% and 27% felt it was. When asked if they were satisfied with the way communicated the results were as follows: poor needs improvement 47%, fairly satisfied 29% and average 24%. When they were asked how they would want to communicate the

Table 5.1: **Summary of user survey results**

Criteria tested	**Dominant results summary**
Percentange of females	55%
Deaf people between the age of 26–35	61%
Primary language as SASL	61%
Deaf participants' written language level as good	49%
Deaf participants from rural areas	42%
Deaf participants who now live in the city	40%
Percentage of the Deaf participants can use a mobile phone	88%
Percentage of Deaf participants who use Internet rarely	33%
Deaf participants who use written English in face–to–face communication	55%
Percentage of Deaf participants who use Facebook	40%
Percentage of pharmacists who communicate with the Deaf participants	27%
Percentage of Deaf participants use written English to communicate with a public worker	44%
Percentage of public workers who use English to communicate with the Deaf participants	56%
Percentage of the Deaf participants who uncomfortable with the use of an interpreter	89%
Percentage of the Deaf participants who feel the use of an interpreter compromises their privacy	67%
Percentage of the Deaf participants who have used a family member for interpretation	65 %
Percentage of the Deaf participants who felt the use of a family member did not compromised their privacy	36%
Percentage of the Deaf participants who want an improvement in communication with hearing people	47% s

results are as follows: written English 38%, interpreter 33% and sign language 25%. Written English is preferred because it appears there are no other alternatives.

5.2 Focus group

A focus group was conducted to involve the Deaf users in the design of SignSupport, for recording SASL videos and testing the pilot SignSupport prototype. The focus group sessions were conducted by the researcher and the results belong to this work and not Looijesteijn's (see Section 1.2 for Looijesteijn's results). Section 5.2.1 presents the focus group's sample size and characteristics. Section 5.2.2 presents the procedures used to obtain an interpreter and participants for the focus group meetings. Section 5.2.3 presents the format of the questionnaire used in the focus group pilot trial. Section 5.2.4 presents the results of the pilot trial. Section 5.2.5 presents the modifications suggested by the focus group after the pilot trial of SignSupport.

5.2.1 Sample

One of the qualitative methods used was a focus group. The focus group consisted of 4 Deaf staff members of DCCT. They are not illiterate, because they can read and write English with varying degrees of literacy. This focus group consisted of two females and two males, and their ages ranged between 25 and 60 years old. The group members were from different economic backgrounds. All 4 worked for the Deaf NGO DCCT. All 4 were part of the adult English literacy class at the Bastion of the Deaf. We used an SASL interpreter to communicate with the group when we were rearranging the questions and answers to handle the SASL structure, SASL video recordings, and they tested the pilot trial of SignSupport.

5.2.2 Procedure

The interpreter was the first person to be asked about availability because it was essential to conduct the focus group with one. Communication between the researcher and the interpreter was achieved by using SMS and voice calls on a mobile phone. Once the interpreter confirmed her availability, the Deaf people were contacted to check their availability on that date. Communication between the researcher and the focus group was achieved using SMS on mobile phones, and email with one of the members of the focus group. All the focus group sessions were held on Wednesdays, including the pilot trial mentioned here. The focus group members, the interpreter and the researcher met at the Bastion building. We used the video camera belonging to DCCT whenever we had focus group sessions. The memory cards for the video camera came with the researcher. We recorded the entire pilot trial. The trial began with each group member signing consent forms. They were told about the project and the role they needed to play. Pilot testing was then carried out. They tested the pilot system on the mobile phone, followed up by a questionnaire. A discussion was allowed at the end of the trial. There were two other pilot trials that were done with this focus group, but these are not included here as they were done without an interpreter. Written English was used instead. The results of these trials are not included in the thesis and are therefore disregarded.

5.2.3 Questions

A Likert scale questionnaire was used to obtain user feedback from the pilot trial (see Appendix G).

5.2.4 Results

The questions and results from the pilot trial can be seen in Appendix F. The results mentioned here are early answers to the evaluation research question. Most of the participants felt that SignSupport mobile was easy to learn. Half of them group felt that navigating through the system was very easy, while the other half had difficulty initially. The reason for the slow start in mastering the navigation was that they had not used the Nokia phone before, but as they continued using the system they got used to the navigation. A third of the focus group members felt the video was very easy to understand. One member could not always understand the signing in the video and required a second and third replay to grasp what was signed. The whole group was very happy with the sign language video quality on the mobile phone screen. All the group members felt that the hand gestures were clear. They all felt that the facial expressions were clear. Half of the group said they would like free use of the system, while the other half were willing to pay around R5.00 for airtime. They all said they would use the system in real life if it was available and they all indicated that they were getting used to using the system. (Note: the system was tested 3 times with the group but the interpreter was only present once, therefore 2 of the 3 sessions were disregarded.

They unanimously agreed that the system had too many questions. Suggestions made by the group can be seen in Appendix F).

5.2.5 Modifications

The navigation buttons to get the next and previous pages were moved from the top left and the top right of the SASL video respectively to beneath the SASL video. This provides a central location for all the buttons. The number of questions used by the system to obtain the symptoms from the Deaf users was cut down from 38 (see Appendix D the entire questions) to 11 questions (see Appendix C for the questions) to avoid user fatigue.

The navigation buttons to get the next and previous pages were moved from the top left and the top right of the SASL video respectively to beneath the SASL video. This provides a central location for all the buttons.

The number of questions used by the system to obtain the symptoms from the Deaf users was cut down from 38 (see Appendix D the entire questions) to a sample size of 11 questions (see Appendix C for the sample questions) to avoid user fatigue.

5.3 User test

User testing in the world of human-computer interaction (HCI) is considered the most appropriate way to assess usability in a software system, especially interaction on a web site, even though user testing is known to be expensive and time consuming. Determining how many users to use for user testing can be influenced by many aspects as each user adds costs, time for that testing session, data analysis and report combination. The final user trial was conducted by the researcher and the results belong to this work and not Looijesteijn's (see Section 1.2 for Looijesteijn's results). Section 5.3.1 presents the user test's sample size and characteristics. Section 5.3.2 presents the procedures used to obtain an interpreter and participants for the user test sessions on all three days. Section 5.3.3 presents the format of the questionnaire used in the user test and the results.

5.3.1 Sample

According to Nielsen, 5 users are not enough to uncover up to 85% of the problems on any web site [43]. In most cases, researchers settle for 5 users to cut down on some of the user testing factors but using too few users can result in a system being

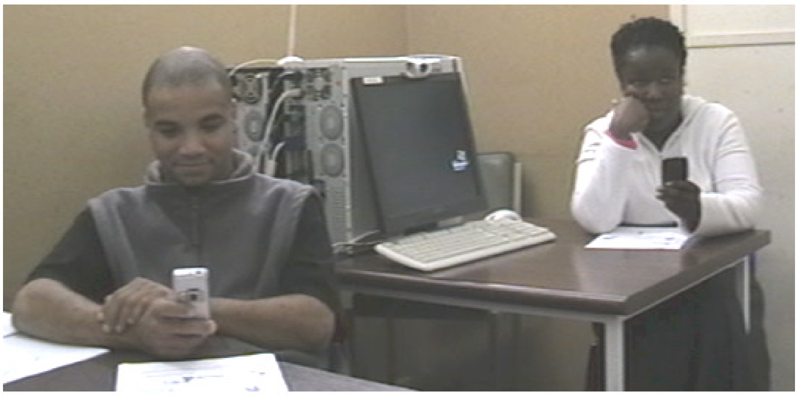

FIGURE 5.1: **Two Deaf users testing SignSupport.**
The figure above shows two Deaf people testing SignSupport on mobile phones.

rendered unusable by the rest of the target population at large. Furthermore, if novice users test the system, a lot of errors can be uncovered but it is difficult to determine which of these problems deserve the highest priority. On the other hand expert users may uncover severe or unusual errors, but they might miss errors that the novice group might find problematic [70]. Faulkner says, that having more than 5 users means that more errors can be uncovered than with only 5 users [19]. This is because 5 users can only uncover up to 55% of problems on a website. He concluded that in an empirical research, the sample size has to be larger than 5 users. Not every set of 5 users can uncover 85% of the problems, and it is also difficult to select a sample of 5 users who actually reach that percentage. It is a matter of luck rather than empirical research [20]. Spool and Schroeder reported that 5 users can only uncover 35% of problems and that there is a low chance of one user finding a specific problem [57].

In Section 1.5 the target community was introduced. This community consisted of over a thousand Deaf members from across Cape Town. For our research we choose to use 31 Deaf users for our user trials as this allowed us to uncover a high percentage of errors or problems in the system. The sample was composed of teenagers, young and elderly people. From Section 1.5 it may be established that the target community had more than a thousand members, and these were hearing-impaired people. From the thousand hearing-impaired, we were only interested in Deaf users, or members who primarily use sign language as their means for communicating with both the hearing world and the Deaf world. We tested the system with 31 Deaf users, which is more than 5 test users as suggested by Nielsen [43]. The researcher knew the market well enough to select a sample of the population. The researcher wanted to control who was selected to form the sample group of the population, this was crucial to produce organized and competent results from the feedback they would be receiving [20]. The judgment criterion was that the Deaf users had to be mobile phone literate. The reason being, that if a Deaf person had no previous knowledge of how to use a mobile phone, the researcher would have had to spend valuable time teaching that to him/her. The main goal in user testing was to get as many users to test the system as much as possible and not teach every Deaf person how to use the system. Other than that, the rest of the sample selection was random. Any Deaf person who had had previous experience on a mobile phone was asked to evaluate the prototypes.

5.3.2 Procedure

The user trial was done on 3 different days, 2 consecutive Mondays and a Sunday. This was done in order to get more than 30 Deaf people to test the prototype. On Mondays, BANG members from both UWC and UCT go to the Bastion of the Deaf to assist with computer lab and DCCT website maintenance. It was ideal to perform user tests on Mondays because other members of the BANG group who were not doing user trials could assist in assuring that the user trial ran smoothly. The Sunday was used because it was the third Sunday in a month, a day when many Deaf people come to the Bastion to attend a public meeting. It is ideal to perform user tests on this day as long as the researchers do not interfere with the activities of the day. The interpreter was booked by a hearing DCCT staff member for the first Monday. The second Monday and the Sunday the researcher had to contact the interpreter using e–mail and a hearing DCCT staff member oversaw the process. On both Mondays and the Sunday there was no need to schedule in advance with the Deaf. That was done on the day of testing. This communication was done with the interpreter's help. The researcher met the Deaf people and the interpreter at the Bastion, where a staff member of DCCT provided a venue.

On the days of the user trial, there were two sessions: namely morning and afternoon sessions. User trials were done in pairs. Two Deaf people were asked if they would like to test a prototype. If they needed convincing they were briefly told about the research and what the prototype does. During this time they were asked if they were mobile phone literate. The Deaf people were found walking around in the Bastion building or outside under the trees. An interpreter facilitated communication between the researcher and the Deaf people. Once they had agreed, they were taken to the room where a user trial was set up. They were asked to give a verbal consent on whether they agreed to participate or not. Once they agreed to participate, they were given a storyboard presentation. They were asked to test the prototype on the mobile phone. Each person had a mobile phone with the system on it. If the researcher saw that they were struggling he would stop them and help them to continue. Upon completion of answering the questions in the prototype, the researcher showed them how the (hearing) medical doctor would respond. The hearing responses were not tested during the user trial. The Deaf pair would then fill in a questionnaire. Upon completion they were thanked and released.

5.3.3 Questions and results

Video quality on the mobile phones

Combining the 21 Deaf users and the 6 Deaf users who felt that they were "very happy" and "happy" respectively with the sign language video quality on the mobile phone we have 27 Deaf users who felt that that they are happy with the sign language video quality (see Figure 5.2) from the 31 Deaf people who tested the prototype or 87%. We asked the 2 Deaf users who felt that the video quality on the phone was "neutral", and the 2 users who indicated that they were "not happy" (see Figure 5.2). Their response was that they would like to see the system on a bigger screen: note that not every one of them responded, some did not respond.

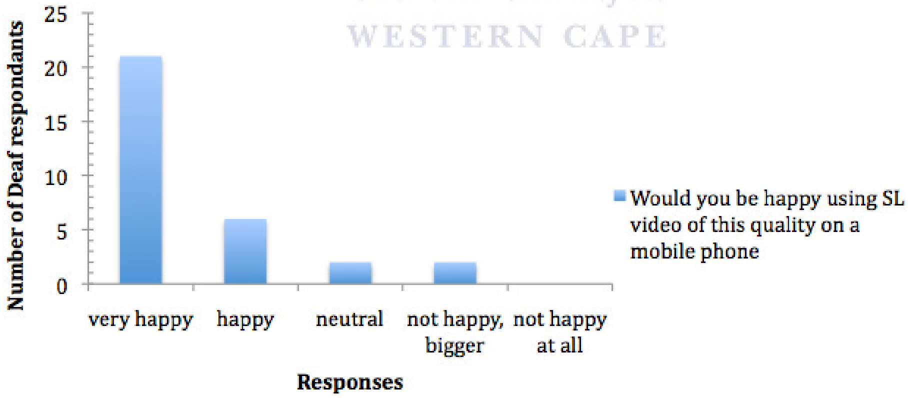

FIGURE 5.2: **SL video quality on the phone.**
The Deaf users were asked to evaluate how the they felt about the sign language video quality on the mobile screen.

Recognition rate

Combining the 15 and 8 Deaf users who found understanding what was signed in the SASL videos to be "very easy" and "easy" respectively, we have 23 out of 31 people tested who were able to understand the signs in the videos on the mobile screen (see Figure 5.3) or 74%. The 7 Deaf users who felt that their understanding of the SASL videos was "neutral" were asked why they felt this way (see Figure

5.3). They indicated that the mobile screen was too small, or that they had eye problems which prevented them from looking at small mobile screens for long periods of time. Note that not all seven responded to the question. The one Deaf user who found the SASL videos too "difficult" to understand (see Figure 5.3), indicated that the dialect sign language was different', and her friend indicated that she had problems understanding the Cape Town sign language dialect of SASL.

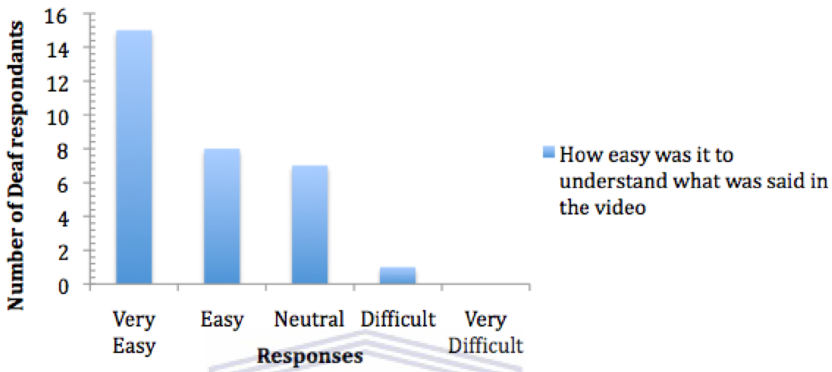

Figure 5.3: **Recognition rate for the SASL videos.**
Most of the users could understand the signing in the SASL video.

Non-Manual Features and Classifiers

In every dialect of sign language in South Africa or any sign language in the world, Non-Manual Features (NMFs) describe things such as nouns and give more information regarding them. Classifiers show movement, location, and appearance [33]. Deaf users were asked as to whether they could understand the NMFs and Classifiers clearly. In the questionnaire, for simplicity, the users were asked if they could see the facial expressions and the hand gestures clearly. Not all NMFs are made using facial expressions, but also the torso and the shoulders can indicate NMFs. Not all Classifiers are signed using the hands gestures, some classifiers are indicated using a signer's body language [33]. Combining the 20 Deaf users and the 5 Deaf users who could understand the NMFs signed in the SASL videos using the facial expressions to be "very clearly" and "clearly" respectively we have 25 Deaf users who were able to understand or recognized the NMFs in the videos on the mobile screen (see Figure 5.4) from the 31 Deaf people who tested the prototype or 81%. Combining the 18 Deaf users and the 8 Deaf users who could understand the Classifiers signed in the SASL videos using the hand gestures to be "very clearly" and "clearly", respectively, we have 26 Deaf users who were able to understand or recognized the Classifiers in the videos on the mobile screen (see Figure 5.4) from the 31 Deaf people who tested the prototype or 87%.

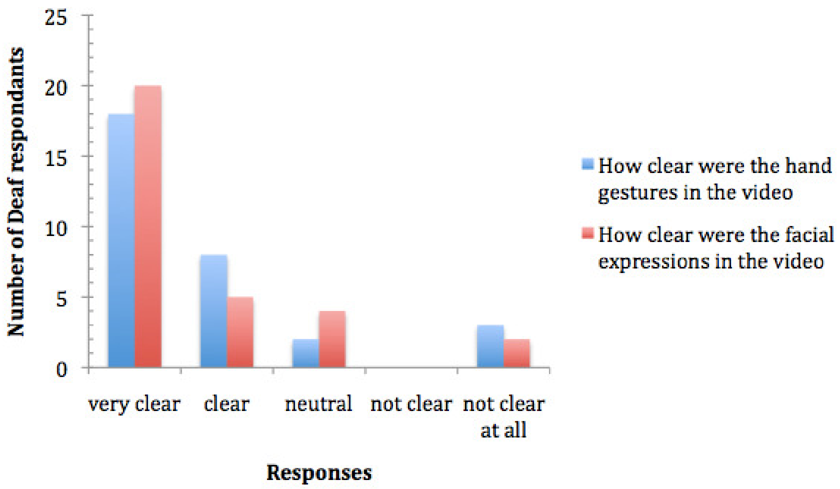

FIGURE 5.4: **Facial expressions and hand gestures.**
In SASL NMFs and Classifiers are some of the important aspects to consider when using sign language. In the graph the NMF are the facial expressions and the Classifiers are the hand gestures.

The 4 Deaf users who felt that their understanding of NMFs in the SASL videos was "neutral" and the one who indicated that the NMFS were "not clear" (see Figure 5.4), were further asked as to why they felt this way. The 2 Deaf users who felt that their understanding of Classifiers in the SASL videos was "neutral" and the 3 who indicated that the Classifiers were "not clear at all" (see Figure 5.4), were further asked as to why they felt this way. Their response for failure to understand the Classifiers and the NMFs was that either the sign language dialect was different or that they had eye problems. Note that not every one of them answered, some did not respond when asked why.

Learning to use the system

Combining the 13 Deaf users and the 11 Deaf users who felt that learning how to use the system was "very easy" and "easy" respectively we have 24 Deaf users who felt that using that learning how to use the system was easy, (see Figure 5.5) from the 31 Deaf people who tested the prototype or 77"%. The 4 Deaf users who felt that the level of learning how to use the system was "neutral" and the 3 who indicated learning how to use the system was "very difficult" (see Figure 5.5), were further asked as to why they felt this way. Their response was that the icons, such as arrows, were confusing. Not all of them answered, some did not respond when asked why. Combining the 7 Deaf users and the 18 Deaf users who felt that navigating through the system using the navigation button, clicking button, scrolling down button and scrolling up button (see Figures A.7, A.8, A.9, and A.10 respectively in Appendix A) on the phone was "very easy" and "easy" respectively we have 25 Deaf users who felt that using the phone's navigation button was easy (see Figure 5.5) from the 31 Deaf people who tested the prototype or 81“%. There were 4 Deaf users who felt that using the buttons to navigate on the Nokia phone to go through the system was “neutral”. The 2 Deaf users who indicated that using the buttons to navigate was “difficult” and “very difficult” respectively (see Figure 5.5), were further asked as to why they felt this way. And their response was that the Nokia N-series navigation buttons was “new to them”, “difficult to use”, “they had never used a smart phone before”, or “the thought a touch screen would be easier to use for the system” note that not every one of them answered, some did not respond when asked why.

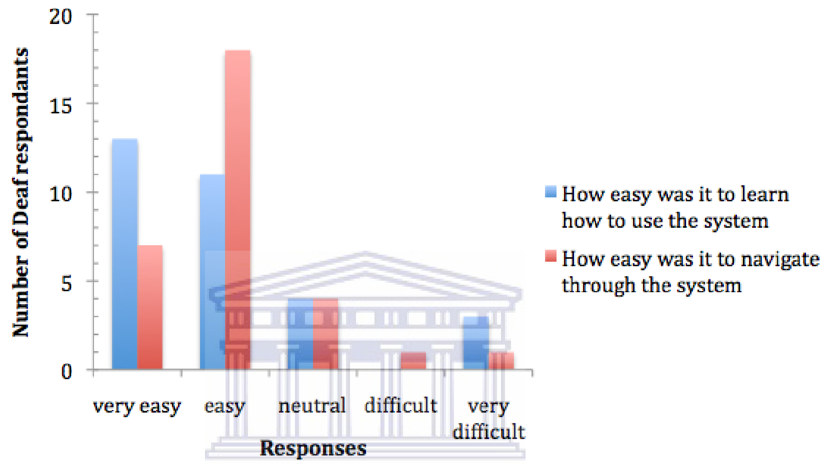

FIGURE 5.5: **Learning to use the system.**
The Deaf users were asked to evaluate learning to use the system - both using the Nokia phone and the software.

Understanding how to use the system

Combining the 9 Deaf users and the 7 Deaf users who felt that “definitely no” and “no” respectively that they did not get lost while using the system and that they understood what they were doing at all times (see Figure 5.6) we have 16 Deaf users out of the 31 Deaf people who did not get lost or 52“%. The 8 Deaf users who felt “neutral” to ‘getting lost’ while using the system (see Figure 5.6). When asked as to why they felt this way, they responded that they had begun by feeling lost, but as they continued using the system their understanding improved with time and practice. These 8 could eventually be added to the 16 who did not get lost at any stage to obtain 24 Deaf users out of 31 or 77“%. The 2 who said “definitely yes” and the 5 who said “yes” (see Figure 5.6) were asked as to why they felt they got lost, they responded by saying that they needed to have training first. Not every one of them answered.

Cost

The Deaf users were asked how much they would be willing to pay while using

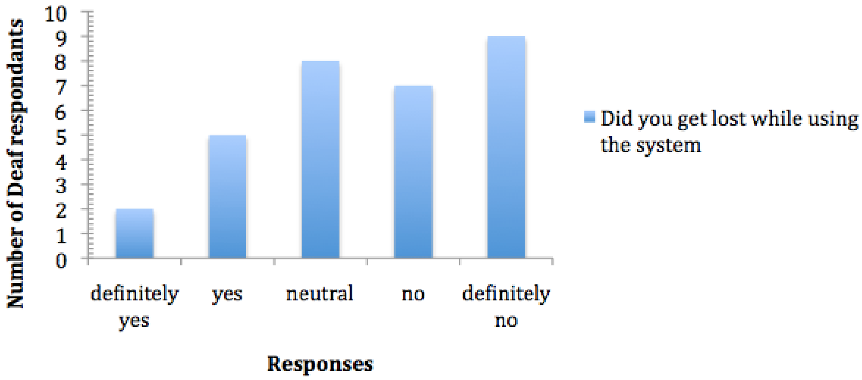

FIGURE 5.6: **Understanding how to use the system.**
The figure indicates if the users felt they did not understand what they were doing while testing the prototype.

such a system on the phone for downloading the SASL videos. The results are shown in Figure 5.7.

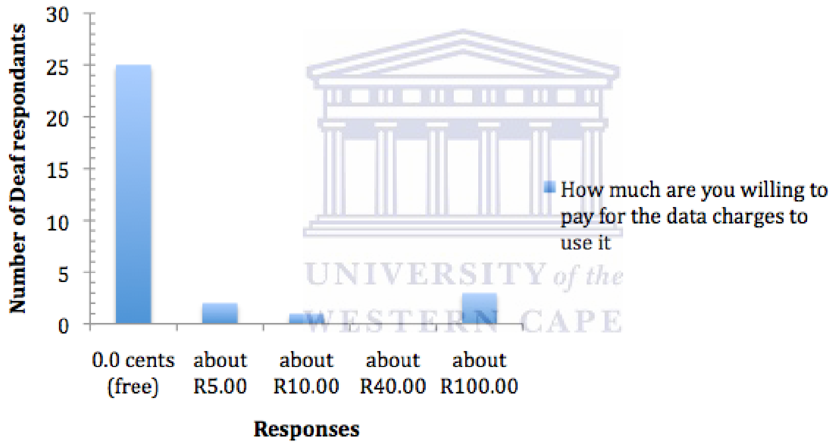

FIGURE 5.7: **How much are users willing to pay while using the system.**
The Deaf users were asked to as to how much they were willing to pay to while using the system.

There were 25 Deaf users who felt that they would not want to pay any amount of money that is paying "0,0 cents (free)" to use the system (see Figure 5.7) from the 31 Deaf people who tested the prototype or 81"%. The rest of the 4 Deaf users were willing to pay from R5.00 – R100.00 (see Figure 5.7), were further asked as to why they felt this way. Their response was that they understood that the system could be used over the Internet if they did not have the system with them on their phone, or that they could use a friend's phone if theirs got lost, or on the hospital/clinic's phone and such they would not mind paying while using the system because they would get assistance that would be worth paying for. Note that not every one of them answered, some did not respond when asked why.

Fatigue and Privacy

The following questions help in understanding if the Deaf users felt that the system is user friendly or not because it phrases too many questions making the users feel fatigued or if they felt the system was private enough to use. The results are shown in Figure 5.8.

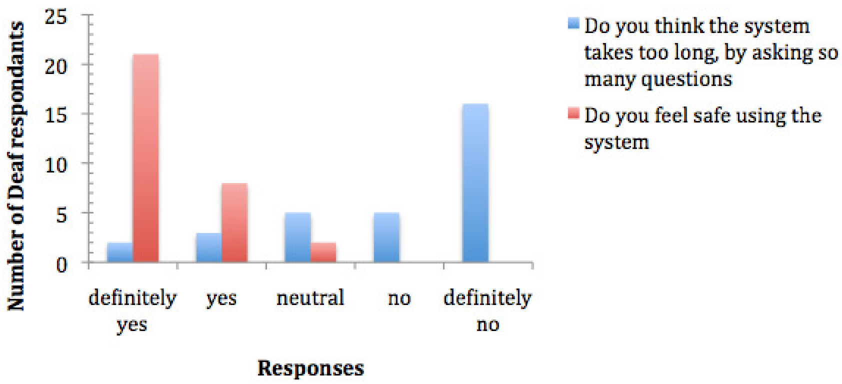

FIGURE 5.8: **Fatigue and privacy.**
This figure indicates the users attitude towards the number of questions and whether their privacy was being protected

Combining the 16 and the 5 Deaf users who felt that “definitely no” and “no” respectively that the system did not ask too many question we have 21 Deaf users who are happy with the number of questions (see Figure 5.8) out of 31 who tested the prototype or 68“%. The 5 Deaf users who felt “neutral” towards the number of questions (see Figure 5.8), were further asked as to why they felt this way. And their response was that they began by getting lost but as they continued using the system they were not sure as to how many questions the system would ask in order for it to obtain their symptoms. They also felt the number of questions asked were ok because sometimes they might get tired of answering questions and sometimes not. The remaining 2 and 3 who said “definitely yes” and “yes” respectively (see Figure 5.8), stated that if they were feeling ill, they would not want to answer many questions. The “neutral”, “definitely yes” and the “yes” respondents did not all reply when asked why they felt that way.

Combining the 21 Deaf users and the 8 Deaf users who felt “definitely yes” and “yes” towards the system being safe to use, and maintaining their privacy, we had 29 who were happy with the system (see Figure 5.8) or 94“%. The 2 Deaf users who felt “neutral” towards the level of privacy while using the system (see Figure 5.8), were asked why they felt this way. They responded that someone might look over their shoulder and see what they were doing on the phone. Not every one of them answered - some did not respond when asked why.

Would Deaf people consider using the system?

Combining the 12 Deaf users and the 16 Deaf users whose response was "definitely yes" and "yes" respectively we have 28 Deaf users who felt that they would use the system in real life, to communicate with a hearing person who cannot sign (see Figure 5.9) out of 31 who tested the prototype or 90"%. The 3 Deaf users who felt that their usage of the system would be "neutral", "no" and "definitely no" respectively (see Figure 5.9), were further asked as to why they felt this way. Their response was that they did not have a phone to run the system on, there was a need for more scenarios, and they could not look at a mobile screen for long periods of time. Again, not all of them replied, some did not respond when asked why.

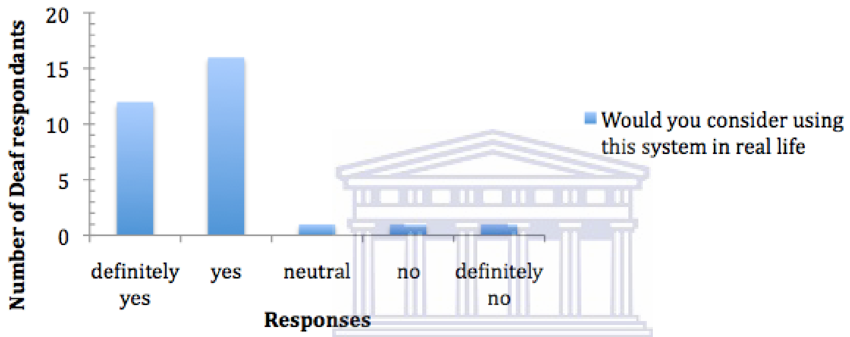

FIGURE 5.9: **System usage in real life.**
The Deaf users were asked if they would consider using this system in real life to aid them in communicating with a hearing person who cannot sign.

5.4 Analysis of results

The final user trial consisted of 31 Deaf people and the results are summarized in Table 5.1. SignSupport's most important feature is its user interface and the sign language videos are central part of the user interface [37]. Looijesteijn's results indicated that the Deaf participants first took time to understand the structure of a question and its answer pages. His results further indicated that the Deaf participants took time to get used to the buttons. The results herein indicate that the Deaf participants found it easy to learn how to use (77%) and navigate (81%) through the system. 52% of the Deaf participants said they did not get lost while using the system. 68% of the Deaf participants felt the system did not take long with all the questions they had to answer to get to the English summary which they would show the doctor. During Looijesteijn's user trial there was no demonstration of how the system worked except for the introduction SASL video and a storyboard. During our user trial, the Deaf participants were presented with a storyboard with a demonstration of a question page structure, how to answer a question, structure of the English summary page, and how the doctor would respond. Looijesteijn indicated that once the Deaf participants had completed the task of using the system then they understood the purpose and the controls of SignSupport [37]. A demonstration of how the system works at the beginning of the user trial helped improve the ease the users had to learn how to use and navigate SignSupport.

Section 2.5 describes a translation system which used four methods [21]. The results obtained from the translation system method which used sign language videos indicated that 81% of the signs were recognized by their participants [21]. This percentage rises to 98% when errors in recognition due to different dialects of sign language are removed. The results they obtained are high because Deaf people were comparing avatars to sign language videos. Our results indicate that 74% of the Deaf participants understood the sign language videos, 81% found the hand gestures clear and 84% found facial expressions clear. The percentages from our results could haven risen higher if some of the Deaf participants who tested our system did not have problems staring at a mobile phone screen for long periods of time and also if different dialects of sign language did not affect the results. Looijesteijn's results indicated that it takes a while to go through the system, answering questions but the participants said it was worth it [37]. They also said the system would be useful in the daily life.

Online dictionaries [63] and MMSSign [28] require the download of the sign language videos from a web server or MMS server. The cost to download data per MB ranges from R0.02 – R1.50; each mobile network provider has different cost per MB [27]. The lowest cost per MB is Cell C at R0.02 when buying the Cell C Prepaid 60GB data package and the highest is R1.50 when buying the MTN Data only 10MB data package. When frequently using either the online dictionary or the MMSSign systems once, the costs are not noticeable. Over time however, using the online dictionary or the MMSSign systems can become expensive for our Deaf community. Most Deaf people in our community are unemployed due to low levels of literacy. Our system implemented herein does not require a data connection because the system is stored on the mobile phone's memory. 81% of the participants in our final user trial did not want to pay when using the system.

The mobile support project's results on video quality are that 40% of their Deaf users understood the sign language, while the other 40% were neutral [6]. Their

Table 5.2: **User testing result summary.**
This is a compilation of Deaf participants who said ‘yes and ‘definitely yes’.

	Total (31)	**Percentage**
How easy was it to learn how to use the system	24	77%
How easy was it to understand what was said in the video	25	81%
How easy was it to learn how to use the system	23	74%
Would you be happy with using SL videos of this quality on a mobile phone	27	87%
How clear were the hand gestures in the video	25	81%
How clear were the facial expressions in the video	26	84%
How much are you willing to pay for the data charge to use it	25	81%
Do you think the system asks too many questions	21	68%
do you feel safe using the system	29	94%
Did you get lost while using the system	16	52%
Would you consider using the system in real life	28	90%

Deaf participants were 70% satisfied with using the system in real life. Their participants were asked if they would use mobile support as a communication tool 50% were neutral and 50% agreed. The results herein are that 87% of the Deaf participants were happy with sign language video quality on the system and 90% said they would use SignSupport in their daily life. Mobile support's results are lower because the Deaf people who participated in their user trial had not seen sign language on a mobile phone and were used to seeing sign language on bigger screens like computers and TVs. Our results are high because the users had seen a demonstration of the system was made before they used it. When our participants began using the system, they had an idea of what to look for in the system.

Cavender et al, found in the results of the MobileASL project that even though sign language video communication has a visual nature, this does not have privacy concerns because if the conversation is private then use the MobileASL system is private [8]. The privacy result herein (94%) is more directed towards allowing only the Deaf person and the doctor to communicate as an alternative to having an interpreter or family member present.

5.5 Summary

The chapter answers the second part of the research question which is how to evaluate SignSupport to determine if the Deaf users can understand the sign language in the videos and if they find the system easy to use. The results come from three main sources: a user survey, a pilot trial and a larger final user trial. The user survey was utilized to have a better understanding of our community prior to system implementation. The pilot trial was used to show how Deaf people felt about the system after it was implemented. The revised and a final larger user trial was used to learn how Deaf people viewed the system. The results from the three data gathering methods only apply to our Deaf community. Section 5.1 presented the user trials results. These are that SASL is their primary language, their level of written English is good–to–average, Nokia phones are common, and on a regular basis they visit pharmacists and medical doctors. Section 5.2 presented the pilot trials results, and the following information was obtained. The Deaf users found it easy to learn to use the system, navigate through the system and understand what was signed in the SASL videos. They were also happy with the sign language video quality on the mobile phone. They said the hand gestures and facial expressions were clear. Half of them preferred to use SignSupport for free. They also said they would use the system if it were available. As they continued testing the system they became accustomed to it, but they felt the system asked too many questions. The pilot trial feedback was used as input for a re-design of the system. Section 5.3 presented the final user trial results. The following information was obtained: most of the users found it easy to learn the system. Most of the users found it easy to navigate through the system. They also found it easy to understand what was signed in the SASL videos. Most of them were happy with the SASL video quality and felt that the hand gestures (classifiers) and the facial expressions (non–manual features) were clear. Most of them said they would prefer to use the system for free and also in their daily lives if it were available. They also felt the system did not ask too many questions. The majority of the Deaf people felt that their private information was secure while using the system. Section 5.4 analyzed the results from the final user trial with respect to the related work. It appears that Deaf people in our community seem happier with our system.

Chapter 6

Conclusion

The work herein describes the design and evaluation of a Deaf–to–hearing communication aid–SignSupport on a mobile phone platform. The mobile communication aid makes use of pre–recorded South African Sign Language videos inside a mobile browser. A Deaf person using the system answers SASL video questions and the answers appear in English for a hearing doctor to read and diagnose. Section 6.1 presents a summary of the thesis and draws a conclusion. Each chapter is briefly summarized. Section 6.2 presents how to continue future projects that involve user trials with Deaf people. Section 6.3 presents the limitations of this research. Section 6.4 suggests avenues for future work.

6.1 Deaf–to–hearing communication aid

This section briefly summarizes the contents of the chapters of this thesis. Subsections 6.1.1–6.1.5 summarize Chapters 1–5, and Section 6.1.6 draws a conclusion for the thesis.

6.1.1 Introduction

This thesis describes the design and evaluation of a Deaf to hearing communication aid for medical diagnosis in a mobile phone browser. Deaf with a capital 'D' refers to people who use SASL as their primary language. Our system, SignSupport, provides Deaf people with a sign language video communication tool to ease communication between a hearing person and a Deaf person. The target users are members of a Deaf NGO located in Cape Town, DCCT. The researcher belongs to a research group at UWC, called BANG. BANG has been involved in the design

83 Chapter 6. Conclusion 84 and testing of ICT4D projects with DCCT since 2001 [62]. Most DCCT members have mobile phones even though they are low–end mobile phones. DCCT maintains its own Internet cafe. A previous computer based mock up of a Deaf–to–hearing communication aid was designed and tested with the Deaf community [37]. Looijesteijn's results and a user survey were utilized as initial user requirement for our work.

6.1.2 Related work

Medical expert systems ask users medical questions before giving them a diagnosis without a medical doctor [52]. WebMD is an online symptom checker and gives users more information about symptoms they are experiencing [34, 68]. Medical expert systems use AI and huge libraries to phrase questions and based on the answers given by its user, a medical diagnosis [29, 61]. Medical expert systems are not directed towards Deaf people in our community because there do not have a Deaf user interface.

Text and video relay are also discussed. Text relay allows Deaf people to communicate with hearing people using written text with the use of a relay operator [23]. Video relay allows Deaf people to communicate with hearing people using sign language with the help of a relay operator [24, 42, 49, 56]. Video relay examples listed herein are TISSA, VP–200 and TESSA. Sign language mobile communication uses mobile phones to aid Deaf people to communicate [14, 42, 49, 56]. Examples include a mobile support used to aid communication between emergency medical responders and Deaf person, video calling and MobileASL [10, 11]. Mobile support and MobileASL are designed for Deaf people and have a Deaf user interface [10, 11]. Video calling can be used by Deaf people but voice communication is still a priority and most phones have a front–end camera with a low–resolution which is not acceptable for sign language communication [66]. Since 2001, BANG has designed and tested prototypes with DCCT members [62]. The prototypes fall in four main phases, namely the Telgo, Softbridge, SIMBA, and Deaf–to–Deaf phases. Other alternatives that Deaf people can use are off–the– shelf systems such as the Allanc eC, SignForum, WinkBall, Skype, GoogleTalk, etc. These systems run on computers and provide good quality sign language video communication between Deaf people [37]. Mobile alternatives for Deaf people include online sign language dictionaries and MMSSign [2, 30, 60]. SignSupport fills the gap mainly because:

- it has a Deaf user interface by using SASL videos,

- it is a kind of expert system but makes use of a real doctor to diagnose the patient,
- it is available locally for DCCT members,
- it does not cost our users anything because the system is stored locally on the phone,
- and it is mobile–based.

6.1.3 Methods

The related work discussed helps identify challenges which our system must also contend with. WebMD and medical expert systems have text interfaces and are not really for Deaf people. Both text and video relay are not available or affordable in South Africa. SMS is not appropriate for formal situations and Deaf people in our community have poor levels of English literacy. Mobile support and MobileASL are not available here. Video calling's priority is still voice and most phones have front–end camera with a low–resolution. GoogleTalk, Skype, WinkBall, Facebook, Allan eC, SignForum, etc. provide good sign language video communication but are computer–based and require a Deaf person's chat buddies to be online simultaneously. Our system is a form of automated system with a Deaf user interface. It phrases questions in SASL and the answers are presented in English for doctor to diagnose. The doctor can use a look–up dictionary to respond to the Deaf person. Online sign language dictionaries and MMSSign require a data connection to download the sign language videos. Over time this can be expensive. Other alternatives such as translation systems are still in development. The research question thus becomes the how to design and evaluate a prototype that will allow a Deaf person using SASL to tell a hearing doctor how s/he is feeling and provide a way for the doctor to respond? The first part of the question focuses on the context free design using an authoring tool. This design should allow for pre–recorded sign language streaming using Adobe Flash inside the XHTML page on a mobile phone. The design should also for the system to be stored on the phone's memory. The second part of the question is answered by setting up a user trial with DCCT members to evaluate the usability of the system. The design uses Looijesteijn's results, related work challenges and the user survey as user requirements in an iterative prototyping of a SDLC. The related work also informs the evaluation methods used herein. The evaluation design uses qualitative and subjective methods to setup a questionnaire which the focus group and the participants of the final user trial fill in after testing SignSupport. Ethical approval was obtained to use participants for the research. These participants signed consent forms and the data we collected was kept safe. An interpreter was used to facilitate the communication between the researcher and the Deaf participants. The researcher's role in the BANG research group was also defined.

6.1.4 System design

The system design chapter answers the part of the research question on how to design and implement SignSupport for a mobile phone browser in a context free manner which will allow for other scenarios to be easily added. Related work challenges, Looijesteijn's results and the user survey are used as user requirements when designing the system. The implementation technologies are Adobe Flash, mobile browsers and PAMP. Flash Lite 3 and Adobe Flash allow for streaming of videos on mobile phones directly in their browsers instead of using third party media players. Adobe provides FLV and SWF file formats which are the most commonly used during video streaming. Video streaming can be embedded in WAP, HTML and XHTML which mobile phone browsers can open. For our user trials we used Nokia N–series phones which have Flash Lite 3 and the videos were converted to SWF. Some mobile browsers are miniature versions of desktop browser or browsers provided by a mobile phone company, e.g. Nokia S60 browser on Nokia phones. Not all mobile browsers are Adobe Flash enabled. PAMP is available on Nokia S60 phones. PAMP allows us to use PHP and MysQL to display the XHTML pages and to use a database respectively. SignSupport user interfaces for both the Deaf user and the hearing doctor were described. The high–level design of SignSupport classes were outlined. The authoring tool which creates the SignSupport pages' user interfaces were presented. The Admin user creates SignSupport pages by uploading SASL videos and typing English text. The high–level design of the authoring tool's classes were also outlined. Video specifications for recording the SASL videos are listed.

6.1.5 Results

The results we obtained from our research indicates that most of the Deaf in the community mainly use Nokia phones, they recently visited pharmacists and medical doctors, they mostly used written English to communicate with a public worker, and the public worker used English in return. The results from the focus group indicated the users were happy with the system, the large number of questions cause fatigue and the navigation buttons were too far. These results were then put into the design of SignSupport prototype used for the final user trial. The results from the final user trial indicate that most of the users found it easy to learn to use and navigate through SignSupport, 77% and 81% respectively. The video quality was acceptable to most of the participants and most Deaf participants understood the sign language in the videos, 87% and 74% respectively. They understood the hand gestures and facial expressions, 81% and 87% respectively. Most of them wanted to use the system without paying for data, 81%. 94% felt safe while using the system. Most Deaf participants did not think SignSupport asked too many questions and did not get lost, 68% and 52% respectively. Most of the users would use the system if were available, 90%. The overall feedback showed that such a system could help Deaf people express their symptoms to a hearing doctor using SASL. There were some problems experienced by a small amount number of the Deaf users such as the screen being too small, sign language dialect and eyes problems.

6.1.6 Conclusion

The research described herein is: How to design and evaluate SignSupport to allow a Deaf person to use SASL to tell a hearing doctor how s/he is feeling and provide a way for the doctor to respond. This system is designed for Deaf people who are members of DCCT. They use SASL as their primary language for communicating. These Deaf people have low–levels of English literacy and cannot afford to pay for an interpreter every time they communicate with a public worker who cannot use SASL. This system is designed to help them communicate with hearing public workers. An authoring tool is designed and implemented to create the SignSupport pages. SignSupport runs inside a mobile phone browser from the phone's local memory displaying SASL videos in XHTML pages for each question, answer and response using video streaming. SignSupport asks the Deaf person about how they are feeling in SASL using SASL videos the answers are recorded in simple English for the hearing doctor to read and diagnose. The doctor can respond by clicking on an English phrase which will play a SASL videos for the Deaf. SignSupport was evaluated by the Deaf people who are members of DCCT. The results from the evaluation are that most Deaf participants found it easy to learn to use SignSupport (77%), navigate it (81%), happy with the sign language video quality (87%) and were able to understand the SASL videos (74%). They felt the hand gestures were clear (81%) and the facial expression were clear (84%).

Most of them did not feel the system took too long (68%) and thus they would like to use the system in their daily lives (90%). The Deaf participants' remarks were: SignSupport can help Deaf people develop, they can't wait to use it because it's an alternative communication tool, they found it easy to use, the videos were clear and easy to understand, and not expensive to use. SignSupport is cheap because all the videos are stored on the phone and no data access is required. All the SASL videos used in the system come to 24.4MB, and the entire system is 24.7MB. SignSupport can be a system that the Deaf people belonging to the community can use because it is mobile, cheap, they can sign their own videos, it runs on a Nokia phone which most of them have, DCCT can buy phones that the system can be installed on, and they were part of the design of the system.

6.2 Suggestions for conducting trials with Deaf people

During the research we learnt many things from Deaf people. Communication barriers are the most important issue, between the hearing and the Deaf. Being Deaf is as different as any culture like any other spoken language culture. We ourselves learned SASL to try and understand that culture, and design the system with the culture in mind, but often it was clear that the basic SASL we learned was inadequate. The use of an interpreter was vital, and often help had to be sought from people who had experience working with Deaf people. Weekly visits to the Bastion to maintain the computers, the network, the website and teach basic computer skills with other BANG members involved in Deaf research helped to make friends with the Deaf people and they got used to us, the researchers. Deaf people then knew us personally, and became more free and open when we required their feedback or help with our individual re-search. Regular conversations in written English with some of the Deaf people during BANG presentations at the Bastion also helped in making friends in the Deaf community. User participation held at the Bastion was vital as we met the Deaf people in an environment that they felt most comfortable in, for research purposes. The use of an interpreter was vital, regardless of how much SASL a researcher might have learned. The interpreter was not permitted to change what the researcher said, but suggestions of better ways to phrase things was important. Communication between the researcher and the interpreter was essential, and better still, if friendships could be established between the two. It became easier to contact the interpreter for research sessions.

It was important for the interpreter to know what the project concerned so s/he could familiarize themselves with the words the researcher would be using. Interpreters were also given breaks during the user survey, pilot trials and the user trials to keep them refreshed.

It was of vital importance for the researcher to listen to advice from people who have years of experience working with Deaf people, regardless of the researchers opinions on right and wrong. The best day to perform user trials was on the third Sunday of the month as Deaf people come to the Bastion in hundreds. It was important to share good feedback with other researchers. We ensured that the questionnaires for surveys and user testing were not too long, as this could cause weariness and people might decide to leave. It was highly advisable to have Deaf friends at the Bastion. Early planning and preparation for user feedback/trials was important and feedback needed to be sought from people who had years of experience working with Deaf people.

The results obtained from this project shows that Deaf members of DCCT are able to use SignSupport to communicate with a hearing person who cannot sign. They will need to get used to the system, in order to it when they need to. A small number of the participants during the final user trial were not happy with SignSupport because they had difficulty understanding the SASL dialect or with the videos being too small. These problems they encountered appeared among few people in the sample size and this might appear in a larger scale in the general population. Problems that might appear in the large population are addressed in Section 6.4 as future work that can be done to improve on SignSupport. Problems with the SASL dialect can be due to the written English questions on being interpreted correctly into SASL structure but rather English SASL which is not SASL. This can cause a difference in communicating an idea or asking a question. Some of the results of where the Deaf participants were not happy with SignSupport occurred in a small sample of the community used for the user trial that is these experiences they had while using SignSupport might not occur in the larger population. Some of the problems encounter during the user trial such as SASL dialect or eye problem are addressed in the future work.

6.3 Limitations of this research

Our results obtained for the data is only applicable to Deaf people who belong to the target community, DCCT (see Section 1.3). The system was only tested on the Nokia N-Series 60 phones; the results might change if only phone models and platforms that can handle the system are used (see Section 4.4). The phones used were button operated, thus if touch screen phones are used the results might change [37]. The user trial results might change if the users are allowed to test SignSupport after a scenario where the Deaf person is told they are sick without the researcher telling him/her how to navigate and use the system (see Appendix A). All the participants tried the prototype for a short period only, and their feedback might change if they used the system for a few days. The system was tested with the researcher present. If the Deaf person tested the system in a real life situation without the researcher present, the results might change. One advantage the Deaf person had was that they could stop and ask a question at any time. The system was only tested with Deaf people and a medical doctor was not included in the user trials, thus actually use of a medical doctor might change the user feedback. The context free scenarios created by the authoring tool cannot be edited. The system's functionality to allow a hearing doctor respond or give a medical diagnosis to a Deaf person was not tested. The system was also not tested with a medical doctor. Some of the questions were removed to cut down the number of questions, better results can be achieved with more questions (see Section 6.4 on how to increase the number of questions and still avoid user fatigue).

6.4 Future work

SignSupport system could be improved. Doctors responses could be sought, recorded as SASL videos, added to SignSupport and evaluated with the Deaf community. User trials involving a Deaf person communicating with a hearing doctor could be conducted. In this case the quality of exchange of information in the conversation could be measured. A touch screen operated phone could be used instead of the Chapter 6. Conclusion 90 button operated phones used herein. Most touch screen operated phones have bigger screens and this might be advantageous in presenting the SASL video. Other complementary scenarios: a Deaf persons visit to a pharmacist to get prescribed medication, using the prototype described here. HTML was used to create the SignSupport, with the introduction of HTML5 the embedding of video can be explored in that language. Other future work should be obtained from the limitations of the research (see Section 6.3). In this work the SignSupport some of the questions were removed to cut down the sample size of questions, for future work the questions can be arranged into a shorter tree to allow more questions to be in the system. A tree with many branches at each level allows the tree to have a short length in depth. A balance can be found between adding more questions and having a shorter depth.

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Appendix A

Deaf communication information sheet

1. Who is running the project?
   Hello my Name is Muyowa, and my sign name is.(i sign my "sign name")
   I am a Computer Science student at the University of the Western Cape
   You might know Bill Tucker. Hes the project leader.
   I am going to tell you about a mobile phone project for the Deaf.
   We want to improve communications between a Deaf person and a hearing person, such as a visit to the doctor.
   This system is software that can help a Deaf person present a medical problem to a doctor who cannot understand sign language.
   This project lets Deaf person use sign language when you visit the doctor and the (the doctor) uses English to understand your problem.
   The doctor will respond to you using English and you will understand this using sign language.

2. Consent
   Hello. First I must ask for your consent to participate.
   The information you give here and your identity will be kept private
   After the project is done, the information you give will be destroyed
   The interpreter will use SASL, and he will not repeat the information he interprets with anyone
   You are free to withdraw from the user testing at anytime
   Do you agree to participate?

3. What is this research project about?

   This system allows a Deaf person to communicate with a hearing doctor or nurse who cannot use sign language

   This communication is on the mobile phone

   You will use sign language to describe your health problem and the system will translate that to English for the doctor or nurse

   The doctor or nurse will use English to respond to you and the phone will show you sign language of what he says, see Fig A.1.

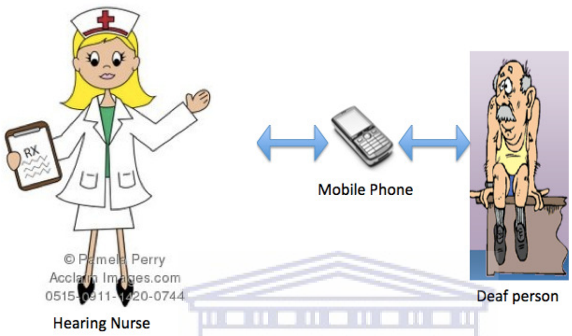


FIGURE A.1: **Users communicate using the SignSupport mobile.** User interaction using the mobile phone, the users take turns interacting with the system on the phone.

4. Imagine you are sick?

   Imagine you wake in the morning and your nose is running, you are coughing and you feel too weak to get out of bed.

   You want to go to the clinic and see a nurse but you know she cannot understand sign language and you cannot hear what she says

   You can use this system on the phone to tell the nurse your symptoms, see Fig A.2.

5. Answering questions in sign language

   The system will ask you questions in sign language about your health

   You will answer these questions in sign language, see Fig A.3.

6. Clinic

   Then you go to the Clinic see Fig A.4.

Figure A.2: **A sick Deaf person.**
A sick Deaf person who has a cough, a running nose and is unable to get of bed due to feeling weak, plans to see a hearing doctor to get a diagnosis.

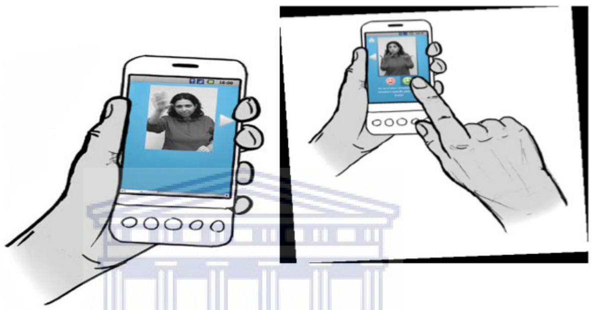


Figure A.3: **A Deaf person interacting with the system.**
A Deaf user watches the SASL video questions and answers the questions using a SASL video answer.

Figure A.4: **The clinic.**
A Deaf goes to the clinic to show the doctor the phone after answering the SASL questions.

7. Showing the nurse the phone

   You will show the nurse the phone

   The phone will show English text of what you said to the nurse see Fig A.5.

8. Nurse gives a prescription

Figure A.5: **A Deaf person shows the doctor the phone.**
The Deaf then shows the doctor/nurse the phone so that the doctor/nurse can read what the Deaf person said.

The nurse can then tell you what you should do.

The phone will show you her advice in sign language see Fig A.6.

Figure A.6: **The nurse/doctor's prescription.**
The nurse/doctor uses the system to give the Deaf person a diagnosis/prescription to take to a pharmacist.

9. How to Navigate through the system

   Now I am going to show you how to answer questions on the phone

   The system will show you videos in sign language

   To move between videos, use the sides around the big button, to move left and right, up and down

   The little arrow will move around when you do this see Fig A.7.

10. Clicking to accept

    Use the big button in the middle to make a choice see Fig A.8.

11. Scrolling Down

    The screen on the mobile phone is very small.

FIGURE A.7: **The main navigation button.**
The main navigation button on the phone, this is the only button required to use the system by the users.

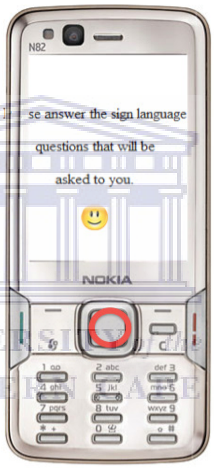


FIGURE A.8: **Click to accept.**
The button used to click on an image, the button is pressed inward on a system icon to accept the answer or move to the next page.

Sometimes, there is too much information to show on one screen.
Then you must scroll down to see more.
Pushing down moves the screen so you can see more, see Fig A.9.

12. Scrolling up

    To move the screen up, push the top part, see Fig A.10.

13. Introduction page

    The system shows sign language on top
    and English below it.
    To move to the next video, move the arrow to the smiling face and push the

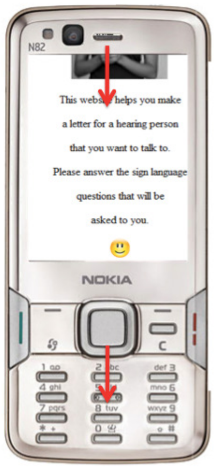


Figure A.9: **Scrolling down.**
The navigation button is pressed downwards to scroll downwards the screen.

Figure A.10: **Scrolling up.**
The navigation button is pressed upwards to scroll upwards on the screen.

big button, see Fig A.11.

14. Question page

    You answer a question in the same way.

    Each question is shown in sign language video up top

    An arrow beneath the video takes you to the answers

    Beneath the arrow the video in English

    Press the arrow to answer the question, see Fig A.12.

15. Answer page(s)

    Answers can be yes or no, or can have more than 3 choices

    This is an example of a yes/no answer.

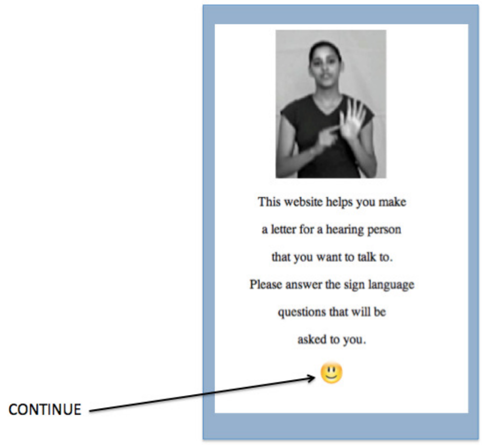


Figure A.11: **Navigating around the introduction page.**
The deaf user has to watch the SASL video, after watching the video, the Deaf user clicks on the smiling image to proceed to the questions and answers.

Figure A.12: **Navigating around the question page.**
The deaf user has to watch the SASL video, after watching the video, the Deaf user clicks on the arrow pointing to the right to proceed to answer the question.

The video shows a possible answer.

to see another possible answer, press the arrow left or right.

Moving right takes you to another answer.

Moving left takes you to an answer you have seen before.

So you can move between answers and choose the one that is right for you.

Press the smiling face to choose an answer, see Fig A.13.

16. When the Deaf user is done answering the questions

    When you are done answering questions, you will see this screen

    When you see the nurse or doctor, choose English Summary and the phone will show what you selected in English, see Fig A.14.

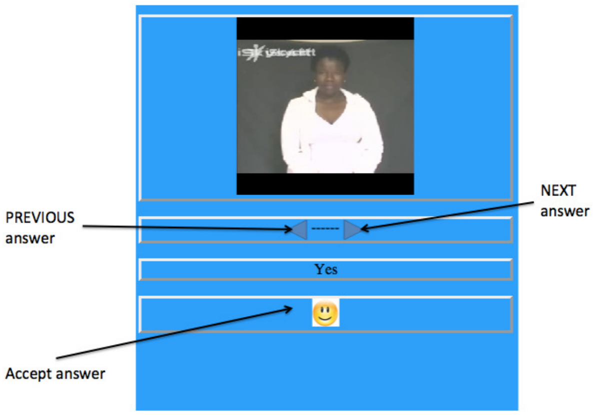


FIGURE A.13: **Navigating around an answer page.**
The deaf user has to watch the SASL video, after watching the video, the Deaf user can click on the arrow pointing to the right to proceed to next answer the question, click on the arrow pointing to the left to proceed to the previous answers, or click on the smiling image to accept the answer.

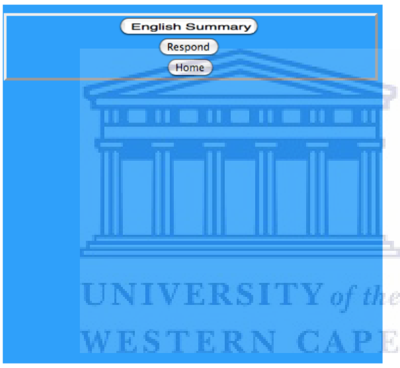


FIGURE A.14: **Doctor's desk.**
When the Deaf person sees this screen then they know they are done answering the questions and they must give the phone to the doctor.

17. English summary

    The doctor or nurse can read your information in English

    And then decide what to tell you.

    The doctor then chooses Respond, see Fig A.15.

18. Doctor's response

    This is the doctors response, see Fig A.16.

19. Prototyping

    Now that you seen a demonstration of how to use the system, you are going to try the system on the mobile phone.

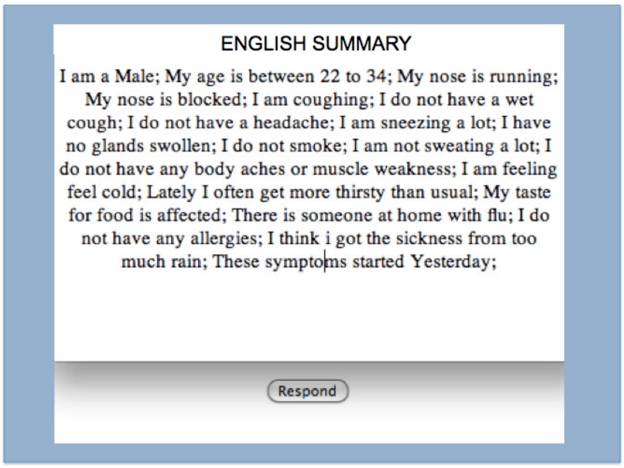


FIGURE A.15: **English summary.**
The is the page containing the English summary of the SASL video answers in plain English.

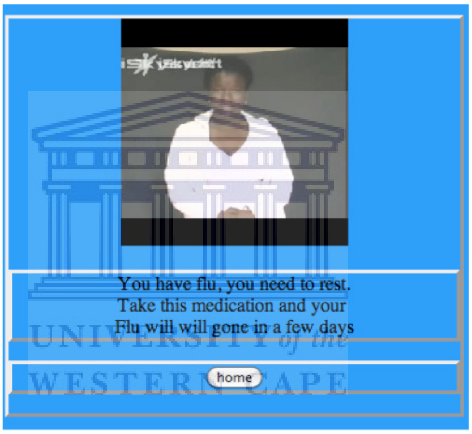


FIGURE A.16: **A doctor's response using SASL video**
When the doctor gives a response, a SASL video shown to the Deaf user.

20. Questionnaire

    Now that you are done testing the system

    I will ask you to tell us what you thought of the system by answering questions

    This is important because we do not sign and we need to understand how you as someone who uses sign languages thinks about the system, see Appendix ??.

21. Gratitudes

    Thanks you for testing the system

    Your help is appreciated

Bye

Appendix B

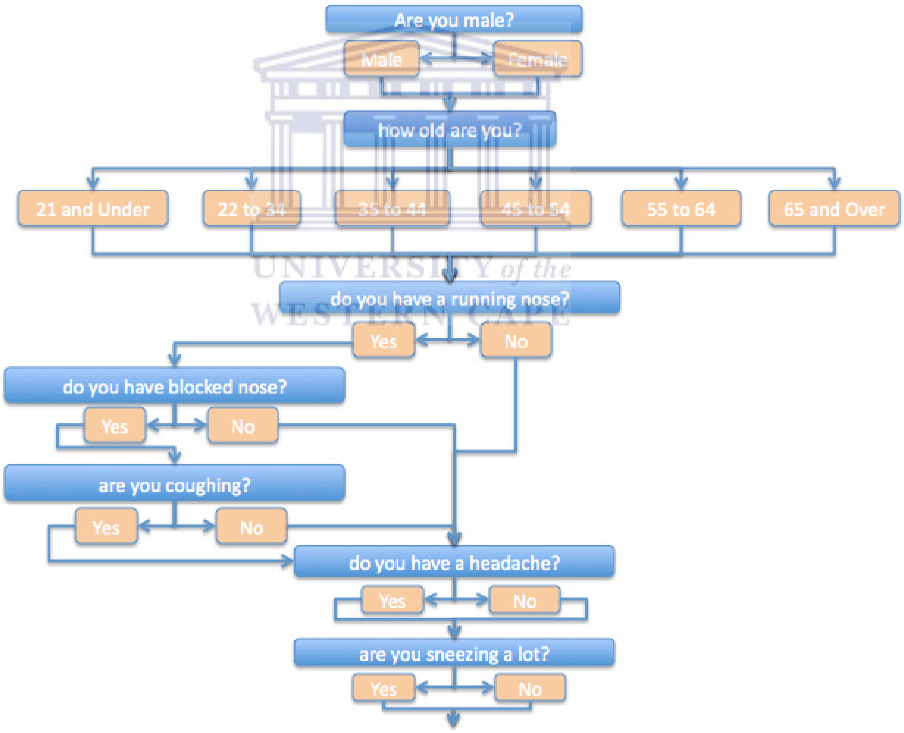
Evaluation questionnaire and raw feedback

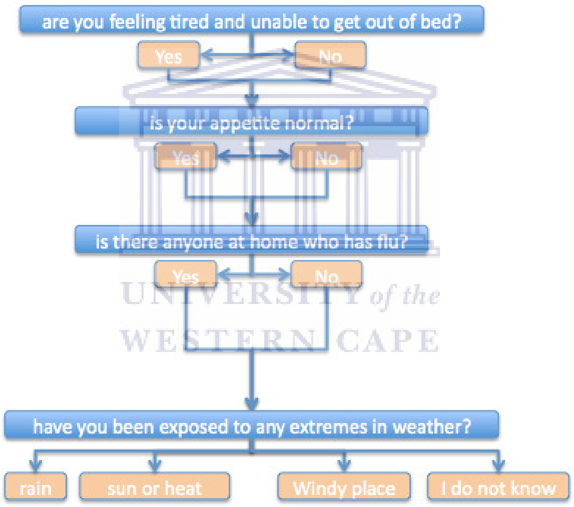
	Very Easy	Easy	Neutral	Difficult	Very Difficult		Total
How easy was it to learn how to use the system	13	11	4	0	3		31
How easy was it to navigate through the system	7	18	4	1	1		31
How easy was it to understand what was said in the video	7	18	4	1	1		31
	-						
	Very Happy	Happy	Neutral	not happy	not happy at all		Total
Would you be happy using SL video of this quality on a mobile phone	21	6	2	2	0		31

	Very Clear	Clear	Neutral	not Clear	Not Clear at all		Total
How clear were the the hand gestures in the video	18	8	2	0	3		31
How clear were the the facial expressions in the video	20	5	4	0	2		31
	-						
	0.0 cents (free)	R5.00	R10.00	about R40.00	about R100.00l		about Total
How much are you willing to pay for data charges to use it	25	2	1	0	3		31
	-						
	Definitely Yes	Yes	Neutral	No	Definitely No		Total
Would you consider using this system in real life	12	16	1	1	1		31
Did you get lost while using the system	2	5	8	7	9		31
Did you think the system takes too long, by asking so many questions	2	3	5	5	16		31
Did you feel safe using the system	21	8	2	0	0		31

Appendix C

Map of the sample questions used for final user testing




are you feeling tired and unable to get out of bed?
Yes
No
is your appetite normal?
Yes
No
is there anyone at home who has flu?
Yes
No
have you been exposed to any extremes in weather?
rain
sun or heat
Windy place
I do not know

Appendix D

Questions doctors ask patients to aid in diagnosis of influenza

1. **Question:** are you a male or female?
Possible answers: male / female

2. **Question:** how old are you?
Possible answers: 21 and Under/ 22 to 34/ 35 to 44/ 45 to 54/ 55 to 64/ 65 and Over

3. **Question:** did you get a flu injection this year?
Possible answers: yes/no

4. **Question:** do you feel sick?
Possible answers: yes/no

5. **Question:** are you experiencing a lot of stress?
Possible answers: Yes/no

6. **Question:** Is your nose running?
Possible answers: yes/no

7. **Question:** do you have blocked nose?
Possible answers: Yes/no

8. **Question:** do you have a sore throat?
Possible answers: yes/no

9. **Question:** are you coughing?
Possible answers: yes/no

10. **Question:** If so, is it dry or wet cough?
Possible answers: dry/wet

11. **Question:** do you have a green thick mucus when you cough or clear your throat?
Possible answers: yes/no

12. **Question:** do you have a tight chest when you cough
Possible answers: Yes/no

13. **Question:** do you have a headache?
Possible answers: Yes/no

14. **Question:** do you have chest pains?
Possible answers: Yes/no

15. **Question:** are you sneezing a lot?
Possible answers: yes/no

16. **Question:** are you sleeping well?
Possible answers: Yes/no

17. **Question:** are you sweating a lot?
Possible answers: Yes/no

18. **Question:** do you smoke?
Possible answers: Yes/no

19. **Question:** is your voice hoarse?
Possible answers: Yes/no

20. **Question:** are your glands swollen?
Possible answers: Yes/no

21. **Question:** do you have any body aches or muscle weakness?
Possible answers: Yes/no

22. **Question:** are you feeling tired and unable to get out of bed?
Possible answers: Yes/no

23. **Question:** do you feel feverish?
Possible answers: Yes/no

24. **Question:** do you feel cold?
Possible answers: Yes/no

25. **Question:** do you have any hot flushes?
Possible answers: Yes/no

26. **Question:** do you get more thirsty than usual?
Possible answers: Yes/no

27. **Question:** is your taste for food affected?
Possible answers: Yes/no

28. **Question:** is your appetite normal?
Possible answers: Yes/no

29. **Question:** is there anyone at home who has flu?
Possible answers: Yes/no

30. **Question:** have you been exposed to any extremes in weather?
Possible answers: rain/sun/windy place/ I do not know

31. **Question:** did you go out of town recently?
Possible answers: Yes/no/not sure

32. **Question:** when did these symptoms start?
Possible answers: Today/ yesterday/e days ago/ about a week ago/ about 2 weeks ago/ about a month ago

33. **Question:** do you have any allergies?
Possible answers: Yes/no

34. **Question:** in the past few days have these symptoms come and gone?
Possible answers: Yes/no

35. **Question:** have you been to a doctor?
Possible answers: Yes/no

36. **Question:** did you take any medication?
Possible answers: Yes/no

37. **Question:** in the past when you had flu, what are some of the medication that you took?
Possible answers: Yes/no

38. **Question:** how long did your flu last, after using the medication?
Possible answers: A few days/ a week/ 2 weeks/a month/I do not know

Appendix E

User survey questions and results

Gender	Male	Female
	15	18

Age	15-25	26-35	36-40	41-50	51-older
	1	20	3	7	2

Home language	SASL	Xhosa	English	Afriakaans	Zulu	Other
	20	4	9	1		

Written English level	Poor	Average	Good	Excellent
	4	12	16	1

I grew up in a:	City	Town	Informal settlement	Rural area
	10	8	1	14

I live in a:	City	Town	Informal settlement	Rural area
	13	6	9	2

I use a:	Mobile phone	Computer	Both	Neither
	13	3	16	1

Internet usage	Daily	Weekly	Monthly	Rarely
	6	9	3	11

I use the following:	face-to-face SASL	written English on PC/phone	video call	video chat	text/video relay service	written English with pen and paper
	18	25	1			

The phone I have is:	Nokia	Samsang	Motorola	LG	Other
	17	4	1	2	1

I have used:	MSN	Gtalk	Facebook	Tokbox	Camfrog	Skype
	5	2	8	1	2	2

I recently went to a:	Doctor	Pharmacist	Policeman	Train ticker seller	Teacher/Reverent	Shop keeper
	8	9	3	5	5	9

What did you use	Written English	SL	Interpreter	Other
	11	4	6	4

What did they use	Written English	SL	Interpreter	Other
	10	2	6	

I have used an interpreter at a doctor before	Yes	No
	9	9

If Yes, were you uncomfortable	Yes	No
	8	1

If No, was your privacy compromised	Yes	No
	2	4

I have used a family member/neightbour	Yes	No
	11	6

If Yes, was your privacy compromised	Yes	No	Other
	3	4	4

Rate your communicate satisfaction	Satisfied	Fairly satisfied	Average	Poor, needs improvement	Totally unacceptable
		5	4	8	

I prefer to communicate using:	Written English	SL	Interpreter	Other
	9	6	8	1

Appendix F

Consent form

I, ____, fully understand the SignSupport (a communication aid on a mobile phone) project and agree to interpret. I understand that all information that is provided here is to be kept confidential, and that the participants identities and information regarding them is not to be used outside the umbrella of this project. 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.

For further information, please do not hesitate to contact:
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University of the Western Cape
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Bellville 7535
Email: Muyowa@gmail.com / wdtucker@gmail.com
Cell: 072 781 1964 / 082 494 8884

Name (Participant): ______________________
Signature (Participant):______________________
Date (Participant): ______________________

Signature (Student):______________________
Date (Student): ______________________

Appendix G

Pilot trial questionnaire and raw feedback

	Very Easy	Easy	Neutral	Difficult	Very Difficult		Total
How easy was it to learn how to use the system	3	1	0	0	0		4
How easy was it to navigate through the system	2	0	2	0	0		4
How easy was it to understand what was said in the video	3	0	1	0	0		4
	-						
	Very Happy	Happy	Neutral	not happy	not happy at all		Total
Would you be happy using SL video of this quality on a mobile phone	4	0	0	0	0		4

	Very Clear	Clear	Neutral	not Clear	Not Clear at all		Total
How clear were the the hand gestures in the video	3	1	0	0	0		4
How clear were the the facial expressions in the video	2	2	0	0	0		4
	-						
	0.0 cents (free)	R5.00	R10.00	about R40.00	about R100.00l		about Total
How much are you willing to pay for data charges to use it	2	2	0	0	0		4
	-						
	Definitely Yes	Yes	Neutral	No	Definitely No		Total
Would you consider using this system in real life	3	1	0	0	0		4
Are you getting used to the system system	2	1	1	0	0		4
Did you think the system takes too long, by asking so many questions	3	1	0	0	0		4
Please specify any problems you experiment and what you did not like about the system?	(1) I want a picture to show me where i am sick (2) The system takes long (3) The navigation buttons to go to the next and previous pages are too far (4) The first video play back is slow, the second is fine						