Guidelines for the Design of a Mobile Phone Application for Deaf People

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Guidelines for the Design of a Mobile Phone Application for Deaf People

By

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Submitted in fulfilment of the requirements for the degree
of Masters in Information Technology in the Faculty of Engineering,
the Built Environment and Information Technology of the
Nelson Mandela Metropolitan University

December 2012

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DECLARATION:

In accordance with Rule G4.6.3, I hereby declare that the above-mentioned treatise/ dissertation/ thesis is my own work and that it has not previously been submitted for assessment to another University or for another qualification.

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DATE: 20 December 2012

ACKNOWLEDGEMENTS

First and foremost, I would like to thank my brother **Alexandros** for all his help and support during this whole process. This achievement would of not have been possible without him.

My family, **Elias**, **Eleni**, **Alexandros**, **Theofilia and Greg**: thank you for your unconditional love, understanding and encouragement.

My supervisor, **Prof. Darelle van Greunen**: thank you for all your help and support and for being by my side whenever your guidance was needed. What I appreciate the most is that you allowed me my space to shine, grow and to prove myself. I am privileged to have shared this journey with you: a journey that started as student and supervisor and which has developed into a friendship.

I wish to express my sincere gratitude to the following:

Research Capacity Development (RCD) at the Nelson Mandela Metropolitan University (NMMU), for their financial assistance; and

My fellow postgraduate students in the lab J113: Thank you for your help and support.

ABSTRACT

Deaf people in South Africa are no longer a minority group and their needs regarding communication and interaction must therefore be taken into consideration. This demographic does not communicate and interact in the same way as hearing people, which means that any existing usability or accessibility guidelines do not apply. As a result, Deaf people do not have access to information in the same way that a hearing person does. Providing proper access to Information and Communications Technology services, which meet their particular needs, will help the hearing impaired to better integrate into society. The importance of demolishing the communication barrier between the hearing and the hearing impaired is very important.

Many people assume that sign language is somehow based on oral language. However, this is not the case. Sign languages are natural visual-spatial languages, and form a contrast with spoken languages which are auditory-vocal based. Acknowledging this fact in 2008, the South African Sign Language Policy Implementation Conference together with several governmental bodies suggested that South African Sign Language should become recognized as the 12th official language of South Africa.

Due to the fact that cell phone technology continues to evolve, it will remain a tool of communication upon which Deaf people heavily rely on. The cell phone fulfils a basic need for everyone, but especially for the Deaf demographic as they rely on the short message system to communicate.

Deaf people are currently faced with a lack of appropriate mobile phone applications, which would allow them to communicate with hearing as well as deaf people. The primary objective of this research was therefore to make mobile technology equally accessible meaning usable to members of the Deaf demographic. The focus of the research was to investigate the communication barrier and a range of variables that can influence the deaf user's experience. Topics such as user interface design, usability and interaction were investigated. The outcome of this research was to propose a set of guidelines that, when applied to the design of a website or to phone application accessibility, would ensure communication and interaction from a deaf user.

The proposed set of guidelines was then applied to the design of the high fidelity prototype of a mobile phone application. The specific application is a messaging phone application that allows deaf users to communicate with other deaf and hearing users via short message system. A mobile phone application that allows Deaf people to send and receive messages based on the sign language alphabet. The application was named Signchat. Purpose of this was to visibly display how the guidelines were implemented in Signchat. While Signchat's main purpose is to accommodate the needs of Deaf people, it is also a learning tool and an application that bridges the gap by allowing deaf and hearing users to communicate.

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ABBREVIATIONS

CRPD	Convention on the rights of persons with disabilities
ICT	Information and communications technology
SASL	South African sign language
SMS	Short message system
UI	User interface
UX	User experience
HREOC	Human rights and equal opportunity commission
HIR	Hypertext information retrieval
WAI	Web accessibility initiative
CEUD	Centre for excellence in universal design
NDA	National disability authority
WCAG	Web content accessibility guidelines
HCI	Human-computer interaction

Layout of Chapter 1

CHAPTER 1: Introduction

1.1Background

In South Africa, one in ten babies is born with some degree of hearing loss (Deaf federation of South Africa, 2009). In sub-Saharan Africa, 25% of children have bilateral hearing loss (i.e. hearing impairment in both ears). It is estimated that 180 000 children are annually born deaf. In South Africa, 6116 infants are annually born with permanent hearing loss, which equates to 17 children born deaf per day (Swanepoel, Storbeck and Friedland, 2009). It is estimated that there are 600 000 deaf people and 1.4 million people with several degrees of hearing loss. In South Africa, 75% of the Deaf demographic is illiterate and 70% is unemployed (Deaf federation of South Africa, 2009).

Providing access for the disabled is becoming a well-recognized subject, either in terms of access to a building or access to information. Several policies regarding ICT and disabilities currently exist. One specific policy, to which all the other policies refer, is of importance namely the UN Convention on the Rights of Persons with Disabilities (CRPD). This policy was espoused by the UN General Assembly on December 13 2006. One of the eight general principles of the policy is that of accessibility. The key statement of the CRPD regarding ICT and people with disabilities is to “enable persons with disabilities to live independently and participate fully in all aspects of life. State Parties shall take appropriate measures to ensure to persons with disabilities access, on equal basis with others, to the physical environment, to transportation, to information and communications technologies and systems, and other facilities and services open or provided to public, both in urban and rural areas” (European Agency for Development in Special Needs Education, 2009).

Many people assume that sign language is somehow based on oral language. However, this is not the case. Sign language is a language with its own syntax and grammar (National Institute on Deafness and Other Communication Disorders, 2011). In 2008, the South African Sign Language Policy Implementation Conference together with several governmental bodies suggested that South African Sign Language (SASL)

should become recognized as the 12th official language of South Africa (Deaf Federation of South Africa, 2009).

From the aforementioned, two major obstacles can be identified. The first relates to the low literacy levels of the hearing impaired, and the second relates to the accessibility issues that the same population group experience regarding the use of ICT services. Both these obstacles highlight the fact that the digital divide still exists and impacts various population groups.

Cell phones became extremely popular devices worldwide. Mobile phone technology is an area of study that is growing rapidly, and that is being applied to a wide range of human activities. It has changed the ways by which we live, socialize and function and have become a dominant technology in the world (Banks and Burge, 2004). Cell phone technology keeps on growing, and it remains a tool of communication upon which the Deaf demographic heavily relies.

The cell phone fulfils a basic need for everyone, but particularly for deaf people demographic as they rely on the SMS (*short message system*) to communicate. The cell phone's usability to the Deaf demographic extends beyond text messaging (also referred to as texting). It provides them with a more compact, convenient and affordable option in relation to alternatives such as the TTY (*TeleTYpewriter*). Cell phone companies have acknowledged this fact and provide data packages (no voice) specifically for Deaf people (About.com, cellphones, 2012).

Texting has lead to an increase in the adoption of cell phones within the Deaf demographic, at the expense of the use of TTYs. The cell phone, and especially SMSes, have become the first communication technology that has broken the shackles of the communication barrier between Deaf people and hearing people (Power and Power, 2004).

Cell phones enable people to communicate, regardless of their location. Since the main phone communication method is through voice, those who are deaf or hard of hearing need to use some alternate form of communication. For Deaf people, access to the

mobile telephone network is currently limited to text messaging, forcing them to communicate in English instead of South African Sign Language (SASL), which is their primary language.

Acknowledging the fact that their needs differ from those of a hearing user, major companies have shown interest in this field of research. Companies such as Nokia, Apple, Samsung and Google Android provide several features on their cell phones that are for deaf people (G3ict the Global Initiative for Inclusive Information and Communication Technologies, 2011). Despite all the interest from these companies, limited guidelines exist for accessibility, and very few for the design of user interface design (UIs) for deaf persons on mobile phones.

The focus of this research was to investigate the communication barrier and a range of variables that can influence the deaf user's user experience. Topics such as user interface design, usability and UX factors are of high importance when designing a successful environment or system for the end user. For an interface design to be considered successful, it must satisfy the following six main qualities: usefulness, efficiency, ease of memorization, reliability and user-friendliness (Use Design, 2009).

The purpose of this research was to propose a set of guidelines. These guidelines can be applied to the design of a mobile phone application, considering specific requirements that make the design accessible and usable for a deaf user. Once the guidelines have been developed, they were applied in context to demonstrate their applicability. In particular, they were applied to develop a prototype design for a mobile phone messaging application. The prototype itself was ultimately tested with deaf users.

1.2 Problem Description

The gap that has been identified in this field of research pertains to the lack of user interface design guidelines when developing mobile phone interfaces for deaf users. Existing guidelines are very limited and need more exploration. Following from this gap is the need to develop mobile applications that allow efficient communication between the hearing and the hearing impaired. Such applications should allow Deaf people to

communicate seamlessly in their primary language (i.e. sign language). The problem statement for this research can therefore be formulated as:

There is a lack of adequate guidelines for the design of suitable mobile user interfaces for deaf users.

1.3 Research Question and Objectives

The research questions and objectives are presented in this section. This includes main and secondary research questions and objectives. The primary research question of the study is the following:

Main Research Question

What are appropriate guidelines for the design of the user interface of a mobile application for deaf users?

Sub-research Questions

1. Which functionalities are currently available on a mobile device for use by deaf users?
2. What are the unique characteristics of deaf users?
3. Which guidelines exist for the design of such applications?
4. What are the typical means of communication and interaction for deaf users?

Research Objectives

1. To define the current functionalities available on a mobile device for use by deaf users.
2. To identify the unique characteristics of deaf users.
3. To determine the existing guidelines for the design of such applications.
4. To determine the most suited means of communication and interaction for deaf users.

1.4 Scope and Limitations

The scope of this research was limited to the geographical area of Port Elizabeth. The research was also limited to the use of the proposed guidelines for the development of a high fidelity prototype, which was evaluated by real users.

1.5 Research Methodology

The research design and methodology of the study follows the research process as outlined in Figure 1.1. (Saunders, Lewis and Thornhill, 2003). Figure 1.1 illustrates the different sections and sub sections of the research process, presented as a so-called *onion model*. The phenomenology approach was adopted as research philosophy. In this approach, phenomena are identified based on how they are perceived by the users. The research strategy that was applied was a case study approach, which requires one to go into depth in one or a few cases.

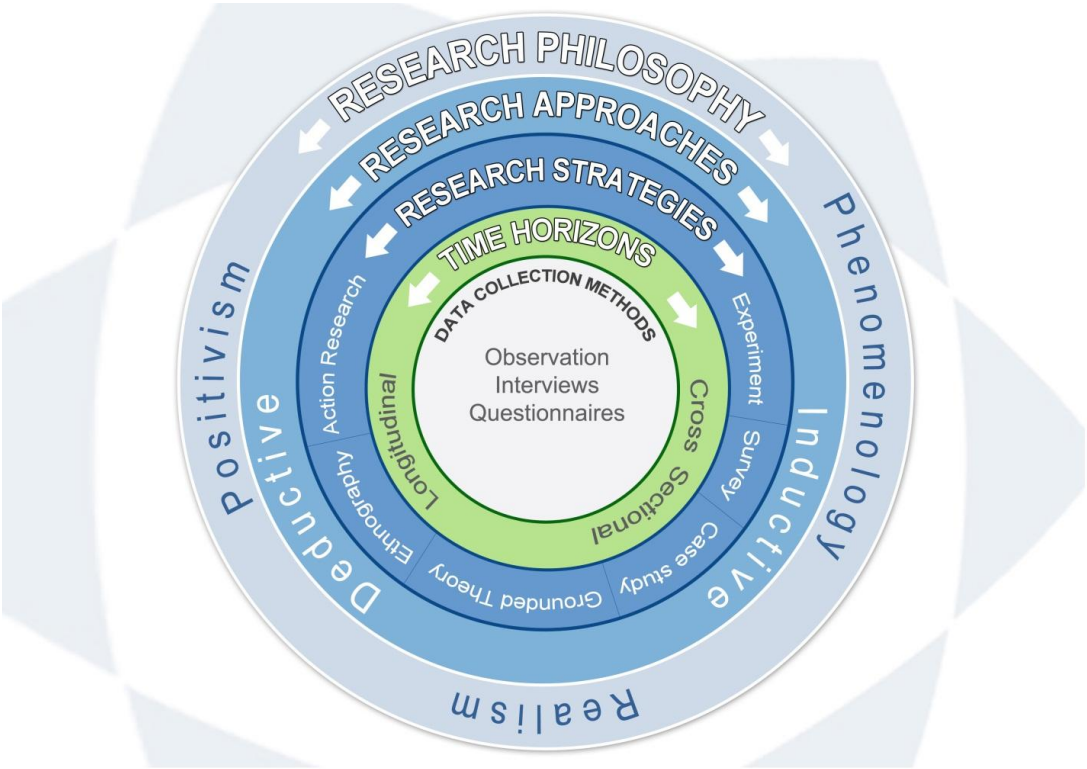


Figure 1.1: The research onion model (Adapted from Saunders *et al*., 2003)

The research approach was inductive, and used qualitative data collection methods. The latter included questionnaires, usability testing and a literature review.

1.6 Ethical Considerations

Ethical considerations are essential in research. They deal with what is morally correct or incorrect when conducting research. Humans differ in terms of cultures and beliefs (Babbie and Mouton, 2001). Therefore, what is acceptable in one culture may not be so in another. The required ethical clearances were obtained by the university in order to conduct this research. The privacy and protection of the participants were also acknowledged.

1.7 Layout of Dissertation

The dissertation is divided into 7 chapters. Chapter 1 introduces the research topic and highlights the problem area. Moreover, it discusses the research questions, the methodology and the scope and limitations of the study.

Chapter 2, 3 and 4 are the literature review chapters, which provide the contextualisation and background information that form the foundations of the research. In chapter 2, an in-depth description is provided on deafness and sign language. Chapter 3 presents a detailed explanation regarding accessible ICT to enhance communication and interaction. Chapter 4 discusses guidelines and UX factors, including topics such as user interface design usability. In addition, chapter 4 introduces the proposed guidelines that were used in the implementation of the high fidelity prototype.

Chapter 5 unfolds the research design and methodology. This is an extensive chapter that covers in detail all the research philosophies, approaches, strategies, choices, time horizons, techniques and procedures that exist based on the onion model (Figure 1.1). It outlines and explains the research process that was chosen for this study, this chapter also presents the proposed guidelines that were used when developing the prototype, as well as the demo that was used for usability testing with the deaf users.

Chapter 6 presents the results, analysis and recommendations based on the data and feedback collected from the participants upon completion of the prototype testing. Data collection methods are explained. Chapter 7 provides a summary of the research. The contribution of the dissertation is highlighted and possibilities for future research in the area are outlined.

Layout of Dissertation

Figure 1.2: Chapter layout of dissertation

Layout of Chapter 2

CHAPTER 2: Deafness and Sign Language

2.1 Introduction

In order to design a user interface or develop a system for a specific target audience, one must first become familiar with the group under investigation. To be able to provide a successful interface or system, one must know the characteristics of the intended end-users. The first topic to be covered in this chapter is that of deafness as a disability, and how the world perceives this disability. Information regarding the different types and levels of hearing loss will be provided. Furthermore, topics such as terminologies, hearing aids, types of hearing aids as well as signs and symptoms of hearing loss will be discussed.

The Deaf demographic in South Africa, organizations on a local and national level that provide for deaf people, schools for deaf people and finally universities that accommodate deaf students will be discussed. International communications methods will also be discussed, as well as attempts to develop an international sign language and SignWriting system: was this attempt successful? This chapter will also provide a description of South Africa's Deaf demographic and its current situation, and will reveal the magnitude of the problem in South Africa.

The aim of the work presented in this chapter was to gather relevant information in order to answer the following research question:

What are the unique characteristics of deaf users?

2.2 Deafness

When referring to deafness two views need to be considered, namely the medical and the cultural. In the medical view, deafness is seen as a medical disability, based on the fact that a deaf person cannot hear. In the cultural view, Deaf people are seen as a demographic amongst hearing people. Since Deaf communities have their own language of communication, of which most are recognized legally by the government and taught at schools, deafness is in the cultural view not seen as a disability or medical condition (Deafness, 2011).

In South Africa alone, one in ten babies is born with some degree of hearing loss (Deaf Federation of South Africa, 2009). There are estimated to be 600 000 Deaf people and 1.4 million people with some grade of hearing loss in South Africa. Of this demographic, 75% is functionally illiterate and 70% is unemployed (Deaf Federation of South Africa, 2009).

In sub-Saharan Africa, 25% of the children have bilateral hearing loss, and it is estimated that 180 000 children are born deaf annually. In South Africa, 6116 infants are born per annum with permanent hearing loss. Of this group, 92% are dependent on the public health sector.

Health Sector	Prevalence	Annual Rate	Daily Rate
Private (15%)[a]	3/1000	496	1.5/day
Public (85%) [a]	6/1000	5620	15.5/day
National (100%) [a]	5.5/1000	6116	17/day

Table 2.1: Estimated extent of congenital and early-onset infant hearing loss in South Africa (Swanepoel, Storbeck and Friedland, 2009).

Table 2.1 shows the birth rate of children with hearing loss in the public and private sector in South Africa. Eighty-five per cent of all Deaf children in South Africa are born in public hospitals, which equates to an annual rate of 5620 children. A total of 15% of the overall number of Deaf children are born in private hospitals, which equates to an annual rate of 496. On a national level, a total of 6116 Deaf children are born across the public and private sectors. This is equal to an estimated 17 children per day (Swanepoel, Storbeck and Friedland, 2009).

There are three types of deafness and they are defined by the area of the ear that is damaged (Fdp, 2009). ***Conductive hearing loss*** occurs when sound cannot be transferred from the ear canal to the middle ear, with results in sound not reaching the inner ear. Conductive hearing loss may be permanent or temporary. ***Sensorieneural hearing loss*** occurs when the minute hair cells in the cochlea in the inner ear have sustained some damage, or have degenerated from normal causes such as old age.

Mixed hearing loss is a combination of both conductive and sensorieneural hearing loss and it affects the outer-, middle- and inner ear.

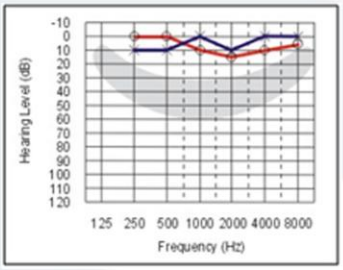
Signs and Symptoms of Hearing Loss (Fda, 2009) include the following:

- People say that you are shouting when you talk to them;
- You need the TV or radio turned up louder than other people;
- You often ask people to repeat themselves because you cannot hear or understand them, especially in groups or when there is background noise;
- You can hear better out of one ear than the other;
- You have to strain to hear;
- You cannot hear a dripping faucet or a high pitched note of a violin; and
- You think people 'mumble' when they speak.

Terminologies regarding deafness ("*Categories*", 2011):

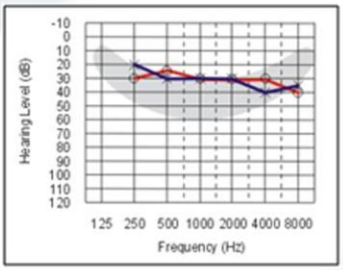
- Unilateral: when a person loses his hearing in one ear only.
- Pre-lingual: when a person was born deaf or when deafness occurred before learning a language.
- Peri-lingual: when deafness occurred while learning a language.
- Post-lingual: when deafness occurred after learning a language.
- Partial: when deafness is limited.
- Progressive: when deafness becomes worse as time goes by.
- Profound: when deafness is complete or at a very high level.
- Tone deaf: when a person is not able to hear differences in relative pitch.

The earlier deafness or some kind of hearing loss occurs in a child's life, the more serious the effects will be. It could severely impact the child's ability to learn, socialize and communicate correctly (American Speech-Language-Hearing Association, 2011). Figure 2.1 outlines the different levels of deafness (Mich, 2008).



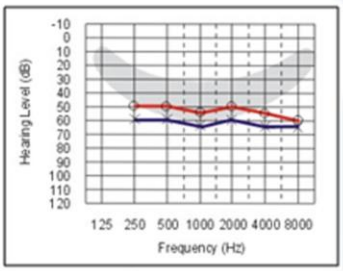
Normal Hearing

Sounds below the lines on the audiogram can be heard. X's shows the left ear, 0's shows the right ear. All the X and 0 are above the 20 line. This means the hearing level is normal.



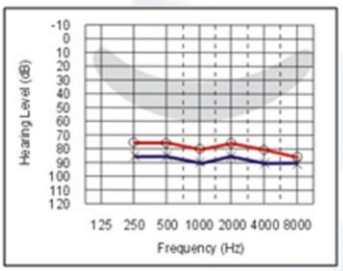
Mild deafness

Sounds heard are between 21 and 40 decibels. Sounds below the lines on the audiogram can be heard. All the X's and 0's are between the 21 and 40 lines.



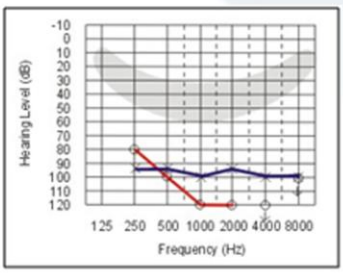
Moderate deafness

Sounds heard are between 41 and 70 decibels. All the X's and 0's are between 41 and 70.



Severe deafness

Sounds heard are between 71and 95 decibels. All the X's and 0's are between 71 and 95.



Profound deafness

Sounds heard are 95 decibels or more. The X's and 0's are mostly below the 95 line.

Figure 2.1: Levels of deafness (Mich, 2008)

2.3 Communication: how do the Deaf communicate?

Sign language is the language of choice for deaf people, and uses manual communication and body language to convey meaning (Kaibel *et al*., 2006). Deaf people communicate by sign language through visual manual communication methods. Such manual communication methods comprise the movement of hands, arms and body in combination with facial expressions (Kaibel *et al*., 2006).

2.3.1 Literacy levels

Early detection of hearing loss, specifically before the age of six months, was found to have a big impact on the development of language modality. Undetected hearing loss has a tremendous effect on the language abilities and skills of the child, delaying language acquisition from two to four years onwards. Failure to detect hearing loss at an early stage will affect the quality of life of a deaf person, by limiting him in the areas of education and employment. This is particularly relevant in developing countries such as South Africa (Storbeck and Calvert-Evers, 2008). Due to poverty, some government policies give priority to the provision of basic services such as food and shelter, and only secondarily provide access to education and technology.

The lack of appropriately qualified instructors is a major contributor to the high levels of unemployment and illiteracy of Deaf people in South Africa. Only 14% of teachers in schools for deaf people can use sign language fluently. This results in the average Deaf high school graduate having the same writing and reading skills as a non-disabled fourth grader (Kaibel, Grote, Knoerzer, Sieprath and Kramer, 2006). The high rates of illiteracy needs to be seen in the context of only 12 schools for deaf people offering grade 12 in only three out of nine provinces (Deaf Federation of South Africa, 2009). In all the provinces in South Africa, there are organizations and schools specifically for deaf people. Table 2.2 indicates all the schools and organizations associated with the Deaf (Gallaudet University, 2011).

South Africa	Organizations	Schools
Eastern Cape	DEAFSA Eastern Cape One Deaf Club Port Elizabeth Deaf Association	Efata School For The Blind And Deaf Greenwood Primary School Reuben Birin School for the Hearing Impaired St. Thomas School for the Deaf Sive Special School For The Deaf
Freestate	Deaf Club Qwa-Qwa Deaf Club Welkom Deaf Club Botshabelo/Thabo Nchu Deaf Club Bethlehem Deaf Club Bloemfontein DEAFSA Freestate Free State Deaf Association	Bartimea School for the Deaf and Blind St. Vincenzo School for the Deaf Thiboloha School for the Deaf and Blind and Learners with Severe Intellectual Barriers to Learning
Northern Gauteng	Tshwane Deaf Association	Carel Du Toit School Dominican School For Deaf Children Filadelfia Secondary School for the Deaf/Physical Disabled/Blind Hedgehog House Sonitus School for Hearing Impaired Learners Transoranje School for the Deaf
Southern Gauteng	Deaf Club DEAFSA: Gauteng Max Ordman Deaf Association (MODA) The Silent Ad Hoc Association The Society for the Hard of Hearing Child	Centre for the Language and Hearing Impaired Children Ekurhuleni School for the Deaf and Blind King David School Unit for Hearing Impaired Children McKharbai School for the Deaf Sizwile School For The Deaf St Vincent School for the Deaf
KwaZulu-Natal	DEAFSA - KwaZulu-Natal KwaZulu Natal Blind and Deaf Society KwaZulu Natal Deaf Association (KZNDA) The Southern Light Association of the Blind	Durban School for the Hearing Impaired Fulton School For The Deaf Indaleni School For The Deaf KwaThintwa School For

South Africa	Organizations	Schools
	and Deaf	The Deaf Kwavulindlebe School for the Deaf St Martin De Porres School VnNaik School for the Deaf and Hard of Hearing Vuleka School For The Deaf
Limpopo	Tshwaranang Deaf Women Club Nebo Deaf Club Namakgale Deaf Club Mphahlele Deaf Club Mokopane Deaf Club Letaba Deaf Club Giyani Deaf Club DEAFSA: Limpopo Province Bushbuckridge Deaf Club Arise and Shine Deaf Women Club Vhembe Deaf Club	Bosele School For The Deaf And Blind Sedibeng School for the Deaf and Learners with Special Needs SetotolwaneElsen Secondary School Tshilidzini School For Specialeducation Yingisani School For The Deaf
Mpumalanga	Bethal Deaf Association DEAFSA: Mpumalanga Embalenhle Deaf Association (EDA) Mbombela Deaf Club Midbank Deaf Association (MDA) Standerton Deaf Association Thembelihle Self-Help Centre	KaMagugu Inclusive School Osizweni Special School Silindokuhle School for Specialised Education
Northern Cape	DEAFSA Northern Cape De Aar - Regional Office DEAFSA Northern Cape Upington - Regional Office Mokopane Deaf Club	Retlameleng School for Disabled Children
North West	DEAFSA North West Mafikeng Deaf Association Mafikeng Deaf Club	Kutlwanong School for the Deaf North West Secondary School for the Deaf
Western Cape	BreederivierDoweVeren-Iging Deaf Demographic Cape Town (DCCT) DEAFSA: Western Cape Deaf Sizenzele Association LewensruimteVirDowes Southern Cape Association for the Deaf (SCAD) Western Province Deaf	Deaf Children Centre Pre-School And Grade Classes De La Bat School For The Deaf Dominican School For Deaf Children Dominican-Grimley School Mary Kihn School for Hearing Impaired and Deaf Learners

South Africa	Organizations	Schools
	Society	Noluthando School For The Deaf Nuwe Hoop Centre For The Hearing Impaired Pioneer School Worcester Deafblind Babies-GR 12

Table 2.2: Organizations and schools in South Africa for the Deaf (Gallaudet University, 2011)

Table 2.3 provides all the organizations that are associated with the Deaf in South Africa on a national level. Universities in South Africa that accommodate the Deaf at some level are listed in Table 2.4.

National Deaf Organizations in South Africa
Deaf Federation of South Africa (DEAFSA)
National Institute for the Deaf
South African National Deaf Association (SANDA)

Table 2.3: National Deaf Organizations in South Africa (Gallaudet University, 2011)

Universities in South Africa that accommodate the Deaf
University of Pretoria: Kommunika
University of the Free State: Unit For Students With Disabilities
The University of the Witwatersrand: The Centre for Deaf Studies
The University of the Witwatersrand: Deaf Education Unit
The University of the Witwatersrand: SA Sign Language Department

Table 2.4: Universities in South Africa that accommodate the Deaf (Gallaudet University, 2011)

2.3.2 Sign Languages and spoken languages

Many people think that sign languages are somehow based on a spoken language, but this is not correct. The difference between a sign language and a spoken languages is that sign language is a visual-spatial language, meaning that it uses imagery to convey meaning (Emmorey, K.,Kosslyn, S.M., and Bellugi, U. 1993). Comparisons between these two types of languages are provided in Table 2.5.

Sign language is a language with its own syntax and grammar (National Institute on Deafness and Other Communication Disorders, 2011). Sign languages are natural

visual-spatial languages, and form a contrast with spoken languages which are auditory-vocal based (Kaibel *et al*., 2006).

On the other hand, a spoken language would be described as an auditory-vocal based language in which individual letters with individual sounds form words. Each word is recorded from its letters while being read into units of sound (Azbel, 2004). Like sign languages, spoken languages have their own grammatical and systematic structure.

Where spoken languages follow a linear path of communication, meaning one word at a time, this is not the case in sign language. Due to the fact that communication with sign language is achieved with the movement of hands, body language and facial expressions, it does not follow a linear path.

Spoken Language	Sign Language
Auditory-vocal based language	Visual-spatial language
Own grammatical systematic structure	Own grammatical systematic structure
Follows linear path	Does not follow linear path

Table 2.5: Comparison between spoken language and sign language (compiled by researcher)

Some relationship can be found between oral language and finger-spelling, as the latter is used for representing letters of a written or numerical system. Finger-spelling is used in the Deaf demographic for educational purposes (Signing Savvy, 2011). Figure 2.2 illustrates the South African one-hand finger-spelling alphabet.

Figure 2.2: The South African one-hand alphabet (Wikipedia, 2012)

The decision to develop an international sign language is understandable, since there are many existing sign languages. Attempts have been made to create an international sign language that could be used by all deaf signers around the world. It was first discussed in 1951 at the world congress of the World Federation of Deaf, and then again in 1973 when the *Gestuno* sign language was created.

Gestuno is Italian and if translated to English it means *the unity of sign language*. It is considered be a constructed sign language, since it is made out of a combination of signs from different sign languages. A book was published on the Gestuno sign language, which comprises 1500 signs. It is not considered to be a real language since it does not have proper grammar, as in the case of other sign languages (Deaf Linx, n.d).

2.3.3 Sign Language in South Africa

Sign languages differ from country to country and in some countries there might even be more than one sign language. In Africa there are at least 25 different sign languages in which some have no relevance at all with African spoken languages (Kamei, 2004) The African sign languages include the following:.

Sign Languages in Africa	
▪ Adamorobe Sign Language	• Malagasy Sign Language
• Algerian Sign Language	• Malian Sign Language
• Bamako Sign Language	• Moroccan Sign Language
• Bura Sign Language	• Mozambican Sign Language
• Chadian Sign Language	• Mbour Sign Language
• Congolesian Sign Language	• Namibian Sign Language
• Egypt Sign Language	• Nigerian Sign Language
• Ethiopian Sign Language	• Sierra Leone Sign Language
• Franco-American Sign Language	• Somali Sign Language
• Gambian Sign Language	• Tanzanian Sign Language
• Ghana Sign Language	• Tunisian Sign Language
• Guinean Sign Language	• Uganda Sign Language
• Hausa Sign Language	• Zambian Sign Language
• Kenyan Sign Language	• Zimbabwe Sign Language
• Libyan Sign Language	▪ South African Sign Language

Table 2.6: Sign languages in Africa (Kamei, 2004)

SASL is a language with its own grammatical systematic structure and meets every reasonable criterion that we might apply to describe a language (Reagan, 2008). From an educational perspective, the South African Schools Act, under the section pertaining to Language Policy in Government Schools, refers to SASL: it states in the “Bill of rights” that everyone has the right to be educated in their official language.

Sign language can be used effectively as a teaching method for deaf people, either for teaching academic content or for teaching literacy skills in the spoken language (Reagan, 2008). The fact that the average deaf high school graduate has the same writing and reading skills as a fourth grader shows us how hard it is for a deaf person to understand a spoken language (Kaibel, 2006).

Although the Constitution of the Republic of South Africa does not directly identify the South African sign language (SASL) as one of the 11 official languages (see Table 2.7), it is nevertheless mentioned in the Constitution of the Republic of South Africa. Attempts are being made to make SASL the 12th official language of South Africa (Reagan, 2008).

Official languages of South Africa	
• Afrikaans	• Setswana
• English	• SiSwati
• isiNdebele	• Tshivenda
• Sepedi	• Xitsonga
• Sesotho	• isiXhosa
• isiZulu	

Table 2.7: Official languages of South Africa (Reagan, 2008)

The SASL Policy Implementation Conference, together with several governmental bodies, suggested that SASL should become the 12th official language of South Africa since it meets all the criteria of a language (Deaf Federation of South Africa, 2009).

2.3.4 Sign writing

Since sign language is a recognized type of language, a written form thereof was developed and named Signwriting. SignWriting is a translation on paper of the hand shapes, facial expressions and body gestures of any Sign Language. Also known as Sutton SignWriting, it was created in 1974 by Valerie Sutton. It was based on Sutton's DanceWriting, which was developed in 1972 as a system for representing dance movements (Dilloway, 2011). Sign Writing may also be described as a featural system since it represents distinctive features (see Figure 2.3). Hand shapes are constructed by combining iconic representations of signs. There are core symbols for basic hand shapes that can be modified in many ways.

Orientations of the hand shapes are based on shading, with white indicating the palm of the hand and black indicating the back of the hand. Orientation is further expressed by the use of a broken line across the hand shape, which tells us the sign should be read horizontally, while the lack of this line means it should be read vertically. Sign Writing was initially written from the receptive point of view, meaning from the perspective of someone facing a signer. This gradually changed into the perspective viewpoint, i.e. from the perspective of the person producing the signs (Dilloway, 2011).

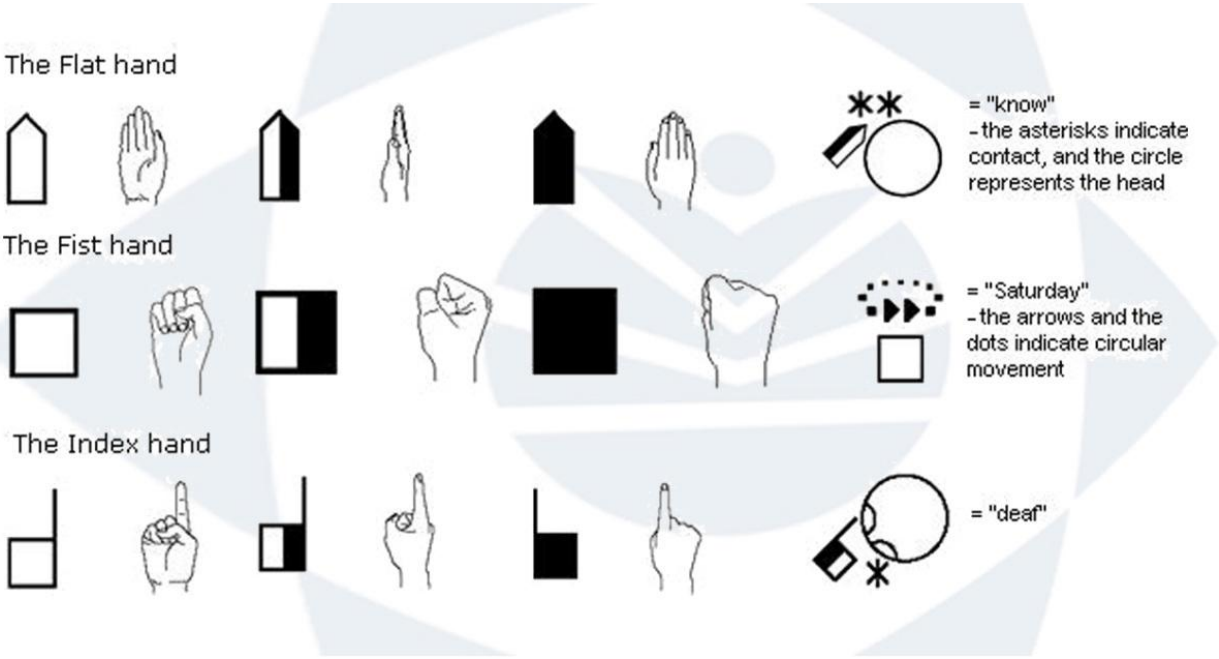


Figure 2.3: Sample of SignWriting (Omniglot, 2011)

Figure 2.4 below depicts a translation from English to SignWriting. The material that is being translated to SignWriting is a segment from the fairy tale Goldilocks.

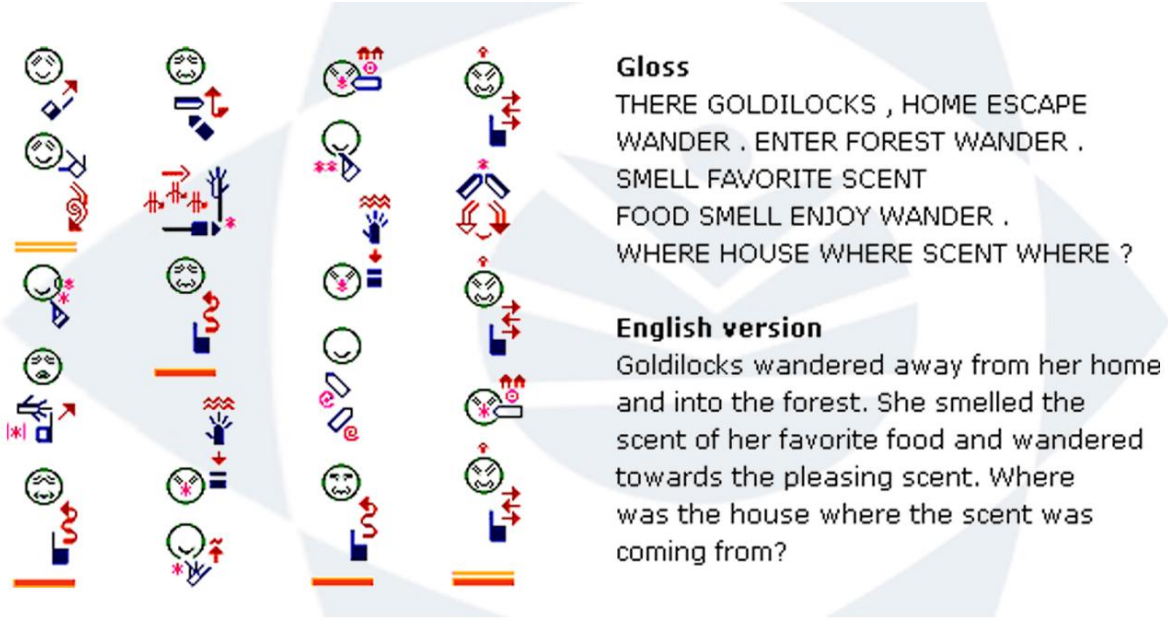


Figure 2.4: Sample text in ASL SignWriting (from Goldilocks and the Three Bears) (Omniglot, 2011)

Figure 2.5 lists the countries that have introduced Signwriting to some level in schools for deaf people. South Africa is one of those countries.

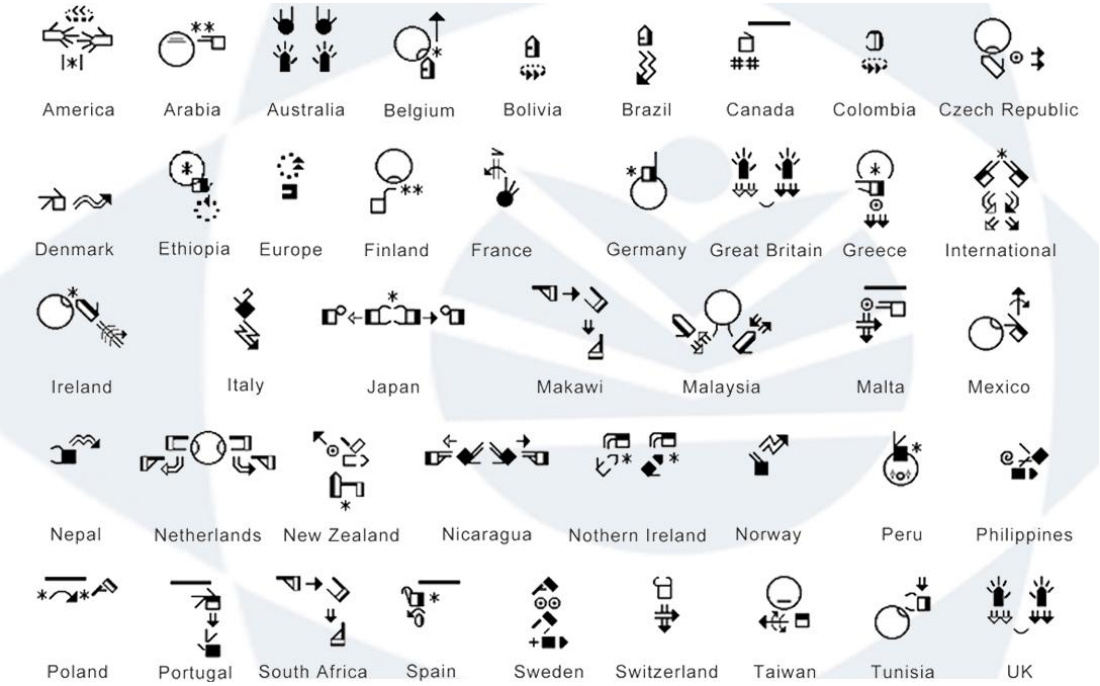


Figure 2.5: Countries that use SignWriting (SignWriting.Site, n,d).

2.4 Summary

This chapter discussed the Deaf demographic of South Africa, highlighting the problems with which they are currently faced. Problems that are found within the Deaf demographic and Deaf schools result in Deaf people not having equal job and educational opportunities. Late hearing detection has a significant impact on the quality of life, education and employment, particularly in developing countries like South Africa.

A comparison between sign language and oral language was provided, revealing the absence of any connection between the two. This was mentioned due to the general misconception that sign language is based on oral language. This chapter also discussed the unique characteristics of deaf users and the importance of the use of sign language as the primary language of communication. As it was found to be the most appropriate and understandable means of information transfer for deaf people.

One can clearly understand that the Deaf demographic is no longer a minority within society, but rather a part of it. With the birth rate of deaf people reaching 17 per day, one can no longer avoid or neglect their needs. They form a large part of the society and as such deserve equal job and educational opportunities.

Layout of Chapter 3

CHAPTER 3: Accessible ICT to Enhance Communication and Interaction

3.1 Introduction

The main focus of chapter two was deafness and sign language. Topics included the perception of deafness as a disability, as well as a comparison between sign languages and spoken languages. The importance of accessibility to digital information is well recognized, and chapter three will therefore be investigating how Deaf people can access information through the use of technology. By providing a proper means of output or input of information, even hearing impaired people can make use of technology to overcome their disabilities. Technologies or devices that support communication and interaction include Hearing Aids, Text Phone Devises, Multimedia Tools and Transcripts. Chapter three investigates interaction devices and existing technologies, as well as methods and policies regarding communication and interaction for deaf people. The aim of this chapter is to present relevant information in order to answer the following research questions:

What are the typical means of communication and interaction for deaf users?

Which functionalities are currently available on a mobile device for use by deaf users?

3.2 Challenges in Communication and Interaction

The removal of the communication barrier between hearing and hearing impaired people is very important, since this will help the hearing impaired to better integrate into society. A means of achieving this integration is the provision of proper access to ICT services that meet their particular needs, and that are designed for their specific abilities and disabilities. Due to two major obstacles, namely literacy levels and access to technology, the digital divide still exists strongly in this digital and modern world. Attempts are being made to reduce the effect of the digital divide and to further the integration of the hearing impaired into society. The aim is to provide access to information and to enable the sharing of information.

3.2.1 Access to technology

With a population of approximately 44.8 million people, of which 55% live in the urban areas, South Africa has a combination of developed and developing world conditions. While cutting edge technology is available to a part of the population, this is not the case for everyone. Most of the population is still affected by the digital divide (Glaser and Tucker, 2004).

While ADSL is available in several urban centers for domestic use, almost half of urban households do not have a telephone line. In South Africa, 10% of the households have no telephone access at all. A study conducted in 2002 revealed that there are 18.6 million telephone and cell phone users, i.e. 41 per 100 of the population. Fourteen million of these people are cell phone users (Glaser and Tucker, 2004).

A 2008 study showed that access to telecommunications and bridging of the digital divide still remains a problem in South Africa. An estimated 4,590,000 South African citizens use the Internet, while 378,000 people use broadband Internet. At a growth rate of 70%, mobile phones are proving to be an essential tool in South Africa, especially in rural areas. In these areas the provision of essential resources such as food and water has priority, and the provision of information and communication technologies (ICTs) is lower on the development agenda (Global Information Society Watch, 2009).

3.3 Technologies and Methods to Support Communication and Interaction

To achieve communication between the hearing and the hearing impaired, interpreters were traditionally needed. This is a method that is very costly and impractical, as interpreters need to be notified in advance. Furthermore, there is a shortage of available interpreters to accommodate the needs of the Deaf demographic (Deaf Federation of South Africa, 2009). This is a universal problem and not specific to South Africa alone.

Each type of disability, leads to special needs, for example a ramp for a person in a wheelchair or assistive devices such as hearing aids for Deaf people. In the following section topics such as hearing devices, speech to text technology, the different types of captioning, transcripts and graphic hypertext are discussed. The purpose of these

methods and devices is to offer access to information for the disabled, and to help them to integrate into society.

3.3.1 Hearing aids

Hearing aids are devices that are designed to amplify sound, and that are used to help people who have hearing problems. Most hearing aids have similar electronic features such as a microphone that picks up the sound, an amplifier that increases the volume, a mini loudspeaker that receives the sound and delivers the amplified sound to the ear canal (Fda, 2009). Figure 3.1 illustrates the different styles of hearing aids that currently exist.

Figure 3.1: Styles of hearing Aids (Fda, 2009)

Differences between hearing aids are usually found in the design of the hearing aid, in the technology used to achieve the amplification (i.e. analogue vs. digital) and in the special features that some hearing aids might provide such as a directional microphone, a T-coil (Telephone switch), direct audio input and feedback suppression (Fda, 2009). There are four types of hearing aids, namely Behind-the-ear (BTE) aids, "Mini" BTE (or

"on-the-ear") aids, In-the-ear (ITE) aids, In-the-canal (ITC) aids and Completely-in-the-canal (CIC) aids.

3.3.2 Speech to text (STT)

Speech to text technology can be useful for deaf people, and especially for those whose first language is English and who have become deafened post-lingual. Speech to text technology translates spoken words to text, with one of the forms being a device with a keyboard. The device records words as a series of phonetic syllables. A Palantype operator records speech, after which the device changes these coded word sounds back into English which then appears on the screen. Requirements of a speech to text device are the following (Brooks, 2000):

- A clearly readable and as accurate as possible transcript;
- High contrast display of text, large size of text and simple font;
- The text display area should be able to display a fair amount of text, i.e. at least fifteen seconds of speech which is equivalent to fifty words;
- As little as possible delay in the process of translation from speech to text; and
- The device should be portable and not too large in size, so that it can be used directly without attracting attention.

3.3.3 Captioning

Captioning of television, movies and cable TV in this digital age is considered to be the deaf person’s right, which came into being after the Broadcasting Services Act was published on the 1st of January, 2000. Interest in this field is now developing and people are increasingly starting to consider and adopt this practice. For example, YouTube added captions to their videos that allow deaf users to keep up (You tube, 2011). Earlier studies revealed that by reducing the language level in captions, the level of understanding of a television program increased. This experiment was conducted on children at a British school. The study objective was to assesss the usefulness of captions for educational purposes on the television (Gulliver and Ghinea, 2003).

The Human Rights and Equal Opportunity Commission (HREOC) are also trying to implement this Act for cinema captioning and for Pay TV captioning (Adelaide, 2002). In many countries, captions and subtitles are considered to be the same (Jelinek Lewis, and Jackson, 2001). However, this is not the case. Captions provide the user with a visual representation of the dialogue, narration and audio effects. Subtitles on the other hand only display the dialogue, leaving out the sound description and effects.

There are two types of caption categories, namely open- and closed- captions. YouTube for example uses closed captions on their videos (You tube, 2011). Closed captions are referred to by the abbreviation cc. Closed captions are an additional feature that is not visible on the screen until the user activates it. In contrast, open captions are visible to the users. It is a built-in feature that is integrated into the video. The user does not have the option of disabling it (Jelinek Lewis and Jackson, 2001).

3.3.4 Transcripts

Transcripts are text translations of multimedia content. Transcripts provide translations of the spoken dialogue from soundtracks to sound effects and video content. It provides the user with a complete text translation of sound, speech, video and visual activity on the screen (Humanising Technology blog, n,d).

3.3.5 Graphic hypertext (icons)

Deaf people are visual learners, as they learn by seeing. Their eyes are their basic sources of information and understanding. Another fact that needs to be considered is the level of graphics, since the visual input needs to be as effective as the auditory. The text input websites that are considered for deaf people should be graphic based rather than text based.

A matter of equal importance when designing for the hearing impaired is Hypertext, also known as Hyperlink or Link. This is a word in a website that functions like a button. When selected, it reveals more text related to the link in question. For Hypertext Information Retrieval (HIR), text and icons will be used for navigation purposes. Textual information combined with pictures will be used for Hypertext Information Retrieval

(links), since it produces better information recall after thirty seconds from time of exposure (Scheidel, 2009). This implies that the selection of graphics is of high importance and must be chosen carefully and as accurately as possible, to avoid any frustration. For example, the home link should be represented by an icon such as a house.

An experiment was conducted in which twenty-seven pre-lingual (deaf by birth) deaf people, composed of 12 females and 15 males who use Spanish Sign Language as their primary language, participated. Most of them had completed Spanish primary school and had 3 years of computer experience. The following conclusions were drawn (Fajardo, Cañas, Salmerón, and Abascal, 2009):

- If interaction with a website or hypertext from deaf users is intended to be frequent, the design of wide structures is recommended for visual search; and
- If interaction with website or hyperlinks is not intended to be frequent, deep structures are recommended, with the intention to avoid information overload.

Previous research has shown that, when designing for the hearing impaired, making the hypertext or links in a graphical manner is more effective. This research pertaining to the effectiveness of hypertext in a graphical and textual manner was conducted with sixty deaf users. Results revealed that deaf students were faster, and were able to visit more websites during their Web search, when using graphical instead of verbal hypertext (Fajardo, Arfe, Benedetti and Altoe, 2008).

3.3.6 Multimedia

As stated by Nelson in 2000 and supported by Alistair G. Sutcliffe and Sri Kurniawan Jae-Eun Shin in 2005, multimedia provides the designer with more options but also requires more design discipline. This implies that overuse or overload of multimedia may have the opposite effect, making it harder for the user to understand the information provided and as such provoking confusion rather than clarity. For example, unnecessary use of sound, animation or video clips may distract the user (Sutcliffe, Kurniawan and Shin, 2005). Frameworks regarding design guidelines for multimedia currently exist. The modality theory categorizes multimedia as dimensions of visual,

audio, and haptic modalities, and further describes the media properties in terms of dimensions such as dynamic or static, and analogue, discrete or linguistics representations.

Another proposed framework categorizes multimedia in terms of text, sound, graphics and motion. The ISO 14915 defines a medium in terms of the various ways in which information is presented to the user, such as text, audio, video, graphics, animation. It describes multimedia as the combination of dynamic and/or static media presented in an application. According to the ISO definition, the following three issues are very important and specifically concern multimedia (Sutcliffe, Kurniawan and Shin, 2005):

Matching the media to the message*,* so that the media actually helps to convey the information clearly and does not confuse the user;

Managing the user attention by making key items in the information clear, allowing the user to follow the message thread across the different media; and

Navigation and interaction by making interaction with the different types of media easy, and by navigating through the information in a pleasant style.

When designing for deaf people, multimedia tools are very important, especially video. Figure 3.2 illustrates the several multimedia tools that can be used in achieving accessibility for deaf people.

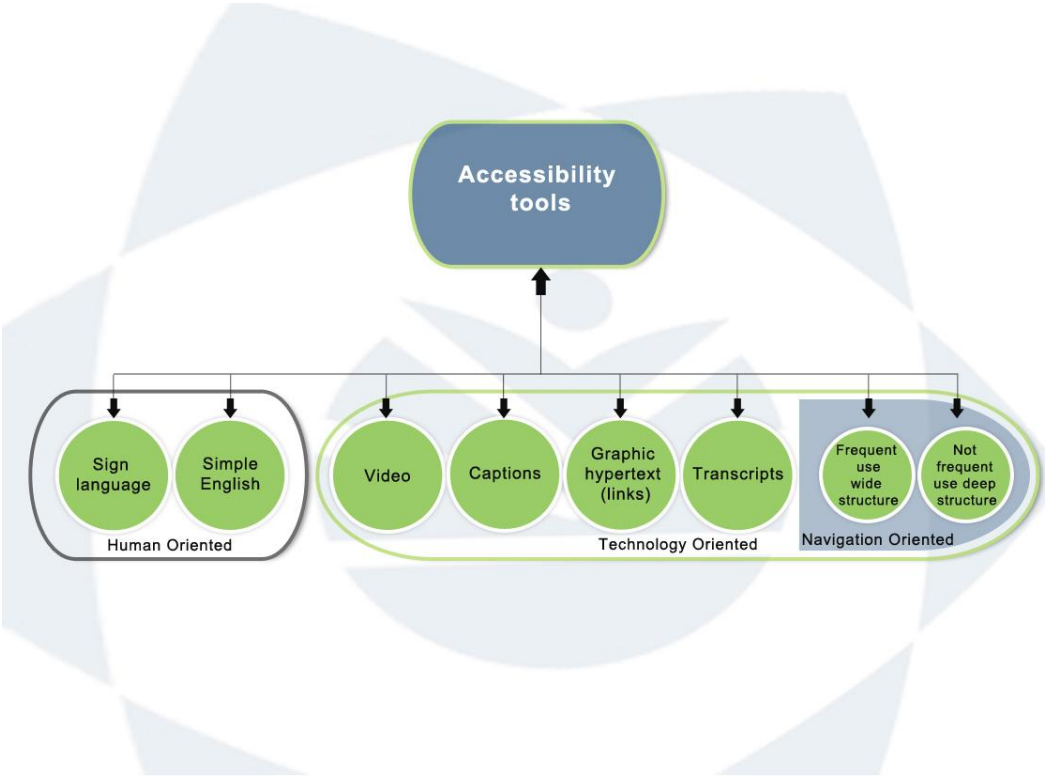


Figure 3.2: Accessibility tools regarding the Deaf (compiled by researcher)

A combination of multimedia tools can broaden the effect, usefulness and understanding of an e-learning website and can contribute to alleviate accessibility issues for deaf people. One example of such a combination may be when one video is playing while another video is at the same time providing the translation in sign language. Multimedia tools are very important when designing websites for deaf people. Videos with sign language must be provided in addition to captions and hypertexts (Mich, 2008).

3.4 Interaction Devices

The provision of access for the disabled is becoming increasingly important, regardless of whether it refers to access to a building or access to information. By providing proper output or input of information, the hearing impaired can make use of the technologies that society has to offer today. Devices that accommodate the needs of Deaf people and allow them to communicate with others are discussed below.

3.4.1 Cell phones

Section 255 of the Telecommunications Act determines that all hardware and software products should be accessible to people with disabilities. This Act applies to any software or hardware that transfers information over the Internet, a network, or phone lines (Lee, 2001). Examples of manufacturers and operating system developers that provide services to the disabled are listed below (G3ict the Global Initiative for Inclusive Information and Communication Technologies, 2011):

- Nokia;
- Apple;
- Samsung; and
- Google android.

Regarding cell phones, some critical accessibility features that must be taken into consideration when products are intended for deaf people and hard of hearing include:

- Visual or vibrating alerts;
- Adjustable volume control;
- Call logs;
- Visual or tactile indicators for the keyboard;
- Messaging options;
- Text Teletypewriter (TTY);
- Multimedia messaging service;
- Mono audio;
- Video conferencing; and
- Captioning.

Visual or vibrating alerts: instead of producing a sound when an email or message is received, the sound can be replaced with a vibration or a visual alert.

Adjustable volume control: this feature is useful for the hard-of-hearing users as well as for improving the functionality of hearing aids.

Call logs: allow the deaf users to view any missed calls in cases where the visual or vibrating alerts were not noticed.

Visual or tactile indicators for the keyboard: by highlighting or vibrating when buttons are pressed, hearing impaired users are receiving confirmation of their interactions with the device.

Messaging options: the messaging feature is the most important one on a mobile phone, since it allows deaf users to communicate with others in the form of SMS (short messaging service), email or MMS (multimedia messaging service), thereby offering an alternative to verbal communication.

Text Teletypewriter (TTY): this device allows deaf users to transmit and receive typed text over a telephone line (see Figure 3.4: Teldem device).

Multimedia messaging service: this feature allows users to send or receive images or videos on their mobile phone. Since deaf users rely on imagery and sign language, and since most of them have low literacy skills, this feature is important.

Mono audio: by producing sound in both the left and right channel, people with difficulties listening from one ear can benefit.

Video conferencing: a feature that has helped the Deaf demographic and altered the means by which they communicate. This specific feature is available on smart phones and allows users to communicate through video (video calling). Deaf users are enabled to communicate through sign language rather than by means of text.

Captioning: the iPhone is an example of a device that allows playback of videos and movies with captions (including closed or open captions, as well as subtitles).

Nokia recently launched the Nokia accessibility initiative which deals with the development of internal design standards, while at the same time initiating research and staff training for servicing people with disabilities. In the Nokia series 60 and 80 phones one can find the text to speech software which operates on a Symbian operating system

(G3ict the Global Initiative for Inclusive Information and Communication Technologies, 2011).

A hearing aid compatible cell phone feature is of high importance, since hearing aid interference is possible when a cell phone is in close proximity of a hearing aid. The interference manifests as a buzzing sound, which makes hearing the other person in most of the cases impossible. The compatibility between cell phones and hearing aids are expressed in terms of the “M” and/or “T” rating of either device.

A higher rating implies a reduced chance of interference. For better results, the rating of a cell phone should be at least M3/T3 or M4/T4. A small selection of cell phones which meet the hearing aid compatibility standards are listed below (Hotapps, 2012):

- LG enV2 VX9100;
- HTC Touch Diamond;
- Motorola ZN4 Krave;
- Samsung Eternity a867;
- Samsung Rugby a837;
- Samsung Propel a767;
- LG Chocolate 3; and
- Samsung Propel a767.

Most of the features that are considered to be applicable for deaf people and hard of hearing are also features that hearing persons have been using for quite a long time, for example vibration video calls and sound amplification. These features might therefore not actually be considered as a special feature for deaf people. On the other hand, one cell phone that can be considered as a cell phone specifically designed for the hard of hearing is the Bellen A100, shown in figure 3.3.

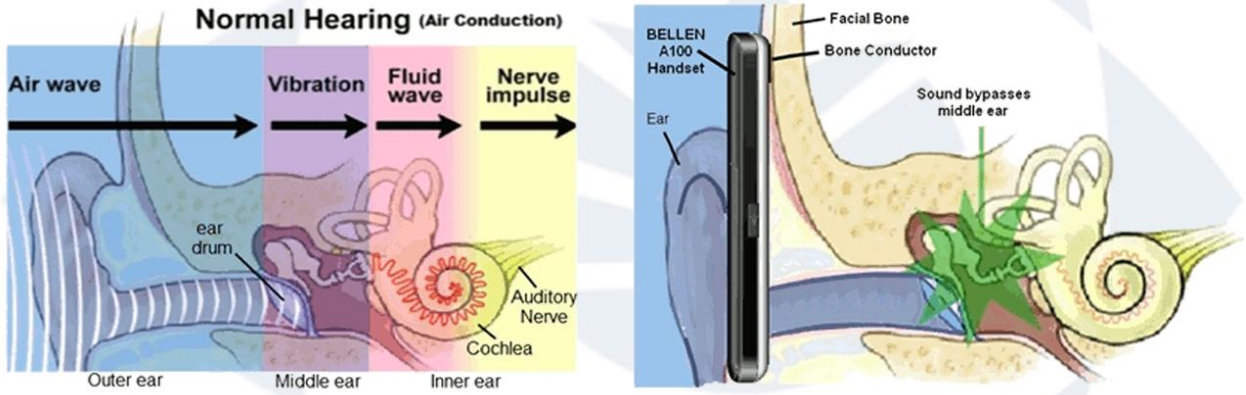


Figure 3.3: Bellen A100 bone conductor technology (Vodacom, 2012)

The Bellen A100 allows users to make and receive phone calls via bone conductor technology. When the cell phone is placed on facial bones near to the ear, sound waves are sent through the facial bones to the inner ear, bypassing the outer and middle ear. This is in contrast to the normal process of receiving sound via air, which passes through the outer and middle ear, to the inner ear (Vodacom, 2012).

3.4.2 Text phone devices

Text phones devices are telecommunication electronic devices (TDD) that allow Deaf people to communicate in text over a phone line. The average size of a TDD is normally the same size as a small laptop. It has a QWERTY keyboard and small screen that uses LEDs or an LCD screen to display typed text electronically (Disabled world towards tomorrow, 2009).

Figure 3.4: Teldem device (Science in Africa. 2002)

Telkom in South Africa built a similar device for their deaf customers, namely the Teldem device shown in figure 3.4. For the specific reason that both users have to have the device to communicate, the user demographic is small (Science in Africa, 2002).

3.4.3 Personal computers (PCs)

Apple has released some tools with every MacBook and iMac that help Deaf people to communicate and interact with others. Such tools include the captions, Internet based sign-language, the iSight camera and the iChat software (Apple in education, 2012).

With the built-in iSight camera, deaf users are able to use the iChat software to communicate in real-time with other users, either through text messages or video conferencing. Because of the fast frame rates and high quality video capabilities, it allows users to communicate clearly by using sign language. It also enables users to participate in group chats. The built-in iSight camera allows the user to record and share photo and video messages in sign language, using the Photo Booth application (Apple in education, 2012).

GarageBand is an award-winning application that comes with every Mac, and that has been used by schools to help deaf and hard of hearing students to improve their auditory comprehension skills (Apple in education, 2012).

3.5 Text to sign translation method

Sign language has its own structure and grammar, and is starting to be acknowledged as a true language. Attempts are also being made to declare it as the 12th official language of South Africa (see section 2.3). Sign language may be referred to as a text to sign translation system, or a text to sign language synthesis tool. Various names are used for these translation methods, but the core substance is still the same, namely to translate input text information to an output of sign language.

3.6 ICT Policies and Disabilities

In the following sections, topics such as ICT for people with disabilities as well as access to information, knowledge, learning, teaching and finally personal communication and interaction will be discussed (European Agency for Development in Special Needs Education, 2009).

3.6.1 South African ICT policies and people with disabilities

Accessibility for people with disabilities is not the primary focus of all policies, since the priority for developing countries is to establish a base for ICT and to reduce poverty. This is clearly the case in the ACCRA Commitment (2005), where the main focus of the specific policy is to build an ICT infrastructure to (European Agency for Development in Special Needs Education, 2009):

- Advance the geographical and political unity of the African continent and strengthen, expand and facilitate growth of the African economy for the improvement of the lives of the people in Africa.

3.6.2 ICT to support access to information and knowledge

As acknowledged by the UN General Assembly in 1948, access to information is a basic human right. Stated in article 3 and 4 in the Convention on the Rights of People

with Disabilities (CPRD), it is an obligation to provide information in an accessible manner to persons with disabilities. Article 9 subsequently states the need for design, development, production and distribution of information and communication systems that are accessible to people with disabilities. The CPRD also states that it is of equal importance that people with disabilities have access to information but also have the ability to share information (European Agency for Development in Special Needs Education, 2009).

- State officials must take the necessary measures to make sure that persons with disabilities can exercise their right of freedom of expression and opinion.

Despite the above policies, the truth is that achievement of these goals are lagging. The speed by which technology changes in the modern society seems to be the biggest barrier.

3.6.3 ICT to support learning and teaching

With respect to education, the Convention on the Rights of People with Disabilities states that (European Agency for Development in Special Needs Education, 2009):

- People with disabilities must not be excluded from the education system;
- Accommodation must be made for requirements of the disabled;
- Facilitation support must be provided to ensure effective education; and
- An alternative mode or format of communication for knowledge or information transfer must be provided.

It is important that learners with disabilities have equal opportunities and have access to information and education. A policy that focuses on this specific area is the Digital Agenda for Europe policy (2010), which states that:

- In order to ensure inclusion in this modern digital society the Internet must be accessible to all. This should also be true for equipment, digital content and tools in education and learning.

3.6.4 ICT to support personal communication and interactions

A reference towards personal communication and interaction can be found in the CRPD (2006), stating that alternative modes of communication must be provided. ICT as a tool is very important and may help to overcome geographical and social isolation barriers. The Declaration of Principles for Building an Information Society (2003) stated the following (European Agency for Development in Special Needs Education, 2009):

- Communication is an important social procedure, and the groundwork of all social organizations.

The Declaration of Principles for Building Information Society (2003) states that accessible ICTs are only tools; it is the state's responsibility to provide the correct conditions.

3.7 Summary

Several methods of communication, interaction and interaction devices were explored and discussed in chapter three. The purpose of these discussions was to determine the most suitable method of information transfer for deaf users, and to highlight the functionalities that exist on a mobile device for use by deaf users. The technology limitations, accessibility problems and literacy problems with which Deaf people are faced, were also considered.

This chapter furthermore investigated several ICT policies regarding disabilities, which deal directly with access to information and knowledge, learning and teaching and finally communication and interaction. The above information was provided in order to reveal the importance of the user requirements of the Deaf. It is concluded that, for an application or website to actually be accessible or usable for deaf users, it is important that a developer or a designer follows some guidelines and selects the correct method of information transfer.

Layout of Chapter 4

CHAPTER 4: Guidelines and UX Factors

4.1 Introduction

Chapter 3 focused on topics such as communication, interaction, and several ICT policies relevant to the hearing impaired.. Chapter 4 investigates several guidelines such as the W3C'sWeb Accessibility Initiative "(WAI) Web Content Accessibility Guidelines 1.0 and 2.0" and Telecoms Accessibility guidelines. Topics such as user interface design guidelines, usability guidelines by Jakob Nielsen and UX factors will be also be discussed.

The purpose of investigating the above policies is to understand their applicability, and to derive a set of proposed guidelines. The proposed guidelines will be presented in this chapter, after which they will be applied to the design of the high fidelity prototype that follows in chapter 5. If the application of guidelines are successful, accessibility, communication and interaction from a deaf user is ensured. The aim of this chapter was to gather relevant information in order to answer the following research question:

Which guidelines exist for the design of such applications?

4.2 User Interface Design

User interface design aims to enhance the visual, usability and technological qualities of an interface. It adds to the satisfaction of the person using a product or a service. For an interface design to be considered successful, it must satisfy the six main qualities that are presented in Figure 4.1 (Use Design, 2009).

These interface design qualities are intended for applications that are used by non-disabled users. This presented an opportunity to consider and test their applicability to hearing impaired users.

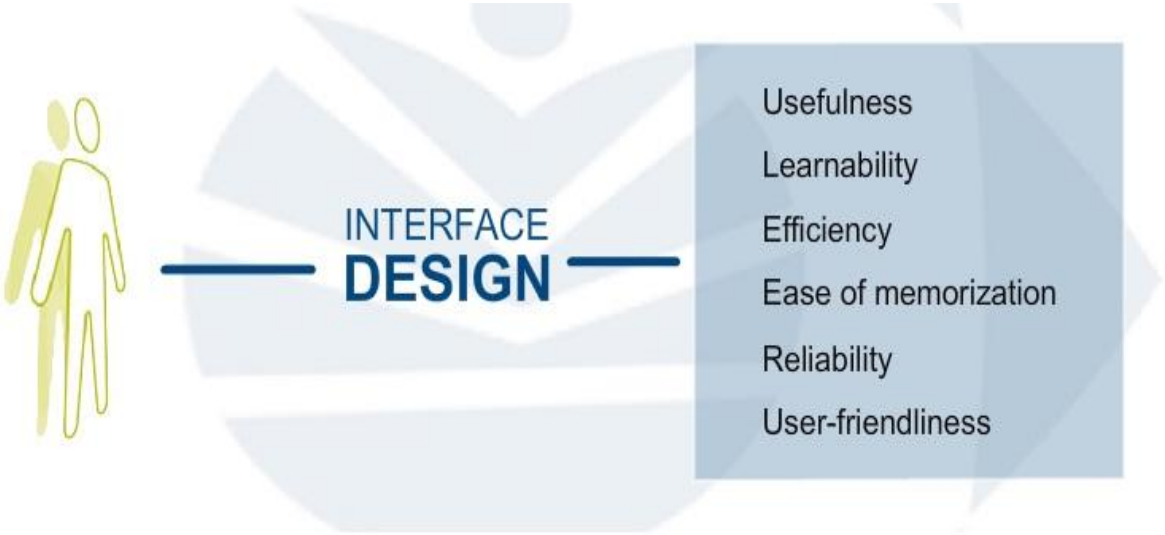


Figure 4.1: Six main qualities of an interface design (Use Design, 2009)

Usefulness: are the end users pleased by the functionality of the interface?

Learnability: *was* it easy for the user to complete basic tasks when using the system for the first time?

Efficiency: how long does it take the user to accomplish given tasks, after becoming familiar with the design of the interface?

Ease of memorization: how easy does the user find the use of various functions, after returning to the interface following a certain period of absence?

Reliability: is the interface designed in such a way that the user makes as few mistakes as possible?

User-friendliness: does the user enjoy using the interface? (Use Design, 2009).

4.3 Usability

There seems to be a misconception with respect to usability and functionality. Functionality is only concerned with the functions and features of the product, and is not concerned with the ability of users to use the functions (Usability Net, 2006). The International standard ISO 9241 series specifies that usability is the extent to which a

product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use. The following three qualities are essential when measuring the usability of a software program or website (Usability Net, 2006):

Effectiveness: can the users fulfill the tasks and achieve their goals with the product?
Efficiency: how much time and effort is required from users to complete the tasks?
Satisfaction: what do the users think about the product and its ease of use?

The above qualities can be affected or compromised by a number of factors, including:

The users: who are using the product, are they experienced users, or beginners?

Their goals: what are the users trying to accomplish with the product, does it support what they want to do with the product?

Content of use: where and how is the product being used?

The usability framework illustrated in Figure 4.2 shows the relationships between the above aspects, as defined by ISO 9241-11.

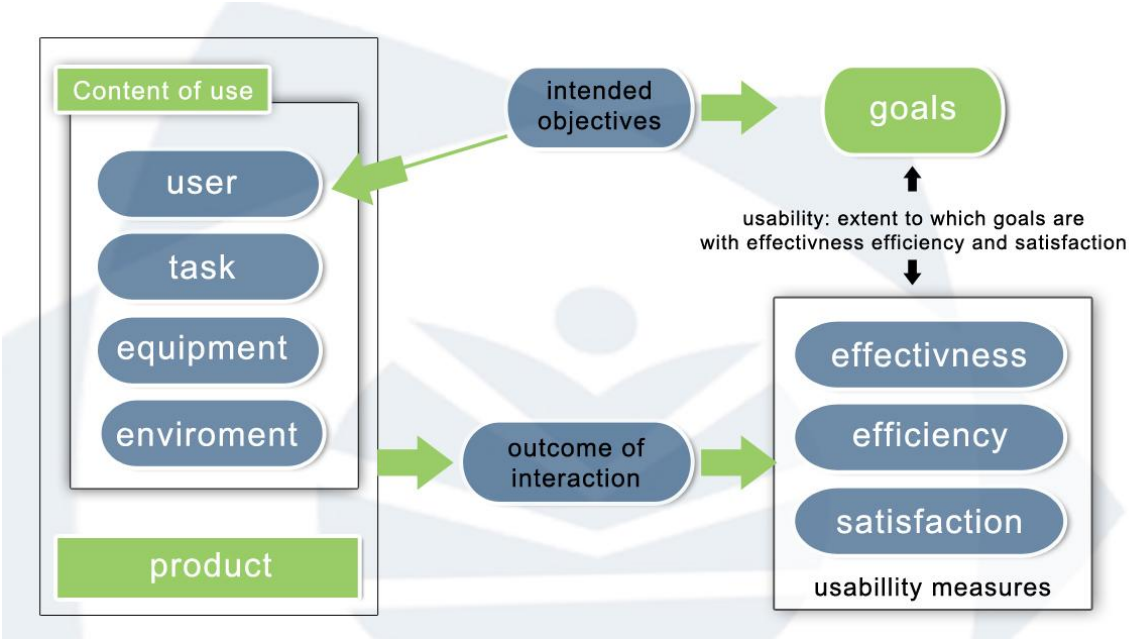


Figure 4.2: Usability framework (ISO 9241-11, 1998)

4.3.1 Model of usability

Leventhal and Barnes (2007) created a model of usability, that considered the relationship between usability and a set of situational and user interface variables (see Fig 4.3). When these two sets of variables are carefully taken into consideration during the design phase, they can affect usability of the application.

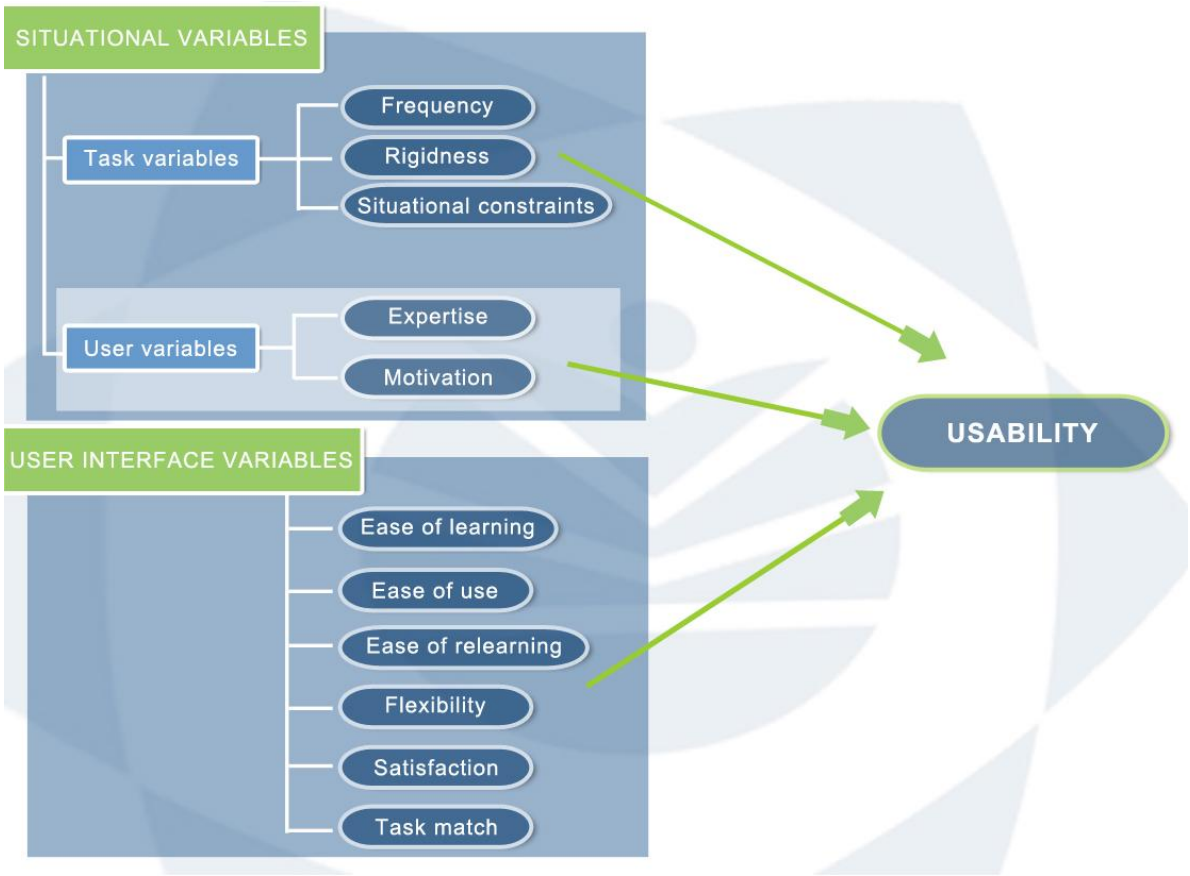


Figure 4.3: Model of usability (Leventhal and Barnes, 2007)

As one can see in Figure 4.3, the model identifies two important aspects within the situational variables, namely the task and the user. Variables involving the user include expertise and motivation. Variables pertaining to the task include frequency, rigidness and situational constraints. Variables related to the user interface include ease of learning, relearning, flexibility, satisfaction and task match. For a system or a design to be considered successful, it must also take topics beyond user interface design and usability into account. The next section investigates factors that might influence the user's experience.

4.4 User Experience Factors

A user experience can be positive or negative, depending upon certain factors which influence the end users experience with the system or product. Such factors include navigation or accessibility, with the latter being more important. Although many definitions of user experience factors exist, the following definition was adopted by Nielsen-Norman Group (All About UX, 2011).

- *All aspects of the end-user's interaction with the company, its services, and its products. The first requirement for an exemplary user experience is to meet the exact needs of the customer, without fuss or bother. Next comes simplicity and elegance that produce products that are a joy to own, and a joy to use. True user experience goes far beyond giving customers what they say they want, or providing checklist features. In order to achieve a high-quality user experience in a company's offerings, there must be a seamless merging of the services of multiple disciplines, including engineering, marketing, graphical and industrial design, and interface design.*

According to Morville (2004), UX experience can be divided into seven hexagons or facets as displayed in Figure 4.4 below (Semantic Studios, 2012).

Figure 4.4: The User Experience honeycomb (Semantic Studios, 2012)

The purpose of the Honeycomb was to assist customers to move beyond usability and understand that there are more features that contribute to a successful user experience. Such features include (Semantic Studios, 2012):

***Useful**:* this relates to the importance of being creative and assuring that the product or system is actually useful and innovative.

***Usable**:* this facet relates to ease of use of a product or system, which is a vital part of the design and development of any system.

***Desirable**:* the purpose of this facet is to highlight the emotional design aspects of a system or product, for example the value of images, identity, brand, etc.

***Findable**:* in an attempt to prevent user frustration, the navigational structure must be simple and the user must be able to easily locate what he is looking for.

***Accessible**:* this highlights the requirement that products and services must also accommodate the needs of and be accessible to persons with disabilities.

***Credible**:* the focus of this facet is to understand the user, and produce design elements that gain the trust of the user.

***Valuable**:* the end product or service must be valuable for both sides, i.e. to the organization as well as to the customer.

4.5 Interaction Styles

The term *Interaction Styles* refers to all the ways in which a user communicates or interacts with computer systems. Many interaction styles exist today, each of which have their advantages and disadvantages. Information regarding the most common ones will be provided.

Command line human interaction is text based, where the user types command strings at a prompt. The computer then performs the commands and displays the results. This method is considered to be fast and powerful since the user has direct access to the system's functionality, as illustrated in 'Figure 4.5.

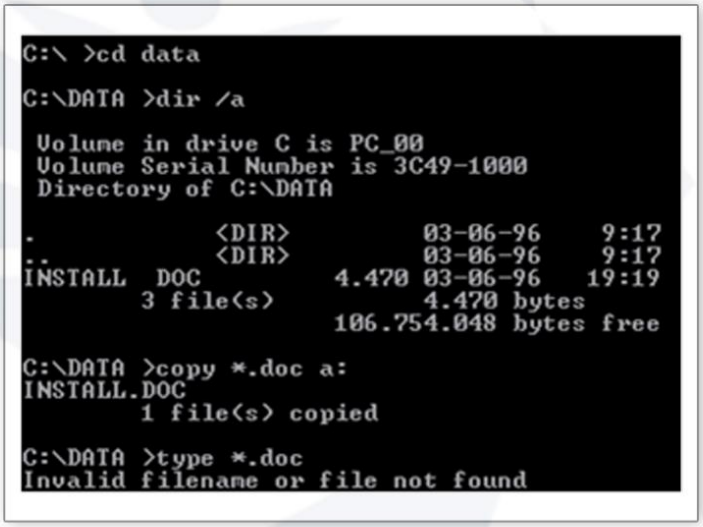


Figure 4.5: Command line human interaction style

Advantages of this style are that it:

- Is suitable for repetitive tasks;
- Is advantageous for expert users;
- Offers direct access to the system's functionality;
- Is efficient and powerful; and
- Is not encumbered with graphic controls.

Disadvantages of this style are the following:

- Low command retention;
- Steep learning curve;
- High error rates;
- Heavy reliance on memory; and
- Frustrating for novice users.

Menu-Based Interface presents the user with a sequential hierarchal menu, which provides users with a list of functions. The user goes through the various levels, and by selecting a specific function the user may proceed to the next level. Menu based

interfaces can be textual or graphical, and for this reason they are considered to be an improvement in usability. This interaction style is most commonly found on mobile devices.

Figure 4.6 is a perfect example of the menu-based interface style where the user selects and option, and as such unveils more options until the intended task is completed.

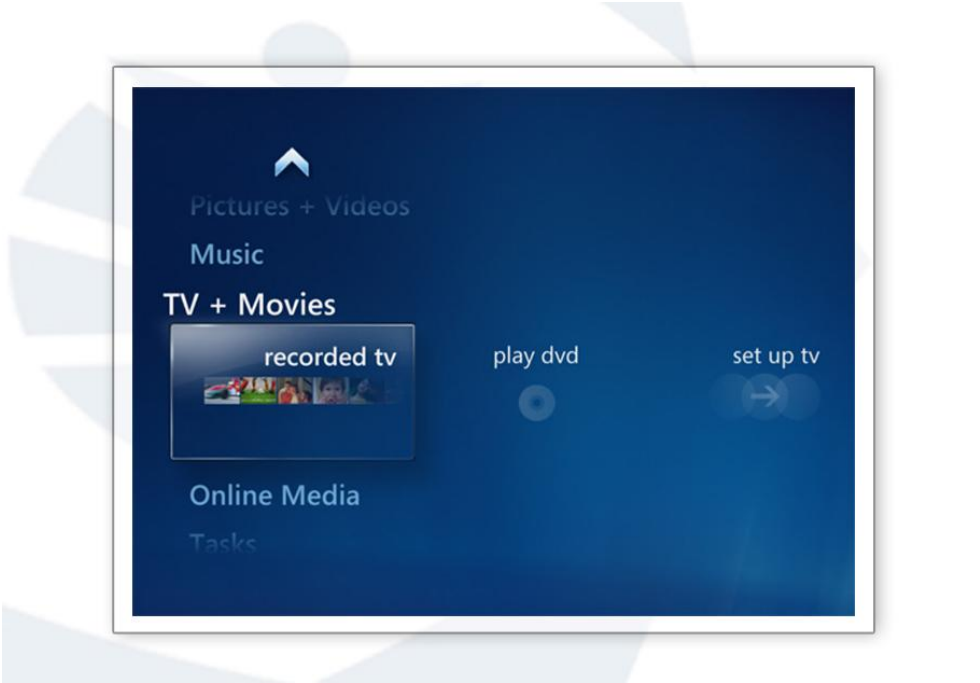


Figure 4.6: Menu-based interface style

The different types of menus are illustrated in Figure 4.7, and are usually a variation of the following basic categories:

- Single;
- Sequential;
- Hierarchal; or
- Network.

Single menus present the user with a set of related options. He or she can then choose one or multiple options, or no option at all. When the menu allows the user to select only

one function choice, the function executes upon selection. When the menu provides the user with more than one option, the function is executed only when the button is clicked.

Sequential menus on the other hand are a string of inter-dependent menus which follows a strictly linear path. Upon selection of an option from the first menu, the user is presented with a subsequent menu prompting the user to another set of menus. This process continues until the user completes the intended task.

Hierarchal menus follow a “drill down” structure, were the user is presented with a series of choices that progressively refines the path to the ultimate goal.

Networked menus share similarities with the sequential menu, since both are a collection of single menus. Both types of menus are loosely structured and not linear. Similarities are also found between the networked and the hierarchal structure, except that multiple paths are sometimes included in order to achieve a goal.

A common interaction style named the ***star structure*** is also used in computer hardware networking. This structure might also follow the Web format like the World Wide Web (WWW). Web networks offer a variation of multiple navigational paths. This allows the user to access any of the menus. Since each menu is independent from another, the user is allowed to jump from menu to menu.

Advantages of this style are the following:

- Low memory requirements;
- Self-explanatory;
- Easy to undo errors; and
- Appropriate for beginners.

Disadvantages of this style are the following:

- Rigid and inflexible navigation;
- Inefficient for large menu navigation;
- Inefficient use of screen and real estate; and
- Slow for expert users.

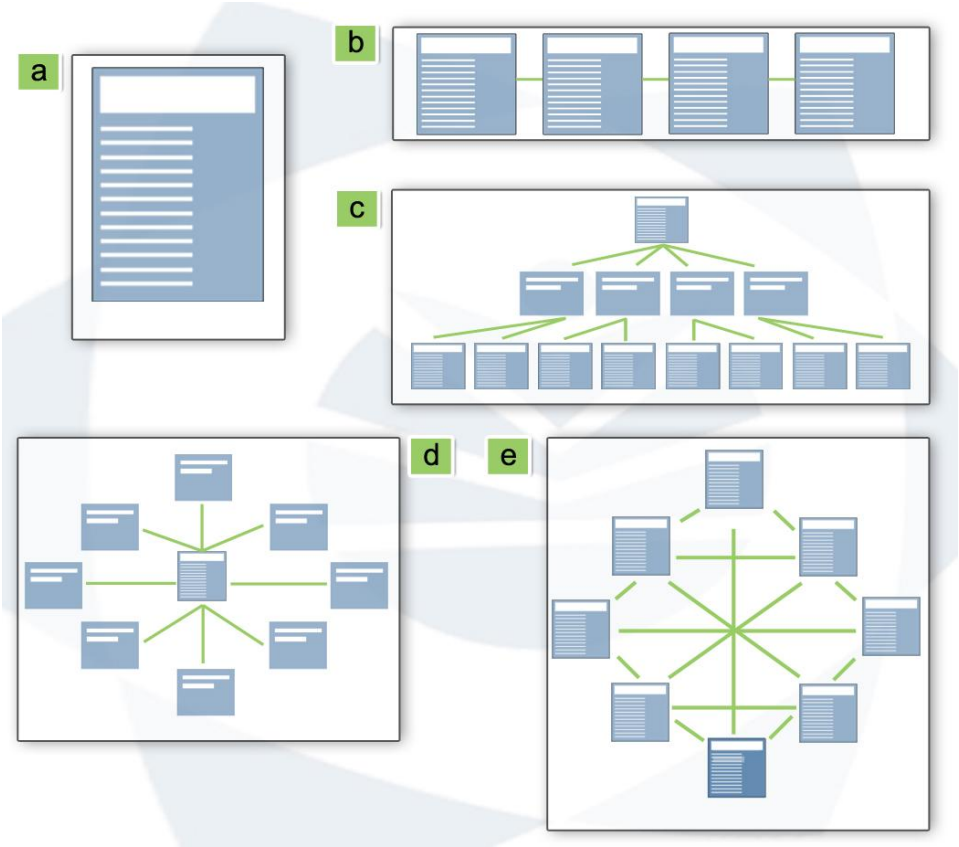


Figure 4.7: Single menus (a), Sequential menus (b), Hierarchal menus (c), Networked menus (d) and Star structure styles (e)

Form Fill-In interfaces have similarities with menu-driven interfaces, since they provide the user with information. The difference is that the primary purpose of form fill-ins is to gather information and proceed in a linear fashion.

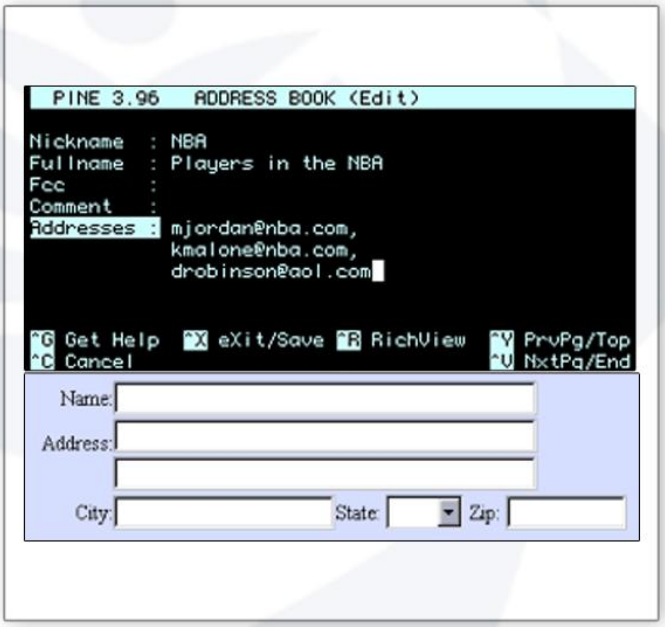


Figure 4.8: Form fill-in style

Advantages of this style are the following:

- Low memory requirements;
- Self-explanatory;
- Gathers a great deal of information in little space; and
- Presents a context for input information.

Disadvantages of this style are the following:

- Requires valid input in a valid format;
- Requires familiarity with interface controls; and
- It can be tedious to correct mistakes.

Question and Answer interfaces guide the user through a series of questions. The computer will then take the information provided by the user and set up an application or a system environment. These interfaces are mostly appropriate for novice users, and are easy to use but yet restricting, as is seen in Figure 4.9.

Figure 4.9: Question and answer style

Advantages of this style are the following:

- Low memory requirements;
- Self-explanatory;
- Simple linear presentation; and
- Easy for beginners.

Disadvantages of this style are the following:

- Requires valid input supplied by the user;
- Requires familiarity with interface controls; and
- It can be tedious to correct mistakes.

So far topics such as user interface design, usability, UX user experience factors and Interaction styles were discussed as separate entities. All of these topics are very important and must be taken into consideration when designing or developing a system.

Guidelines that currently exist and accommodate the needs of Deaf people to some extent are discussed in the sections that follow.

4.6 Telecoms Accessibility Guidelines

Table 4.1 below represents the accessibility guidelines from The Centre for Excellence in Universal Design (CEUD). These guidelines deal directly with fixed or mobile telecommunications devices and services regarding accessibility issues (The Centre for Excellence in Universal Design, 2012).

Established in 2007 by the National Disability Authority (NDA) under the Disability Act in 2005, the focus of The Centre for Excellence in Universal Design (CEUD) is on universal access. Universal design is the ability to design a system where anyone regardless of age, size or disability, can access and use the system to the full extent. The *system* can in this context refer to public places, buildings, streets, products, services or information and communications technology (ICT). The guidelines included below have been separated into priory 1 and priority 2, and more details will provided only to the guidelines that are relevant to the hearing impaired. The guidelines that will be discussed in more detail will be from the **priority 1 sections***1.8, 1.9, 1.10, 1.12, 1.15* and from the **priority 2 section** *2.4* (The Centre for Excellence in Universal Design, 2012).

Priority 1		Priority 2	
1.1	Ensure that all operable parts are reachable by people of all heights and people sitting in a wheelchair or buggy.	2.1	Allow sufficient time to accommodate the slowest users.
1.2	Ensure that displays are within sight of people of all heights and people sitting in a wheelchair or buggy.	2.2	Ensure that the user interface and task flow is similar across different functions and remains the same across repeated visits.
1.3	Ensure that controls are adequately sized and	2.3	When deploying more than one version of a

	sufficiently spaced to be operated by people with limited dexterity.		device, ensure that the user interfaces are similar.
1.4	Ensure that operation requires minimal strength, grip and wrist twisting.	2.4	Ensure that videophones allow simultaneous text dialogue.
1.5	Ensure that the device can be operated using only one hand.	2.5	Do not require users to remember a fixed supplied PIN.
1.6	Ensure that users with restricted or no vision can use all functions of the device .	2.6	Provide for users with multiple impairments.
1.7	Ensure that all outputs under the control of the device can be perceived by users with restricted or no vision.		
1.8	Ensure that videophones provide accurate reproduction of text and sign language.		
1.9	Ensure that all outputs under the control of the device can be perceived by users with restricted or no hearing.		
1.10	Ensure compatibility with assistive technologies.		
1.11	If using telephone cards, ensure that the card can be inserted into the card reader in its correct orientation without requiring vision.		
1.12	Use the simplest language possible for		

	instructions and outputs and, in visual displays, supplement it with pictorial information or spoken language.
1.13	Do not cause the display to flash at a frequency of above 2Hz.
1.14	Ensure that users can get to the device along an unobstructed path and operate it from a stable position.
1.15	For Interactive Voice Response (IVR) systems, provide an equivalent service through an accessible channel for users who still cannot use the system.

Table 4.1: Guidelines for telecoms accessibility (The Centre for Excellence in Universal Design, 2012)

The focus of *Priority 1 guidelines* is to ensure that all devices or services can be used or accessed by most people with disabilities, regardless of whether the disability comprises impaired mobility, vision, hearing, cognition or understanding of language. Since the focus of this research is the Deaf, priorities related to this topic only will be discussed.

Priority 1.8 *Ensure that videophones provide accurate reproduction of text and sign language.*

Quality of image and the screen size must be good enough to support lip-reading, sign language with no delay and textual communication.

Priority 1.9 *Ensure that all outputs under the control of the device can be perceived by users with restricted or no hearing.*

All of the outputs of the device must be perceivable by users that are deaf or hard of hearing. Audible information should be presented in a form where hard of hearing

people can perceive it. In the case of the profoundly deaf, another method should be provided so that they can receive the same information.

Priority 1.10 *Ensure compatibility with assistive technologies.*

Devices should be compatible with assistive technologies, for example cell phones with hearing aids.

Priority 1.12 *Use the simplest language possible for instructions and outputs and, in visual displays, supplement it with pictorial information or spoken language.*

Features such as operating instructions, button labels, interactive voice response, voicemail menus and displayed information should be presented clearly and should be easy to read. Where it is possible to improve the understanding of information, explanatory icons or pictures should be used. Additionally, wherever it is possible, text information should be provided in a spoken format for users who have difficulty reading.

Priority 1.15 *For Interactive Voice Response (IVR) systems, provide an equivalent service through an accessible channel for users who still cannot use the system.*

If an Interactive Voice Response (IVR) service is still not understandable by the user despite the fact that it meets all the applicable priority 1 guidelines, an alternative method should be provided. The alternative method should be provided at no extra cost, and should also minimize the amount of inconvenience when accessing the service. The guidelines provided in the priority 2 sections which are intended for people with cognitive impairments or multiple disabilities are discussed below.

Priority 2.4 *Ensure that videophones allow simultaneous text dialogue.*

Text functionality should be provided where possible, either as part of the videophone or by connecting a separate device.

As mentioned above, these guidelines deal directly with fixed or mobile telecommunications devices and services regarding accessibility issues. It is important to review both guidelines as the proposed set of guidelines from this research is

intended for websites and phone applications. Guidelines dealing with Web accessibility are therefore also important. These are discussed below.

4.7 Web Accessibility

The W3C (World Wide Web Consortium) and WAI (Web Accessibility Initiative) defines Web accessibility as: "Content is accessible when it may be used by someone with a disability."The W3C WAI has played an important role regarding accessibility and the development of guidelines, with the main purpose of making Web resources accessible to the disabled. W3C'sWeb Accessibility Initiative (WAI) has developed guidelines which help to ensure that Web resources are disabled-friendly, including visual, auditory, physical, speech, cognitive, language, learning and neurological disabilities. The W3C offers very limited recommendations on how mobile phone applications should be designed, since their key focus is to make Web resources accessible. The "Web Content Accessibility Guidelines 1.0" was published on the 5th of May 1999 (WAI, 1999). A survey regarding the compliance and relevance of the WAI "Web Content Accessibility Guidelines 1.0" was undertaken, leading to the results that are shown in Table 4.2 (Kelly, Phipps and Howell, 2005).

Topics	Comments
Understanding the guidelines	Guidelines can be difficult to understand and interpret consistently
Conflicts between accessibility and usability	Complying with accessibility guidelines may conflict with the website usability
Guidelines too theoretical	Some guidelines are felt to be too theoretical, promoting format that has not yet been widely deployed or accepted within the marketplace
Use of proprietary solutions	There is a need to make use of proprietary formats which provide an effective solution to users' needs

Other IT developments	The guidelines address only Web standards and fail to acknowledge wider IT accessibility issues

Table 4.2: Compliance and relevance of the WAI "Web Content Accessibility Guidelines 1.0"(Kelly, Phipps, and Howell, 2005)

In an attempt to provide a wider range of guidelines regarding Web accessibility, W3C released the "Web Content Accessibility Guidelines (WCAG) 2.0" in 2008. These guidelines include a more detailed and understandable description on how to apply the guidelines. The four basic principles of the "Web Content Accessibility Guidelines (WCAG) 2.0" and a description of each are shown in Table 4.3.

Principles	Description
Principles 1	Perceivable - Information and user interface components must be presentable to users in ways that they can perceive.
Principles 2	Operable - User interface components and navigation must be operable.
Principles 3	Understandable - Information and the operation of the user interface must be understandable.
Principles 4	Robust - Content must be robust enough that it can be interpreted reliably by a wide variety of user agents, including assistive technologies.

Table 4.3: The four basic principles of the "Web Content Accessibility Guidelines (WCAG) 2.0"(Kelly, Phipps and Howell, 2005)

In August 2002, a survey was carried out regarding accessibility issues on the websites of 160 UK, revealing a 57% failure to comply with the WCAG 1.0 guidelines (Kelly, Phipps and Howell, 2005).

In the United States there are currently laws that at some level help with the accessibility issues and unemployment levels that deaf people face every day. The Americans Disability Act that states that any company with fifteen or more employees must have reasonable accommodation for persons with disabilities. This act also states that commercial websites must be accessible to persons with disabilities (Lee, 2001).

4.8 User Interface Design Guidelines

The general objectives of user interface design were discussed in section 4.2. The six main criteria that must be satisfied was highlighted, namely *User-friendliness, Usefulness, Learnability, Efficiency, Ease of memorization and Reliability* (Use Design, 2009). The ten general principles regarding Usability Heuristics by Jakob Nielsen are discussed below (useit.com, 2012).

***Guideline 1**: Visibility of system status*

The user should be kept informed by the system about what is going on, and must be provided with feedback within reasonable time.

***Guideline 2**: Match between system and the real world*

The system should use the user's lingo rather than system-oriented terms. This can be achieved by using language, words, phrases and concepts that are familiar to the user. Information provided to the user should follow real-world conventions and should present any information in a natural and logical manner.

***Guideline 3**: User control and freedom*

When the user mistakenly selects a function which is of no use, the user must be provided with a quick option of exiting the specific function. This option should be quick and effective, without expecting the user to go through an extended dialogue.

***Guideline 4**: Consistency and standards*

By following conventions one eliminates the case were users may find themselves wondering whether different words, situations or actions have the same meaning.***Guideline 5****: Error prevention*

The system should be designed in such a way that errors are prevented from occurring. If that is not the case, users should be presented with a confirmation option before continuing.

Guideline 6*: Recognition rather than recall*

With the use of objects, actions, and clearly visible options, overload of the memory of the user's memory is avoided. Any instruction regarding the use of the system should be easy to understand and retrieve when needed.

Guideline 7*: Flexibility and efficiency of use*

The system should satisfy both novice and expert user needs, and the user should be able to tailor frequent actions.

Guideline 8*: Aesthetic and minimalist design*

Only important information should be displayed. Any irrelevant or unnecessary information should be excluded.

Guideline 9*: Help users recognize, diagnose, and recover from errors*

Error messages should be simplistically written, should pinpoint the precise problem that caused the error to be displayed and should propose a solution.

Guideline 10*: Help and documentation*

In the case that the user needs help or documentation, the user must be able to easily retrieve the specific documents. Instructions should be clearly written, should provide concrete steps to follow and the document size must not be too large.

4.9 User Interaction Guidelines

Regardless of whether the application is intended for the web, a mobile device or a traditional GUI environment, some vital guidelines must be implemented in a design. These guidelines aim to deliver a successful and effective interface to the end user (Nielsen Norman Group, 2012).

***Guideline 1**: Anticipation*

Applications should attempt to anticipate the user's wants and needs. Do not expect users to search for or gather information or invoke unnecessary tools. Provide the user with all the information and tools needed for each step of the process.

***Guideline 2**: Autonomy*

The computer, the interface, and the task environment all "belong" to the user, but user-autonomy does not mean that rules should be abandoned.

- Use status mechanisms to keep users aware and informed; and
- Keep status information up to date and within easy view.

***Guideline 3**: Color Blindness*

Whenever colour is used to convey information in the interface, clear, secondary cues should also be used to convey the information to those who are not able to perceive colour differences.

***Guideline 4**: Consistency*

Levels of consistency: The importance of maintaining strict consistency varies. The following list is ordered from those interface elements demanding the most effort in terms of consistency to those demanding the least. Paradoxically, many people assume that the order of the first five items should be exactly the reverse, leading to applications that look alike, but act completely different in unpredictable ways:

- Interpretation of user behaviour, e. g., shortcut keys maintain their meanings;
- Invisible structures;

- Small visible structures;
- The overall "look" of a single application or service--splash screens, design elements;
- A suite of products;
- In-house consistency; and
- Platform-consistency.

Inconsistency: It is just as important to be visually inconsistent when things must act differently as it is to be visually consistent when things act the same. The most important aspect is to be consistent with user expectations.

***Guideline 5**: Defaults*

- Defaults should be easy to "blow away". Fields containing defaults should be selected when they appear, so that users can replace the default contents with new material quickly and easily.
- Defaults should be "intelligent" and responsive.
- Do not use the word "default" in an application or service. Rather use "Standard", "Use Customary Settings", "Restore Initial Settings" or some other more specific terms describing what will actually happen.

***Guideline 6**: Efficiency of the User*

- Look at the productivity of the user, not that of the computer.
- Keep the user occupied.
- To maximize the efficiency of a business or other organization you must maximize everyone's efficiency, not just the efficiency of a single group.
- The most significant efficiency breakthroughs in software are to be found in the fundamental architecture of the system, not in the surface design of the interface.
- Write help messages tightly and make them responsive to the problem: good writing has a large pay-off in terms of comprehension and efficiency.
- Key words should be displayed up-front on menu and button labels.

***Guideline 7**: Explorable Interfaces*

- Give users well-marked roads and landmarks, and then let them shift into four-wheel drive.
- Sometimes, however, you have to provide deep ruts.
- Offer users stable perceptual cues for a sense of "home."
- Make actions reversible.
- Always allow "Undo".
- Always allow a way out.
- However, make it easier to stay inside the interface.

***Guideline 8**: Fitts' Law*

- The time to acquire a target is a function of the distance to and size of the target.

***Guideline 9**: Human Interface Objects*

- Human-interface objects can be seen, heard, touched, or otherwise perceived.
- Human interface objects that can be seen are quite familiar in graphic user interfaces. Objects that play to another sense such as hearing or touch are less familiar. Good work has been done in developing auditory icons.
- Human-interface objects have a standard way of interacting.
- Human-interface objects have standard resulting behaviours.
- Human-interface objects should be understandable, self-consistent, and stable.

***Guideline 10:** Latency Reduction*

Reduce the user's experience of latency.

- Acknowledge all button clicks by visual or aural feedback within 50 milliseconds.
- Display an hourglass for any action that will take from 0.5 to 2 seconds.
- Animate the hourglass so that they know the system hasn't died.
- Display a message indicating the potential length of the wait for any action that will take longer than 2 seconds.
- Communicate the actual length through an animated progress indicator.

- Offer engaging text messages to keep users informed and entertained while they are waiting for long processes, such as server saves, to be completed.
- Make the client system beep and give a large visual indication upon return from lengthy (>10 seconds) processes, so that users know when to return to using the system.
- Trap multiple clicks of the same button or object. Because the Internet is slow, people tend to press the same button repeatedly, causing things to be even slower.
- Make it faster. Eliminate any element of the application that is not helping. Be ruthless.

***Guideline 11**: Learnability*

- Limit the trade-offs.

***Guideline 12**: Metaphors, Use of*

- Choose metaphors well, and use metaphors that will enable users to instantly grasp the finest details of the conceptual model.
- Bring metaphors to life by appealing to people's perceptions – sight, sound, touch, and kinaesthesia – as well as by triggering their memories.

***Guideline 13**: Protect Users' Work*

Ensure that users never lose their work as a result of error on their part, the vagaries of Internet transmission, or any other reason other than the completely unavoidable, such as sudden loss of power to the client computer.

***Guideline 14**: Readability*

- Text that must be read should have high contrast. Favour black text on white or pale yellow backgrounds. Avoid grey backgrounds.
- Use font sizes that are large enough to be readable on standard monitors. Favour particularly large characters for the actual data that you intend to display, as opposed to labels and instructions. For example, the label "Last Name," can

afford to be somewhat small. Habitual users will learn that the specific two-word grey blob refers to "Last Name." Even new users, based on the context of the form on which it appears, will be able to deduce that it says "Last Name." The actual last name entered or displayed, however, must be clearly readable. This becomes even more important for numbers. Human languages are highly redundant, enabling people to "heal" garbled messages. However, numbers have no redundancy unless they follow a very strict protocol People therefore need the ability to examine and comprehend every single character.

- Pay particular attention to the needs of older people. Presbyopia, the condition of hardened, less flexible lenses, coupled with reduced transmission of light into the eye, affects most people over the age of 45. Do not trust your young eyes to make size and contrast decisions.

***Guideline 15**: Track State*

- Because many browser-based products exist in a stateless environment, we have the responsibility to track state as needed.
- State information should be held in a cookie on the client machine during a session with a transaction service, and should then be stored on the server when the user logs off.

***Guideline 16**: Visible Navigation*

- Avoid invisible navigation.

4.10 Limited UX Factors for the Deaf

In this section a table will be provided displaying a side-by-side summary of all the guidelines from the interaction, interface, Telecoms Accessibility guidelines and the Crooked Wheel User Experience Factors for deaf people. The purpose of this table is to visibly display all the guidelines that apply directly to the Deaf. Figure 4.10 below outlines the factors that influence the satisfaction of the experience of deaf users.

The diagram below is divided into four basic sections, namely navigation, usability, accessibility and usefulness. For more information regarding accessibility for deaf people refer to Figure 3.2: Accessibility tools regarding the Deaf in chapter 3.

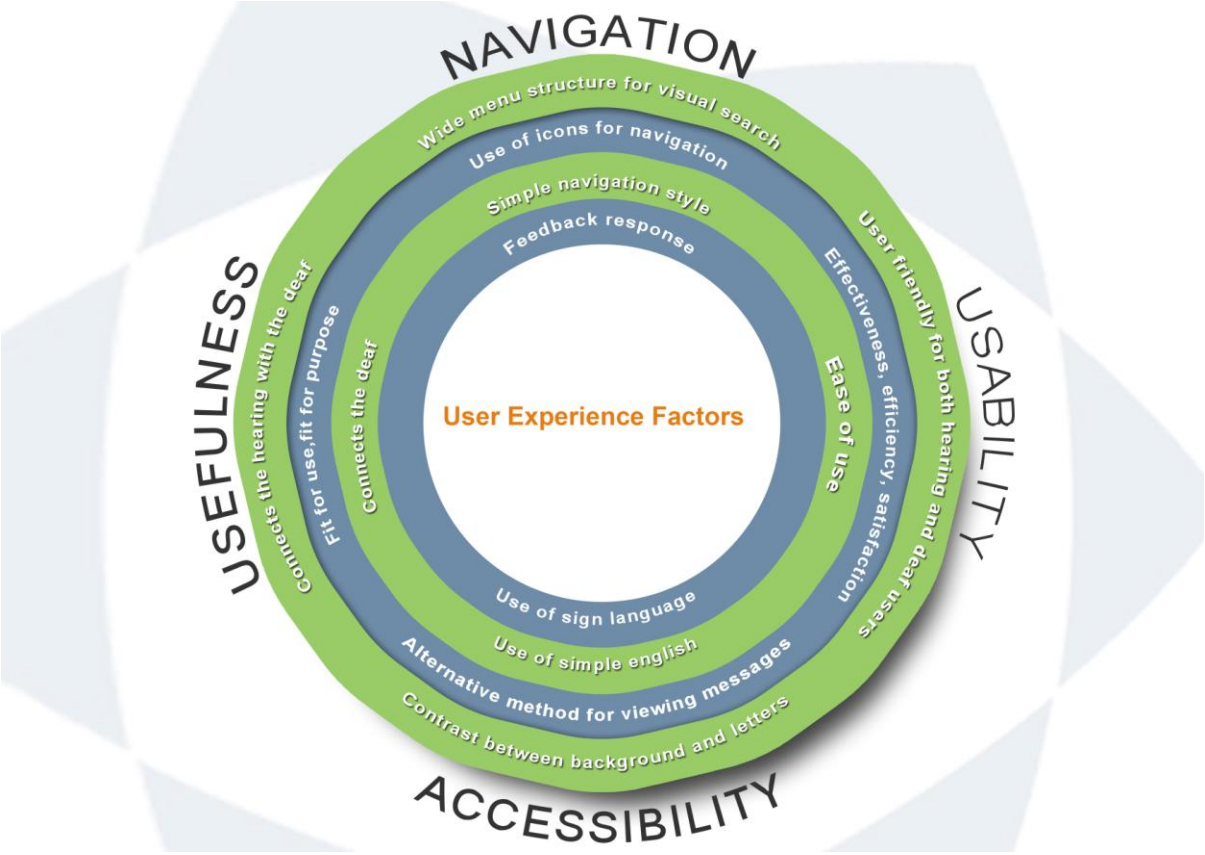


Figure 4.10: The Crooked Wheel User Experience Factors diagram for the Deaf (compiled by researcher)

Navigation

Subsections refer to ease of navigation. The purpose of these features are to make navigation clear and understandable to the user, and the use of icons as menus instead of text only, wide menu structures, simple navigation style and feedback response is therefore essential.

Usability

Since the system is intended for both hearing and deaf users, ease of use is critical and methods that hearing users are accustomed to are included. For example, the simple

design to achieve ease of use and the use of icons is a feature that is widely used in many applications or websites. This makes the system user- friendly for both hearing and deaf users.

Accessibility

Several factors had to be taken into consideration in this section in order to accomplish this task. Two important conclusions have been deduced from the literature review, namely:

- Sign language is essential when designing for deaf people, since it is their mother tongue; and
- The literacy skills are low when compared with those of a hearing person. Any text is therefore simply written and easy to understand.
- The ability for the user to write a message and to send or receive a message in his mother tongue has been provided.

Several more features can be used to provide contrast between the sign language figures and the background. Font, font size and quality of gestures have been taken into consideration as well, since it makes reading easier for the user. Finally, an alternative method of viewing messages has been provided. Deaf people are used to sign language, which is described as a visual language in motion. The option of viewing a message in motion has been provided as simple signs in a message format.

Usefulness

The usefulness of the prototype is that it allows deaf people to communicate with hearing people as well as with other deaf people. One scenario could be a mother who has a deaf child, but who does not know sign language. The application allows the mother to communicate with her child over the mobile device and *vice versa*. As with any project, it is essential for one to absolutely know the target audience for whom the system or application is intended and designed. The more information one gains about the target audience, the better the chances are that the application or system will accommodate the specific end user's needs.

As stated in the Crooked Wheel User Experience diagram, the application is intended for both deaf and hearing users. This implies that the hearing user does not have to learn sign language to be able to communicate with a deaf person. Neither is the deaf user required to know English to communicate with a hearing user. Although this application provides both users with the opportunity to learn each other's languages, it does not require one to know it in order to be able to communicate.

Table 4.4 below summarises the guidelines from all sections that were taken into consideration and that were implemented in the high fidelity prototype design. For some sections, only the title of a specific guideline is provided. This does not mean that all the subsections that correspond to the specific guideline will be implemented. However, at least one of them will be implemented. All the selected guidelines are strictly related to the interface and interaction design of the high fidelity prototype, and not to the development of the system. If the system is to be developed in future, some of the topics that should be taken into consideration include efficiency of the system, compatibility with other platforms and the language in which the system will be developed.

Guidelines for Telecoms Accessibility	User Interface Design Guidelines	User Interaction Guidelines	The Crooked Wheel User Experience factors for the Deaf
Priority 1.8 Ensure that videophones provide accurate reproduction of text and sign language.	**Guideline 1** Visibility of system status.	**Guideline 1** Anticipation	**Navigation** -Wide menu structure. -Use of icons for navigation. -Simple navigation style. -Feedback response.
Priority 1.9 Ensure that all outputs under the control of the device can be perceived by users with restricted or no hearing.	**Guideline 2** Match between system and the real world.	**Guideline 4** Consistency	**Usability** -User-friendly for hearing and deaf users. -Effectiveness, efficiency and satisfaction. -Ease of use.

Priority 1.12 Use the simplest language possible for instructions and outputs and, in visual displays, supplement it with pictorial information or spoken language.	**Guideline 3** User control and freedom.	**Guideline 6** Efficiency of the User	**Accessibility** -Use of sign language. -Use of simple English. -Alternative way for viewing messages. -Contrast between background and letters.
	Guideline 6 Recognition rather than recall.	**Guideline 7** Explorable Interfaces.	**Usefulness** -Connects the hearing with the Deaf. -Fit for use, fit for purpose. -Connects the Deaf.
	Guideline 8 Aesthetic and minimalist design.	**Guideline 9** Human Interface Objects.	
		Guideline 10 Latency Reduction.	
		Guideline 11 Learnability.	
		Guideline 14 Readability.	

Table 4.4: Guidelines and user experience factors for the high fidelity prototype (compiled by researcher)

4.11 Proposed Set of Guidelines

The proposed set of guidelines is presented in this section. These guidelines, when applied to a website or a phone application design, ensure accessibility and interaction from a deaf user. The main focus of the guidelines are to make sure that the environment is user-friendly for a deaf user and that it allows him to understand, function and interact within the environment provided to him.

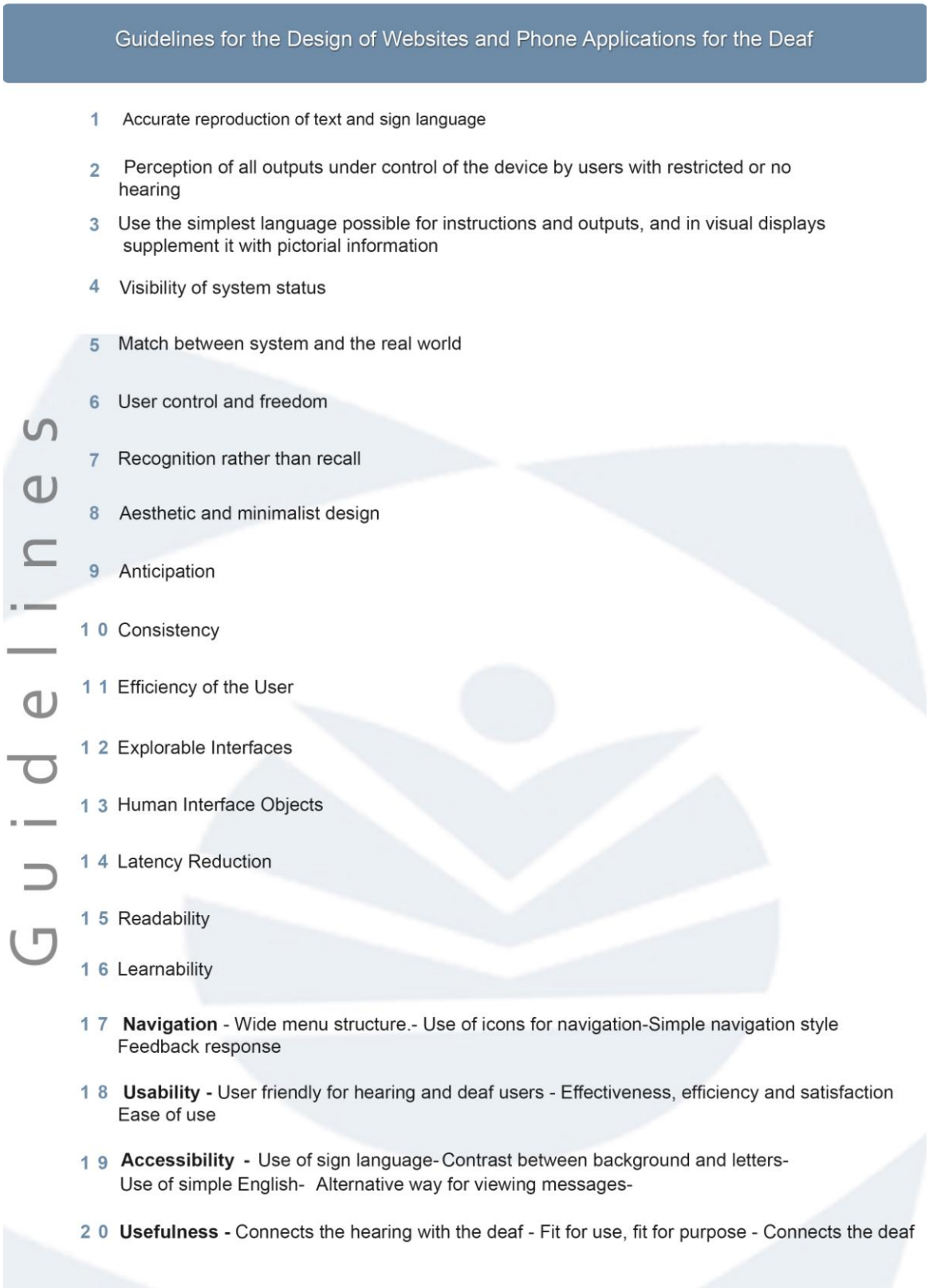


Figure 4.11: Proposed guidelines (compiled by researcher)

4.12 Summary

The purpose of this chapter was to investigate guidelines that exist to provide an accessible environment for deaf people, and to derive a proposed set of guidelines (see Figure 4.11). This final set of guidelines will be implemented in the high fidelity prototype design in chapter 5: *Guidelines for the Design of a Mobile Phone Application for Deaf People*

Layout of Chapter 5

CHAPTER 5: Research Methodology

5.1 Introduction

The previous chapters addressed topics such as the South African Deaf Landscape (chapter 2), Accessible ICT to Enhance Communication and Interaction (chapter 3) and finally Guidelines and UX factors (chapter 4). Based on the information collected and summarized in those chapters, a research methodology has been selected to guide the process from problem definition to its solution.

The research methodology provides a structured approach to the research problem under consideration. The main purpose is to prove that the solution that one is presenting is indeed meeting the specific objectives, and is providing a valid solution to the problem.

When designing or developing a system that should be usable by specific users, which is in this case the Deaf demographic, it is crucial to first understand the target audience, as well as their abilities and disabilities. One way to measure success of a system is to measure interaction. Are the intended users able to interact with the system?

5.2 HCI Research Disciplines

Human-computer Interaction (HCI) emerged in the early 1980's as an area of study, and was a field that was initially focused on computer science. In the last three decades, HCI has evolved beyond being a computer science field only and has merged with several other disciplines to become what it is today (Carroll, 2009).

HCI is the study of the relationship between human and machine, of how people interact with computers and the extent to which computers are developed for successful interaction with human beings. Even though HCI has become a recognized field taught at many academic institutions, one still might say that not many computer system developers pay any attention to ease-of-use of computers (Lorenzi, 1999).

This section aims to introduce you to the research disciplines of human–computer interaction (HCI). Figure 5.1 below, illustrates the different fields that are influenced by human-computer interaction (HCI).

HCI definition (Hewett, Baecker, Card, Carey, Gasen, Mantei, *et al*., 1996):

"HCI is a discipline concerned with the design, evaluation and implementation of interactive computing systems for human use and with the study of major phenomena surrounding them."

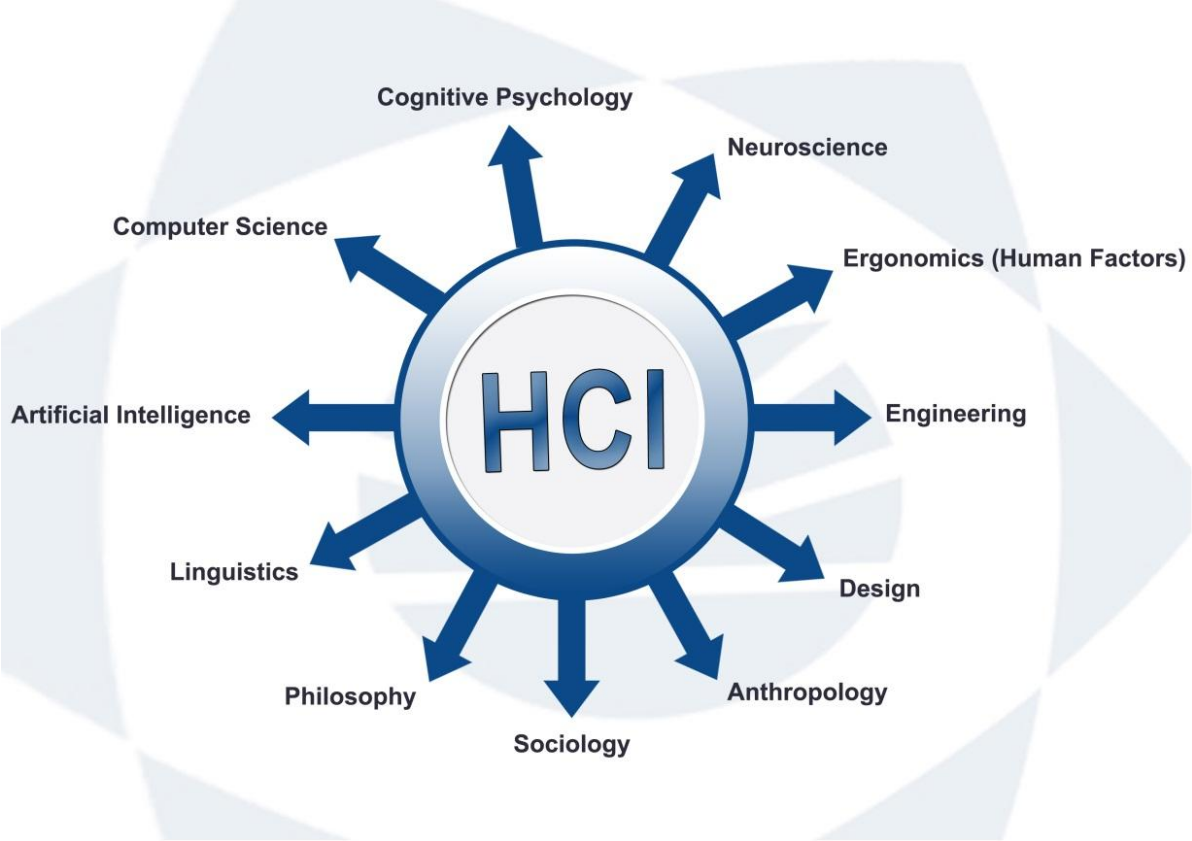


Figure 5.1: The different fields of HCI (Adapted from Richter, 2004)

HCI is a complicated and important multidisciplinary area of study, with various fields contributing towards it. For this dissertation, the application is intended for use on mobile phones. Disciplines that are involved in mobile human–computer interaction will therefore be discussed. The following are some of the main disciplines in mobile human computer interaction:

- Psychology;
- Computer science;
- Sociology;
- Design; and

- Information systems.

***Psychology**:* one of the disciplines that has a major effect on HCI and constantly keeps on contributing to the body of knowledge. Many research methods as well as system evaluation techniques which are used in mobile HCI research have their roots in psychology. A key aspect in the successful design of a mobile system, device or application is to understand the end user's needs. Characteristics such as age, personality and disabilities can have an effect on the user's performance and can affect the user's attitude towards the design of the system or application.

***Computer science**:* Computer sciences as well as the engineering disciplines are the fields that provide the necessary software tools to develop the interfaces and systems that are intended for interaction with the end users. For example, some of the development tools that can be used are Visual Basic and Java.

***Sociology**: s*ociology, as related to HCI, deals with socio-technical matters such as the impact of mobile technology on social situations. It contributes methods and techniques from the social sciences such as observational studies and ethnography that are applied when evaluating or designing mobile devices or applications.

***Design**:* this field's contribution to the HCI area is through design issues such as the layout of the interface. This includes issues like colours and positioning of the text or images and graphics on the screen display area. This discipline is very important in HCI research, due to the limited screen area on mobile devices.

***Information systems**:* this discipline focuses and investigates how people interact with information and technologies from an organizational, managerial and business point of view. For example, one of the issues that information systems focus on, is how to make mobile technologies and mobile applications within an organizational content more effective.

5.3 Research Process

The HCI disciplines were introduced in section 5.2. The purpose of this section is to describe how such research can be conducted in a structured way in order to provide a valid solution to the problem.

The research process forces the researcher to ask:

- To which research questions (problems) does he want to find answers; and
- How should he go about finding the answers?

In order to answer the above questions, one must go through practical steps. The journey to finding the answers is guided by the research methodology. At each step of the research process one must choose from a variety of methods, procedures and models of research methodology that are appropriate for achieving the desired objectives. Figure 5.2 below illustrates the different aspects of the research onion model.

Figure 5.2: The research onion model (Adapted from Saunders *et al*, 2003)

Definition of Research Process (Mondofacto, 2010):

"The ordered set of activities focused on the systematic collection of information using accepted methods of analysis as a basis for drawing conclusions and making recommendations"

The layers of the research onion model are the following (see Figure 1.1 in chapter 1):

- Research Philosophy
    - Positivism
    - Realism
    - Phenomenology
- Research Approach
    - Inductive
    - Deductive
- Research Strategies
    - Experiment
    - Survey
    - Case Study
    - Grounded Theory
    - Ethnography
    - Action Research
- Time Horizons
    - Cross-sectional
    - Longitudinal
- Data Collection Methods
    - Observations
    - Interviews
    - Questionnaires

The methodology followed in this research project is influenced and based on the research onion model which aims to provide a detailed explanation of the research process.

5.3.1 Research philosophy

Based on the research onion model, three different research philosophies exist, namely positivism, realism and phenomenology. Each of these philosophies reflects on the point of view from which one develops knowledge or approaches knowledge (Saunders *et al*, 2003).

Definition of research philosophy (Saunders *et al*, 2003):

"The Research Philosophy depends on the way you think about the development of knowledge"

The layers of Research Philosophy are:

- Positivism;
- Realism; and
- Phenomenology.

Where *positivism* applies scientific reasoning to the process of constructing knowledge (Remenyi *et al*., 1998), realism identifies the existence of external social objectives which can have an effect on people's interactions, in order to create knowledge (Saunders *et al*., 2003).

The purpose of the *phenomenology* philosophy approach is to identify phenomena as they are perceived by the users in a specific situation. The phenomenology approach deals with the study of experience rather than assumptions (Lester, 1999).

Table 5.1 below highlights the different aspects of the positivist and phenomenological paradigms. The comparison is based on the basic beliefs of the paradigms, the researcher's point of view and the preferred methods used for each paradigm (Tobin, 2006).

	Positivist paradigm	Phenomenological paradigm
Basic beliefs	The world is external and objective	The world is socially constructed and subjective
	Observer is independent	Observer is part of what observed
	Science is value-free	Science is driven by human interests
Researcher should	Focus on facts	Focus on meanings
	Look for causality and fundamental laws	Try to understand what is happening
	Reduce phenomenon to simplest elements	Look at the totality of each situation
	Formulate hypotheses and then test them	Develop ideas through induction from data
Preferred methods include	Operationalising concepts so that they can be measured	Using multiple methods to establish different views of phenomena
	Taking large samples	Small samples investigated in depth or over time

Table 5.1: Research paradigms (Tobin, 2006)

5.3.2 Research approaches

In terms of a research approach, one may select and apply either the deductive or the inductive approach.

The layers of Research Approach are:

- Inductive; or
- Deductive.

The *deductive* research approach is mostly associated with scientific research. A hypothesis is formulated and the researcher tests and examines it so that a theory can be established (Hussey and Hussey, 1997).

The *inductive* research approach formulates a theory based on research data. The inductive research approach also provides the researcher with more flexibility as well as

the opportunity to modify the research focus at any point, based on the findings throughout the research process (Easterby-Smith *et al*., 2002).

Figure 5.3: Deductive vs. inductive (Adapted from Trochim and Donelly, 2006)

Figure 5.3 above displays the process of both the deductive and inductive research approaches. As one can see, the deductive approach starts with the theory and concludes with the confirmation, whereas the inductive approach starts with observation and ends with the theory.

5.3.3 Research strategies

Literature highlights six recognized research strategies, namely: experiment; survey; grounded theory; ethnography; action research and case study (Saunders *et al*., 2003).

The layers of Research Strategies based on the research onion model are:

- Experiment;
- Survey;
- Case Study;
- Grounded Theory;
- Ethnography; and
- Action Research.

Research strategies are normally categorized as either quantitative or qualitative. Saunders *et al* (2003) defines the research strategy as the tools that the researcher selects to address the research question. Figure 5.4 illustrates data collection methods for each category.

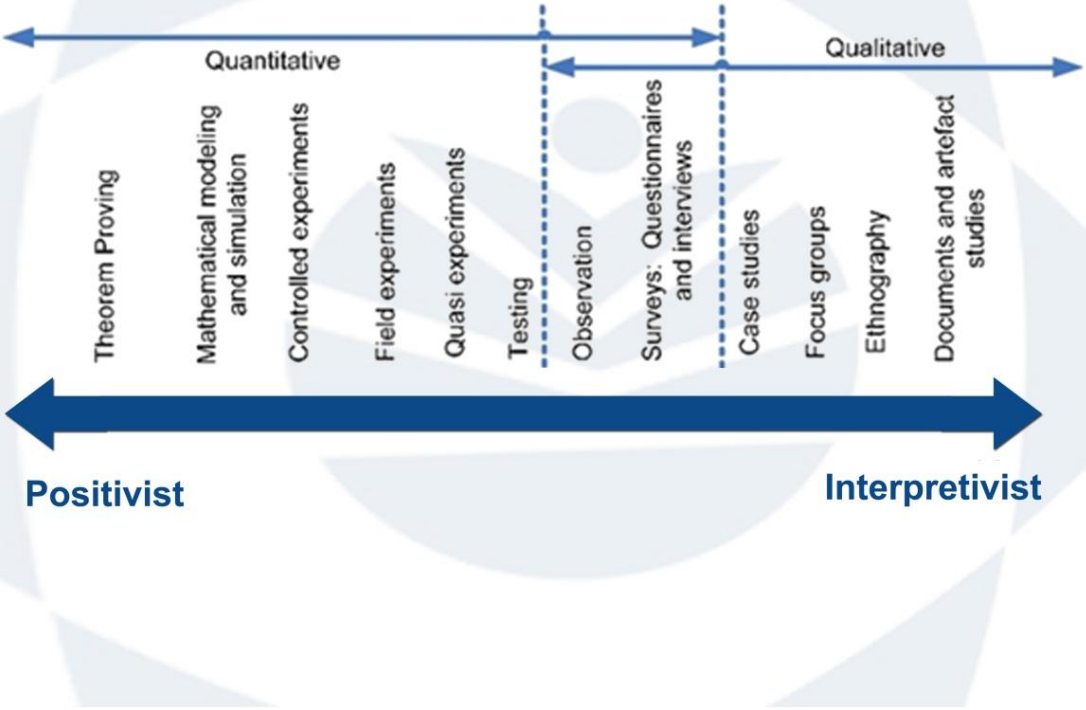


Figure 5.4: Research strategies that are representative of the positivism and interpretivism philosophies (De Villiers, 2005)

Case study strategy

The case study research strategy requires that the researcher conducts an in-depth investigation of an observation in a specific context, which may reveal new information within a real life phenomenon (Yin, 2008).

Definition of case study (Yin, 2008):

Case study research is an empirical inquiry that investigates a contemporary phenomenon within its real life context'.

Procedure	Mode of reasoning	Result	Generalisation
HYPOTHESIS TESTING A theory (hypothesis) is tested in a case, and validated or falsified	Deductive	The establishment of the domain of the theory	From a hypothesis and facts to the validation of a *theory*
THEORY GENERATING A principle (theory) is generated from facts in the case	Inductive	A theory (Conceptualisation)	From facts in a case to *theory*
NATURALISTIC GENERALISATION An actual problem situation is compared with known cases	Abductive	Ability to act based on the conception of a case	From cases to a *case*
SYNTHESISING A CASE A case is synthesised from facts in the case and a principle (theory)	Abductive	The (re)construction of a case	From facts and a theory to a *case*

Figure 5.5: Modes of generalization and reasoning within a case study methodology (Johansson, 2005)

Case studies are mostly used as a research strategy in fields such us psychology, sociology, political science, social work, business, and demographic planning (Yin 2003). Figure 5.5 reveals the different modes of generalization and reasoning within a case study methodology. It is commonly used in these fields, since case studies are in-depth analyses and are aimed at increasing knowledge about individuals, groups and organizations.

As mentioned earlier, case study research is an empirical inquiry that investigates a contemporary phenomenon within its natural setting (Harling, 2002).

- The phenomenon can be a program, an event, an activity, a problem or individual(s).
- The natural setting can be defined as the context within which the phenomenon appears.

- Holistic inquiry is the collection of in-depth and detailed data that involves multiple sources of information, some of which are direct observation, participant observation or interviews.

Survey strategy

Commonly used in studies such as health services and social research, the survey method goes back to the Victorian Britain were social reformers would collect information regarding poverty and the working class. Despite the fact that the term survey is used in many ways, it usually refers to the selection of a fairly large sample of people, that represents the wider population on whom the particular research is focused (Kelley, Clark, Brownand Sitzia, 2003). Three distinct characteristics are of importance when surveys are used for research purposes, as are presented in Table 5.2.

Definition of a survey

"A survey is a means of gathering information about the characteristics, actions, or opinions of a large group of people, referred to as a population"

Characteristics of surveys when used for research purposes	
First Characteristic	• To produce quantitative descriptions of some aspects of the study population. • Primarily concerned either with relationships between variables, or with projecting findings descriptively to a predefined population. • Survey research is a quantitative method, requiring standardized information from and/or about the subjects being studied.
Second Characteristic	• Main way to collect information is by asking people structured and predefined questions. • The answers, which may refer to themselves or some other unit of analysis, constitute the data to be analysed.
Third Characteristic	• Information is generally collected about only a fraction of the study population, a sample. • It is collected in such a way as to be able to generalize the findings to the population. • The sample is large enough to allow extensive statistical analyses.

Table 5.2: Characteristics of surveys (Pinsonneault and Kraemer, 1993)

Survey data are usually collected by means of questionnaires or interviews. The purpose of a survey is to produce a snapshot of how things are at a specific point in time. With the survey strategy, the researcher has no power over the conditions. This means that the researcher cannot manipulate the variables to suite his purpose (Kelley, Clark, Brown and Sitzia, 2003).

Experiment strategy

This is a strategy that can be classified as a classical form of research. The specific research strategy aims to test theories and to demonstrate relationships between variables for factual prediction and control. It is commonly used in the pure sciences, where researchers demonstrate a cause and effect between variables by means of experiments (Saunders *et al*., 2003).

Grounded Theory strategy

This strategy was developed by Glaser and Strauss in 1967, and bases its theory on grounded data. The grounded theory strategy begins by selecting the field of interest and observing it, after which the theory emerges from the data observed (Mavetera & Kroeze, 2009).

Definition of grounded theory (Strauss and Corbin, 1990):

"A grounded theory is one that is inductively derived from the study of the phenomenon it represents. That is, it is discovered, developed and provisionally verified through systematic data collection and analysis of data pertaining to that phenomenon. Therefore, data collection, analysis and theory stand in reciprocal relationship to one another"

The grounded theory strategy has many ways by means of which one may approach his research. According to Strauss and Corbin(1998) some of these approaches are inflexible and some flexible, thus allowing the researcher to navigate his research in a way that he finds the most appropriate to his research environment (Mavetera & Kroeze, 2009).

Figure 5.6 below illustrates the steps that a researcher would follow when applying grounded theory to his research topic.

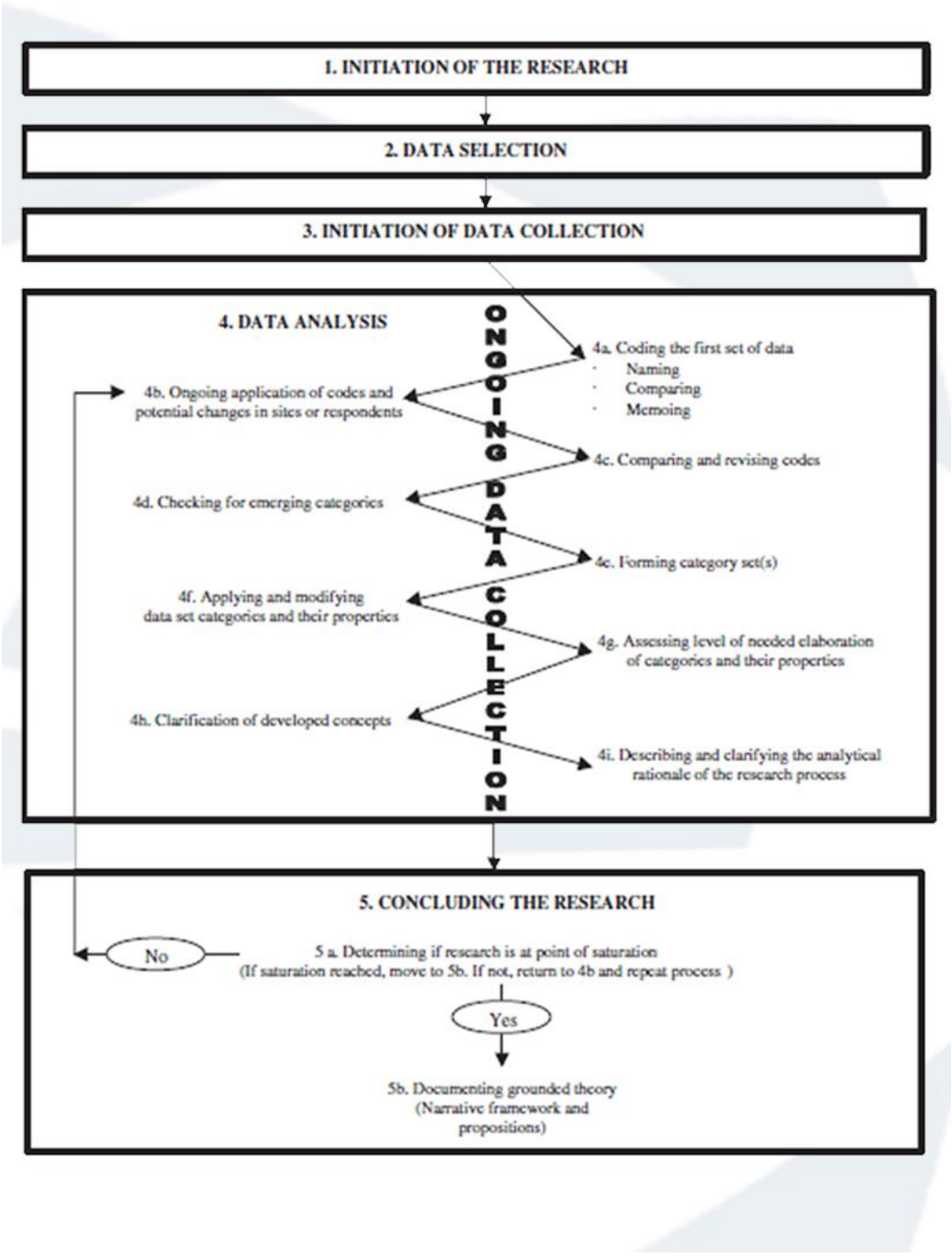


Figure 5.6: The Process of grounded theory (Egan, 2002)

Although the steps may seem similar to other research frameworks, the process regarding the interchange between data collection and analysis is unique to the grounded theory strategy (Egan, 2002).

Ethnography

The ethnography strategy has its roots in social and cultural anthropology, and requires the researcher to spend a significance amount of time in the field. The purpose of the time spent in the field is to enable ethnographers to immerse themselves in the lives of the people that they are studying. This allows the phenomena under study to be placed in a social and cultural context (Myers, 1997).

This specific strategy is increasingly being used in the study of information systems in organizations, specifically with respect to the development of information systems and aspects of information technology management. Interesting work regarding the design and evaluation of information systems is taking place in the UK and Europe, where ethnographers are working with designers, Information Systems (IS) professionals, computer scientists and engineers (Myers, 1997).

Action research

Action research is considered to be a valid research method in the field of organization development and education (Myers, 1997).

Definition of action research:

"*Action research aims to contribute to both the practical concerns of people in an immediate problematic situation and to the goals of social science by joint collaboration within a mutually acceptable ethical framework"*

The definition points out the collaborative aspect of action research, and highlights the possible ethical dilemmas that the researcher is faced with when using this strategy. It also clarifies that action research is not concerned with adding to the body of knowledge, but rather to enlarge the stock of knowledge of the social science

demographic (Myers, 1997). A summary of different types of action research is provided in Table 5.3.

	Individual teacher research	**Collaborative action research**	**School-wide Action research**	**District-wide action research**
Focus	Single classroom issue	Single classroom or several classrooms with common issue	School issue, problem, or area of collective interest	District issue Organizational structures
Possible support needed	Coach/mentor Access to Technology	Substitute teachers Release time Close link with	School Commitment Leadership Communication	District Commitment Facilitator Recorder
	Assistance with data organization and analysis	administrators	External partners	Communicatio n External partners
Potential impact	Curriculum Instruction Assessment	Curriculum Instruction Assessment Policy	Potential to impact school restructuring and change Policy Parent involvement Evaluation of programs	Allocation of resources Professional development activities Organizational structures Policy
Side effects	Practice informed by data Information not always shared	Improved collegiality Formation of partnerships	Improved collegiality, collaboration, and communication Team building Disagreements on process	Improved collegiality, collaboration, and communicatio n Team building Disagreements on process Shared vision

Table 5.3: Summary of Types of action research (DEP-SSA, 2012)

The action research strategy can be categorized into four types namely individual action research, collaborative action research, school-wide action research, and district-wide action research. Figure 5.7 illustrates the differences between the different types, along with some other details (DEP-SSA, 2012).

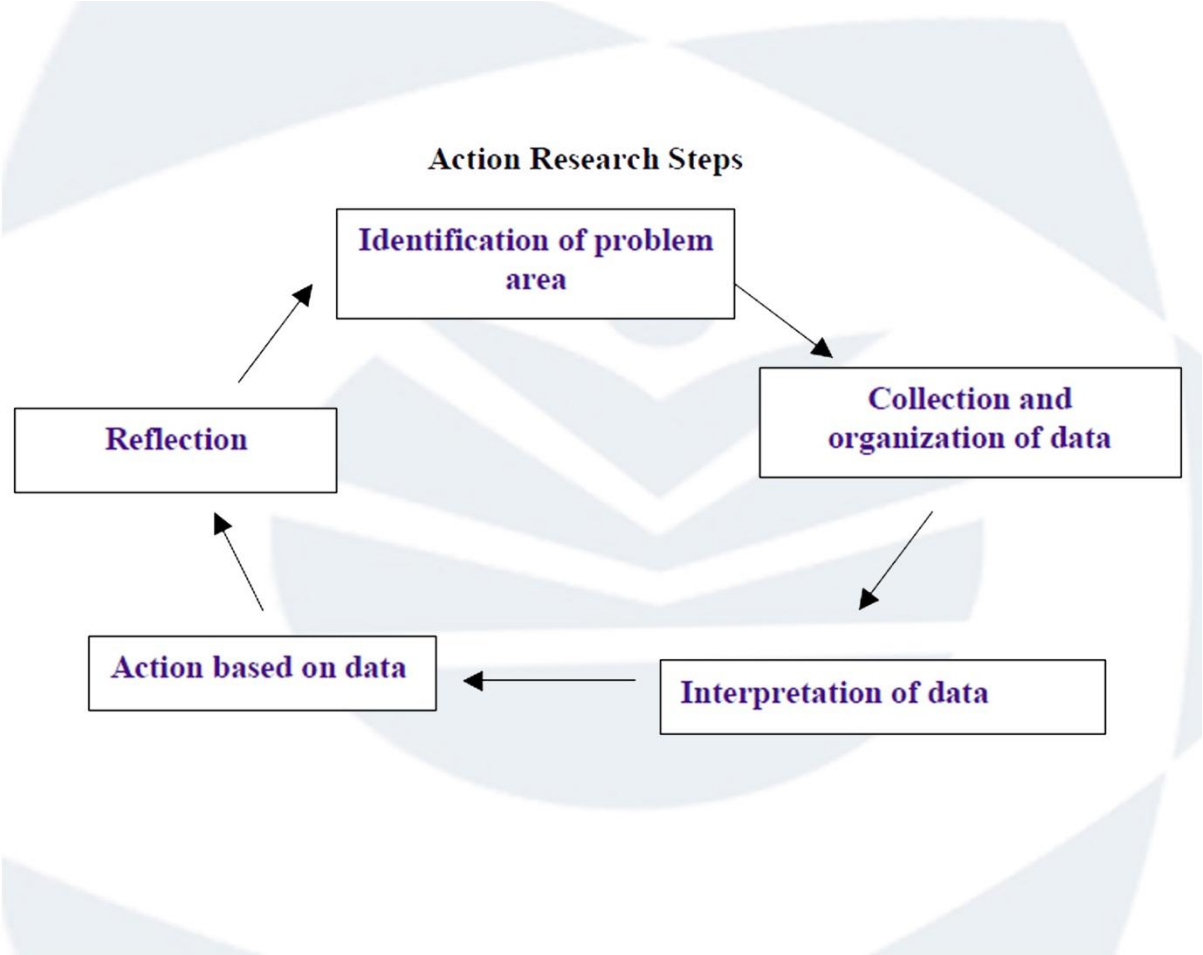


Figure 5.7: Steps in conducting action research (DEP-SSA, 2012)

As discussed earlier, action research follows a systematic process for providing a solution to a problem. The above figure illustrates the steps that the researcher will follow to carry out the research process (DEP-SSA, 2012).

5.3.4 Methods

The researcher can select from two methods that are directly opposite to each other, namely quantitative and qualitative research methods. Were qualitative research is

based on subjectivity, quantitative research is based on objectivity. Regarding the qualitative method, researchers argue that it is of primary importance to have close connections with the object of study to prevent results from being distorted. On the other hand, quantitative researchers argue that the researcher should not have close connections to the object of study (Abussabha, & Woelfel, 2003). Table 5.4 below provides a comparison between qualitative and quantitative methods.

Qualitative Versus Quantitative Research

Criteria	Qualitative Research	Quantitative Research
Purpose	To understand & interpret social interactions.	To test hypotheses, look at cause & effect, & make predictions.
Group Studied	Smaller & not randomly selected.	Larger & randomly selected.
Variables	Study of the whole, not variables.	Specific variables studied
Type of Data Collected	Words, images, or objects.	Numbers and statistics.
Form of Data Collected	Qualitative data such as open- ended responses, interviews, participant observations, field notes, & reflections.	Quantitative data based on precise measurements using structured & validated data-collection instruments.
Type of Data Analysis	Identify patterns, features, themes.	Identify statistical relationships.
Objectivity and Subjectivity	Subjectivity is expected.	Objectivity is critical.
Role of Researcher	Researcher & their biases may be known to participants in the study, & participant characteristics may be known to the researcher.	Researcher & their biases are not known to participants in the study, & participant characteristics are deliberately hidden from the researcher (double blind studies).
Results	Particular or specialized findings that is less generalizable.	Generalizable findings that can be applied to other populations.
Scientific Method	Exploratory or bottom–up: the researcher generates a new hypothesis and theory from the data collected.	Confirmatory or top-down: the researcher tests the hypothesis and theory with the data.
View of Human Behavior	Dynamic, situational, social, & personal.	Regular & predictable.
Most Common Research Objectives	Explore, discover, & construct.	Describe, explain, & predict.
Focus	Wide-angle lens; examines the breadth & depth of phenomena.	Narrow-angle lens; tests a specific hypotheses.
Nature of Observation	Study behavior in a natural environment.	Study behavior under controlled conditions; isolate causal effects.
Nature of Reality	Multiple realities; subjective.	Single reality; objective.
Final Report	Narrative report with contextual description & direct quotations from research participants.	Statistical report with correlations, comparisons of means, & statistical significance of findings.

Table 5.4: Qualitative vs. quantitative research (The content in the above table was taken from the following sources: Johnson, & Christensen, 2008 and Lichtman, 2006)

The table above provides a detailed overview of the differences between the qualitative and quantitative method by comparing them side by side. It includes information pertaining to the purpose of each method, the means of data collection and the type of data analysis.

5.3.5 Time horizons

The research onion model highlights two options related to the time horizon of the study. Two methods are recognized in literature, namely the longitudinal research study and the cross-sectional research study.

Longitudinal study

The longitudinal study focuses on investigating a phenomenon or phenomena over an extended period of time. This study always requires the researcher to collect and analyse data several times over the time period. In this type of study, the researcher has more control over the variables being studied. Based on Babbie (2005), there are three types of longitudinal studies:

- A trend study, used to monitor a specific characteristic of a population over a period of time;
- A cohort study, used to study a specific subpopulation over a period of time; and
- A panel study, used to collect data from the same set of participants at different points in time.

Cross-sectional

Cross-sectional studies focus on investigating a phenomenon or phenomena over a particular period of time. It is mostly used in academic work where deadlines are pre-determined (Babbie, 2005). Cross-sectional studies are characterized as descriptive research and are observational by nature. Researchers do not have the ability to manipulate the variable, but rather observe and record the information from the population of interest. The purpose of this type of research is to describe characteristics

that currently exist in the population of interest, and not to determine cause and effect between the variables (About.com,psychology, 2012).

5.3.6 Data collection methods

The data collection methods that are represented in the research onion model are sampling, secondary data, observations, interviews and questionnaires. The purpose of the data collection method is to help the researcher to collect data and to analyse the findings. Qualitative researchers commonly rely on four methods for information gathering (SAGE Publications, 2012), namely:

- Participating in the setting;
- Observing directly;
- Interviewing in depth; and
- Analysing documents.

These methods form the core of the data collection process, and are supplemented by secondary methods of data collection. In this section information regarding primary and secondary methods will be provided. These methods must be taken into consideration when designing a qualitative study (SAGE Publications, 2012).

Table 5.5 illustrates the different kinds of data collection methods that currently exist and which are based on the research onion model.

Method	Appropriate Uses	Strengths	Weaknesses
Archival Data	Longitudinal observations, questions looking at trends	Easy, cost-effective, credible Provides quantitative data Historical context of the program	Difficulty in collecting multi-site data Can become expensive Poorly maintained databases can cause problems
Modified Archival Data	See archival data, with added benefit of having evaluation-specific data collected		
Observations	Capture detailed descriptions of day-to-day behavior	Natural setting Capture program-context Capture unintended consequences Interaction between participants	Qualitative data can be difficult/time-consuming to aggregate
Surveys/Questionnaires	Obtain input from a large sample on attitudes, goals or priorities	Greater honesty in responses/less influence of social desirability Allows for more respondents to participate Relatively efficient data collection Easy aggregation of data	Hard to develop a sound, reliable instrument Data may be difficult to interpret if questions were not clear/straight-forward Issues with primacy effect
Focus Groups	Poll group as a way of collecting information on feelings on issues Provide insights about the effects, advantages, and limitations of a program after implementation Initial step in survey research to generate topics, questions, and response options Corroborate & interpret survey findings	Provides data relatively quickly and inexpensively (faster results) Exploration of unanticipated issues Insight into the respondents' ways of thinking Allows for reaction and interaction between participants Exploration of unanticipated issues	Risk moderator bias - might give cues towards desirable responses Requires a trained moderator Issues with social desirability Limited generalizability of the results Can not address sensitive topics Qualitative data can be difficult/time-consuming to aggregate
Interviews	Gather in-depth perspectives from individuals	Allows for obtaining real examples and stories Exploration of unanticipated issues Insight into the respondents' ways of thinking Can address sensitive topics	Time-consuming and expensive Qualitative data can be difficult/time-consuming to aggregate Issues with social desirability Limited generalizability of the results Issues with recency effect

Table 5.5: Guide to data collection methods

Data collection methods based on the research process onion:

- Observations;
- Interviews; and
- Questionnaires.

Observations*:* Observation requires from the researcher systematic noting and recording of events, behaviours and objects in the environment selected for the study. The observational record must comprise aspects such as detailed notes, non-judgmental and concrete descriptions. Observation can range from a highly structured detailed notation of behaviour controlled by a checklist to a more holistic observation of events and behaviour.

This enables the researcher to discover patterns of behaviours and relationships. Even when conducting an in-depth interview, observation plays an important role since it

allows the researcher to note the interviewee's body language and affect rather than the words only (SAGE Publications, 2012). Saunders *et al* (2007) describe two types of observation techniques:

***Participant observation**:* a qualitative technique, influenced primarily by cultural anthropology and qualitative sociology. Participant observation can be used as an overall approach to inquiry as well as a data collecting method. If the researcher decides to use this specific technique, he is presented with the opportunity to select any one of the following roles:

- Complete participant;
- Complete observer;
- Observer as participant; or
- Participant as observer.

***Structured observation**:* a method of observation that is described as a quantitative technique and in which the observer has a more detached role. Structured observation is more concerned with the frequency of the user's actions. The specific observation technique is more interested in quantifying behaviour which is based on a prearranged structured and systematic approach.

***Interviews**:* qualitative researchers rely extensively on in-depth interviews, a method that is often described as interviewing with a purpose. It may be a method applied by itself as the overall data collection method, or it could be one of several methods that are employed. Patton (2002) breaks down the interview method into three general categories, namely the informal conversational interview, the general interview guide approach and lastly the standardized open-ended interview (SAGE Publications, 2012).

Qualitative in-depth interviews follow a more conversational path than formal interviews, exploring general topics that help the researcher to uncover the participant's views and perspectives on the topic. It is important from the interviewer's perspective to convey to the participant that his opinion is valuable and useful. The success of an interview depends on how well prepared the interviewer was as well as on how well he anticipated and practiced his role regarding ethical issues (SAGE Publications, 2012).

One of the benefits and at the same time weaknesses of this method is that a large quantity of data is provided. The weakness relates to the large amount of data that is obtained, which makes the analysis thereof time-consuming. This method requires personal interaction between the interviewer and the participants, and cooperation and understanding is therefore very critical (SAGE Publications, 2012).

Questionnaires*:* questionnaires are commonly used by researchers in an attempt to understand a sample of a population. It seeks answers and information regarding the distribution of characteristics, attitudes and beliefs of the sample under study. This method relies heavily on the honesty and accuracy of the participant's responses. Questionnaires usually involve questions that have structured response categories and that are used on small groups to establish their usefulness and reliability (SAGE Publications, 2012).

Babbie (2005) defines a questionnaire as a document that contains questions and other types of items to extract information that is appropriate for analysis. In an attempt to produce a successful questionnaire, one must consider the length thereof and its effect on the response rate. The researcher must also consider doing a pilot test of the questionnaire in an attempt to avoid any misunderstandings regarding the questions selected for the questionnaire (Bernardo, 2005).

5.4 Research Process for this Study

As mentioned earlier, the research process for this study is based on the research onion. An adapted version of the research onion model is presented in Figure 5.8 below. Figure 5.8 illustrates the methods and techniques that will be used and implemented in this study.

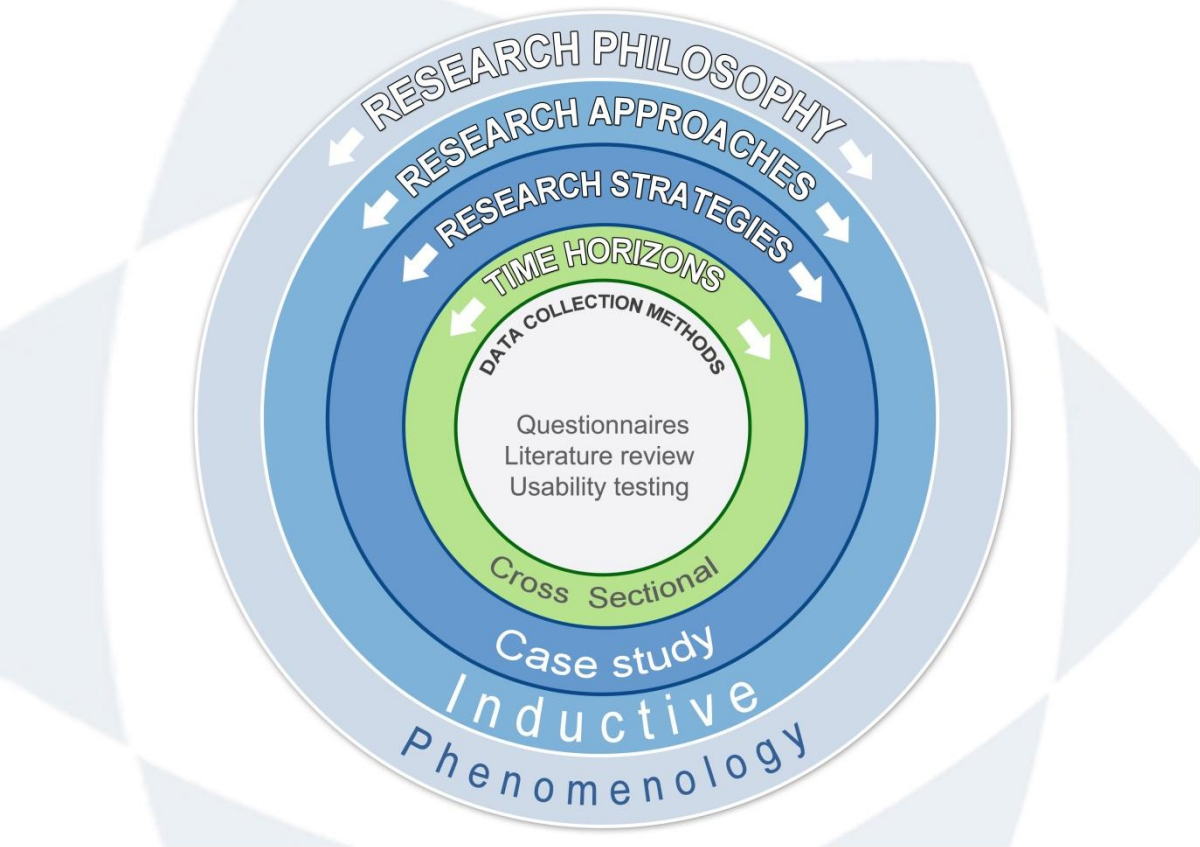


Figure 5.8: The process applied for this study

The research philosophy that was adopted for this study was the phenomenology philosophy. The purpose of phenomenology is to identify phenomena as they are perceived by the users in a specific situation. Phenomenology focuses on understanding how humans make sense of the world and the environment around them. The population in this research study would be Deaf people. Human interaction would be required to complete this study, and the phenomenology philosophy was found to be more suitable.

The research approach was an inductive approach, using qualitative data collection methods. This approach was selected because it formulates a theory based on research data, and also provides the researcher with more flexibility regarding the research focus. The guidelines used for the application of the different design variables regarding navigation, usefulness, usability, and accessibility were based on research data.

The case study research strategy was selected out of the six strategies that are presented on the research onion model. This specific strategy was found to be more appropriate because case studies facilitate an in-depth analysis that aims to increase knowledge about individuals, groups and organizations. Case study research requires that the researcher conducts an in-depth investigation, which would in this case focus on the Deaf demographic and directly related topics such as sign language, and how text and graphics is perceived and understood.

The cross-sectional time horizon was selected. This time horizon is mostly associated with academic work, because cross-sectional studies focus on investigating a phenomenon or phenomena over a particular period of time. Additionally, the cross-sectional time horizon is by nature an observational method that does not allow the researcher to manipulate the data. In this research, the final outcome will be tested on a sample of the population of interest. Their responses will be observed and documented.

The data collection methods that will be used to obtain information will be questionnaires, a literature review and usability testing. All of these are qualitative data collection methods. Information gathered from these methods will be analysed and presented in chapter 6. The research design of this study is based on the problem statement, research questions and objectives outlined below.

Problem statement

The gap identified in the research field pertains to the lack of user interface design guidelines when developing mobile phone interfaces for deaf users. These are very limited at present and needs more exploration. Following from this gap is the need to develop mobile applications that allow efficient communication between the hearing and the hearing impaired. These should allow Deaf people to communicate instantly in their primary language, namely sign language. The problem statement for this research can therefore be formulated as:

There is a lack of adequate guidelines for the design of suitable mobile user interfaces for deaf users.

Research questions

The following main research question guides the focus of the research design:

Main research question

What are appropriate guidelines for the design of the user interface of a mobile application for deaf users?

The following secondary research questions will help to provide a solution to the stated main research question:

Sub-research Questions

1. Which functionalities are currently available on a mobile device for use by deaf users?
2. What are the unique characteristics of deaf users?
3. Which guidelines exist for the design of such applications?
4. What are the typical means of communication and interaction for deaf users?

Research objectives

The objectives and purpose of this study are to:

1. Define the current functionalities available on a mobile device for use by deaf users;
2. Identify the unique characteristics of deaf users;
3. Determine the existing guidelines for the design of such applications; and
4. Determine the most suited means of communication and interaction for deaf users.

5.5 Case Study Description

The purpose of this case study was to derive a set of proposed guidelines. This was accomplished by investigating existing guidelines, as was summarized in the literature chapters. In order to conclude that the proposed guidelines do indeed accommodate the needs of Deaf people, a usability testing was required. The guidelines were applied in content to the design of a high fidelity prototype of a mobile phone application. The specific application is a messaging phone application that allows deaf users to communicate with other deaf and hearing users via SMS. The application was named Signchat.

To investigate the user experience of Signchat, a usability testing and post-test questionnaire were used as the data gathering techniques. While Signchat's main purpose is to accommodate the needs of Deaf people, it is also a learning tool and an application that bridges the gap by allowing deaf and hearing users to communicate. The participants involved in the evaluation were separated into two groups, namely people who know sign language and people who do not.

A total of five participants were used for the one group (people who know sign language). They were purposively sampled and selected to participate in the evaluation exercise. The usability testing was conducted individually on each participant. A total of five participants were used for the second group (people who do not know sign language) as well. The usability testing was conducted individually on each participant.

The purpose of the research and the process of usability testing was explained to the participants in advance. After the participant was informed of the process and had agreed to participate, the evaluation of Signchat began. The first step of the evaluation required the participant to complete a biographical questionnaire. Thereafter, the participants were presented with an interactive flash presentation that allowed them to see the features and functions of Signchat.

The Signchat presentation was divided into two parts: the warm-up section and the demo section. The warm-up section was a series of screenshots of the application that allowed the participants to become familiarized with the application before viewing the

demo. For the demo section, the participants were presented with a task list, which required them to follow the tasks in order to be able to complete this section. For both sections the participants were provided with the necessary space to provide comments, either negative or positive. Upon completion of the flash presentation demo of the application, the participants were required to complete a post-test questionnaire. The purpose of the post-test questionnaire was for the participants to evaluate the overall design, features and functions, and most importantly to determine if the application satisfied their needs.

5.5.1 Selection of case

The selection of the appropriate representative sample from the population and the selection of cases are very important when building theory from case studies, it is important when generalization of findings are made. The sections that follow contain a detailed description of the participant's profile, the sampling selection process and finally the UX requirements.

5.5.2 Participant's profile

The groups of participants from whom data were collected, were based on the following criteria:

Sign language group (people who know sign language):

- Age group;
- Knowledge of South African Sign Language (SASL); and
- Gender.

English group (people who do not know sign language):

- Age group;
- Knowledge of English; and
- Gender.

Sign language group

Age group*:* since the application is intended for both younger and older users, as well as hearing and non-hearing users, the age group of the participants was between 15

and 40. The selection of users between the ages of 15 and 40 was helpful in the sense that it led us to get a better understanding from both perspectives, i.e. from younger and older users. This allowed us to determine if the application (Signchat) satisfies both an older and a younger generation of users.

Knowledge of South African Sign Language (SASL)*:* the sign language used for the phone application is based on the South African fingerspelling alphabet. One of the criteria is that the deaf participants must have knowledge of the South African fingerspelling alphabet to be able to participate.

Gender*:* both females and males were selected to take part in the data collection process.

English group

Age group*:* since the application is intended for both younger and older users, as well as hearing and non-hearing users, the age group of the participants was between 15 and 40. The selection of users between the ages of 15 and 40 was helpful in the sense that it led us to get a better understanding from both perspectives, i.e. from younger and older users. This allowed us to determine if the application (Signchat) satisfies both an older and a younger generation of users.

Knowledge of English*:* for the purpose of the demo of the phone application, (Signchat) information provided is in the English language. Participants must therefore have a basic knowledge of the English language.

Gender*:* both females and males were selected to take part in the data collection process.

5.5.2.1 Sampling

The purpose of sampling is to select participants from a population of interest. From this sample, results can then be generalized back to the greater population that is represented by the selected sample (Research Methods Knowledge Base, 2006). Sampling can be divided into two major sections, namely probability sampling and nonprobability sampling. The key difference between these two sampling methods is

that probability sampling involves random selection while nonprobability sampling does not. Nonprobability sampling can be divided into accidental and purposive sampling (Research Methods Knowledge Base, 2006).

In this research, nonprobability purposive sampling was used as sampling method. Samples were taken with a purpose, for example from a specific predefined group, which in this case was the Deaf. One first had to verify that the selected participants did indeed meet the criteria for participating in the sample (Research Methods Knowledge Base, 2006).

5.5.2.2 UX requirements

The UX factors were previously introduced in chapter 4 (see the Crooked Wheel User Experience Factors in Figure 4.10). Accessibility for deaf people was discussed in chapter 3 (see accessibility tools regarding the Deaf in Figure 3.2). The factors presented below are of high importance, as they can influence the satisfaction of the experience of deaf users:

- Navigation;
- Usefulness;
- Usability; and
- Accessibility.

5.6 High Fidelity Prototype

Figure 5.9 below reveals all the guidelines that were used in the design of the Signchat mobile application. Each guideline was carefully selected and used in order to satisfy the elements of navigation, usefulness, usability and accessibility. As mentioned in chapter 4 (see section 4.9), all the guidelines selected are strictly related to the interface and interaction design of the high fidelity prototype and not to the development of the system. Topics that should be taken into consideration during development include efficiency of the system, compatibility with platforms and the language in which the system will be developed.

The purpose of this section is to visibly display how the guidelines were implemented in Signchat. For each guideline that was used, a snapshot will be presented so that one can see the guideline in imagery. At this point it is important to clarify that not all guidelines can be displayed with a screenshot. The latter can be used to represent matters regarding to the design, but not those relating to the functionality of the device. They are nevertheless still included because of their importance. For example in the Guidelines for Telecoms Accessibility, priority 1.8 refers to the actual mobile device.

Additionally, one of the guidelines under the navigation section of the crooked wheel user experience factors refers to feedback response. Not all feedback responses can be presented in a screenshot, and some of these will be provided separately (for example feedback regarding the actions of the user). Actions regarding the device will not be included. An example is the vibration that will occur while pressing a button, allowing the user to know that his action had a reaction.

Keep in mind that some guidelines may overlap with each other or have similarities. For example, priority 1.12 refers to outputs in visual display or to the supplementation of information with pictorial information. In the Crooked Wheel User Experience, under the navigation section, one of the guidelines refers to the use of icons. In conclusion: screenshots of a guideline will be presented where possible, and where the guideline is directly linked to matters regarding the design of the application. However, one must keep in mind that all the guidelines are of primary importance.

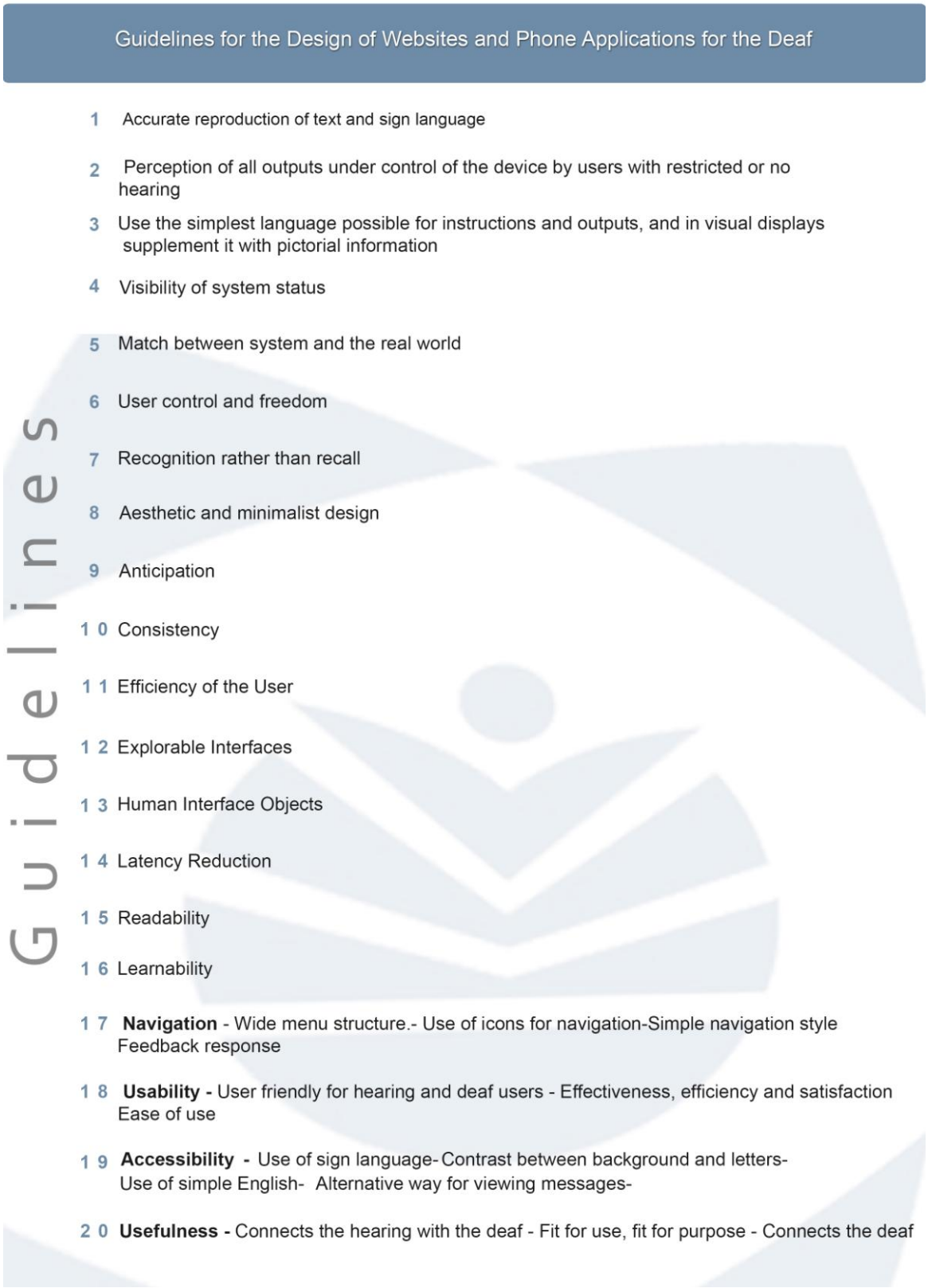


Figure 5.9: Proposed guidelines (compiled by researcher)

High Fidelity Prototype

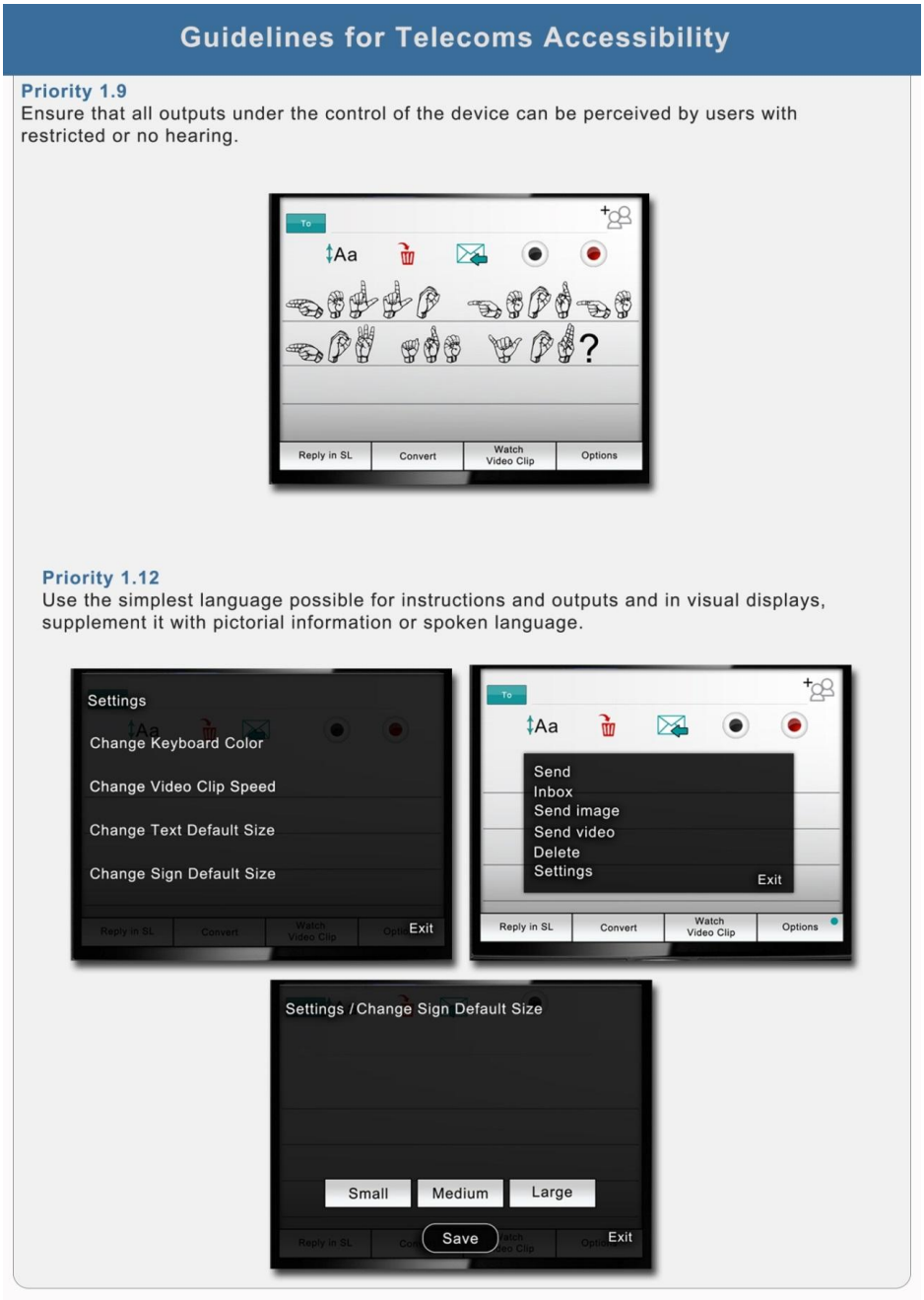


Figure 5.10: Proposed guidelines 2 and 3

- All outputs under the control of the device can be perceived by users with restricted or no hearing.
- Use the simplest language possible for instructions and outputs and, in visual displays, supplement it with pictorial information.

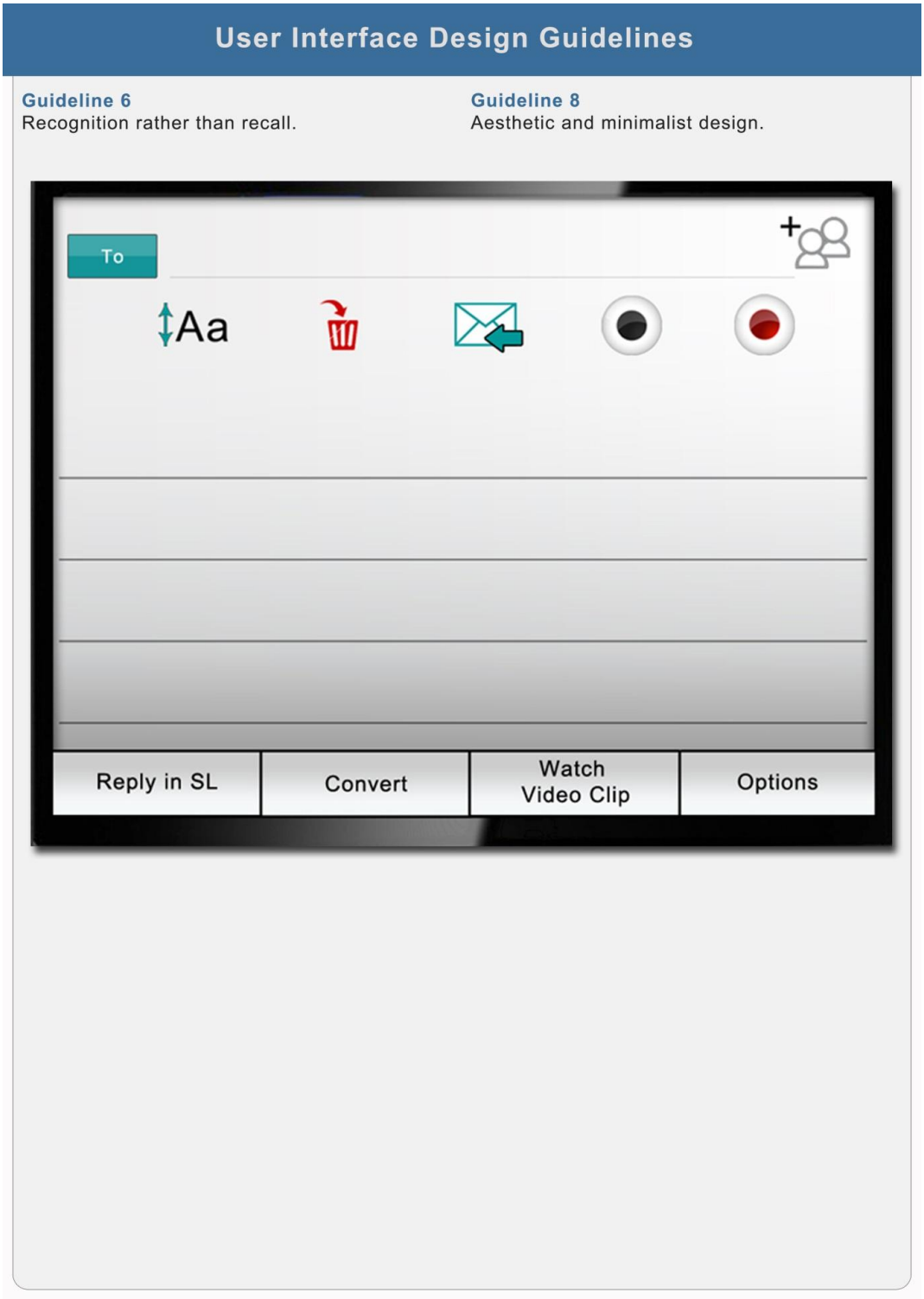


Figure 5.11: Proposed guidelines 7 and 8

- Recognition rather than recall.
- Aesthetic and minimalist design.

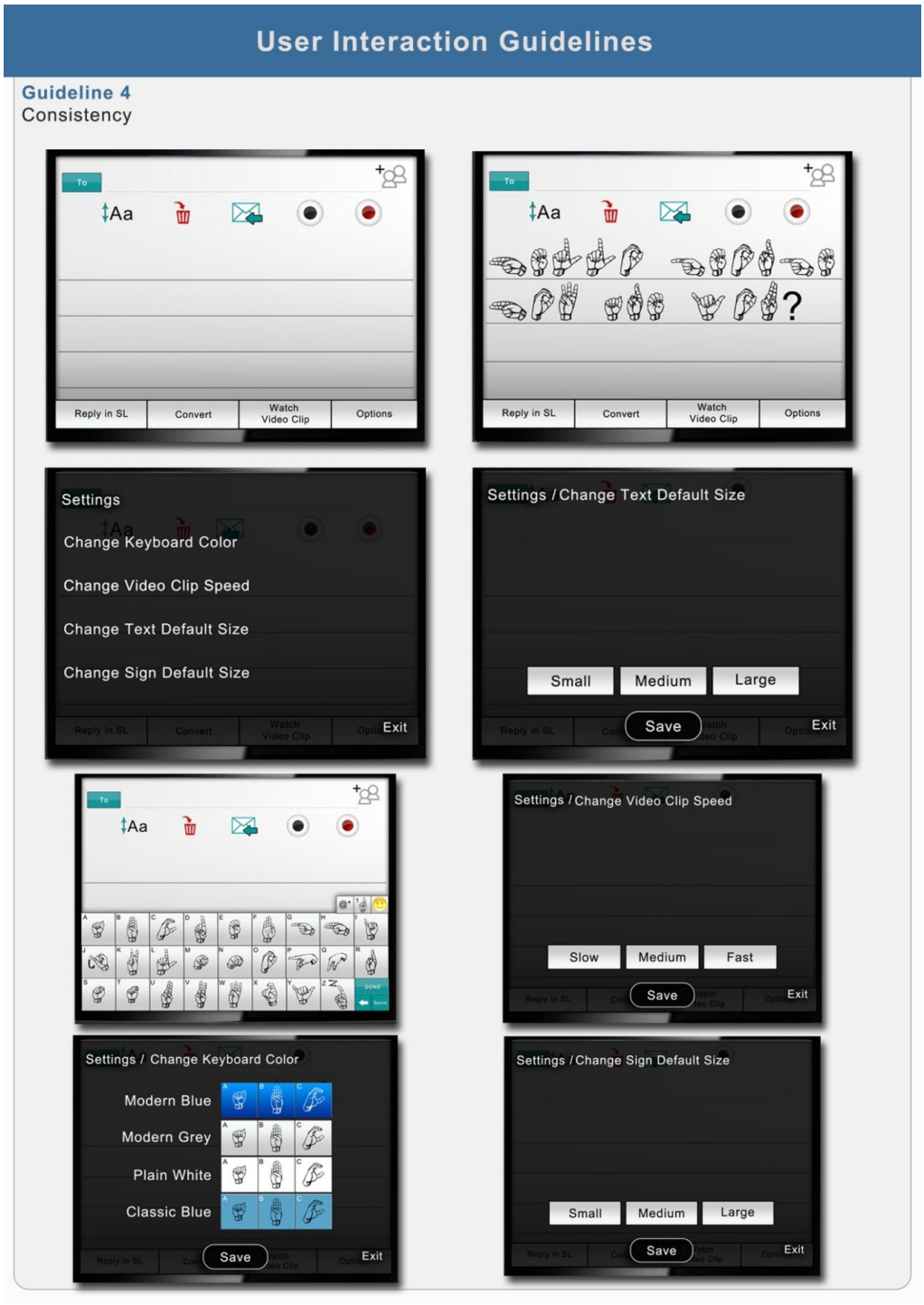


Figure 5.12: Proposed guideline 10

- Consistency

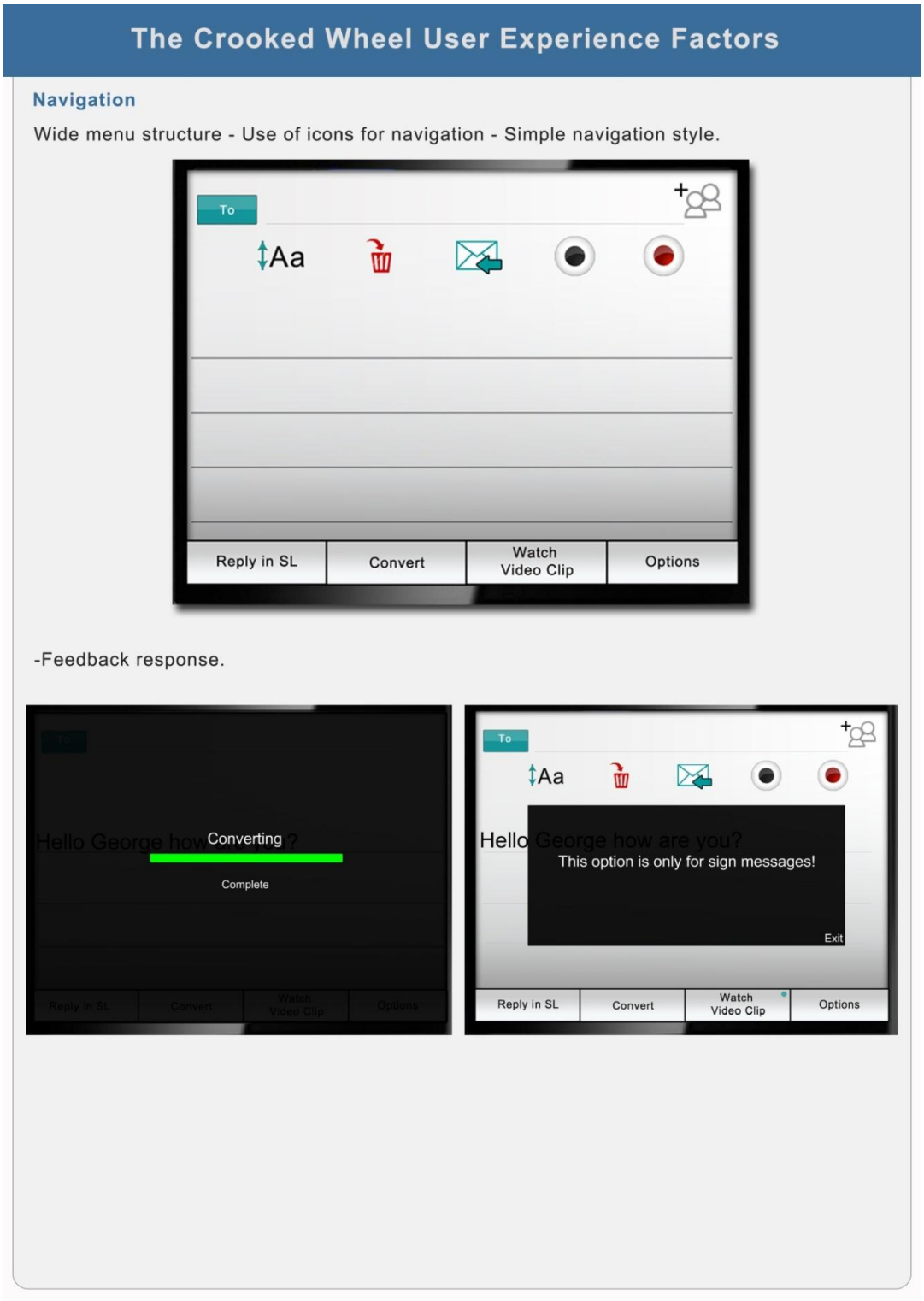


Figure 5.13: Proposed guideline 17

- **Navigation -** Wide menu structure - Use of icons for navigation - Simple navigation style Feedback response.

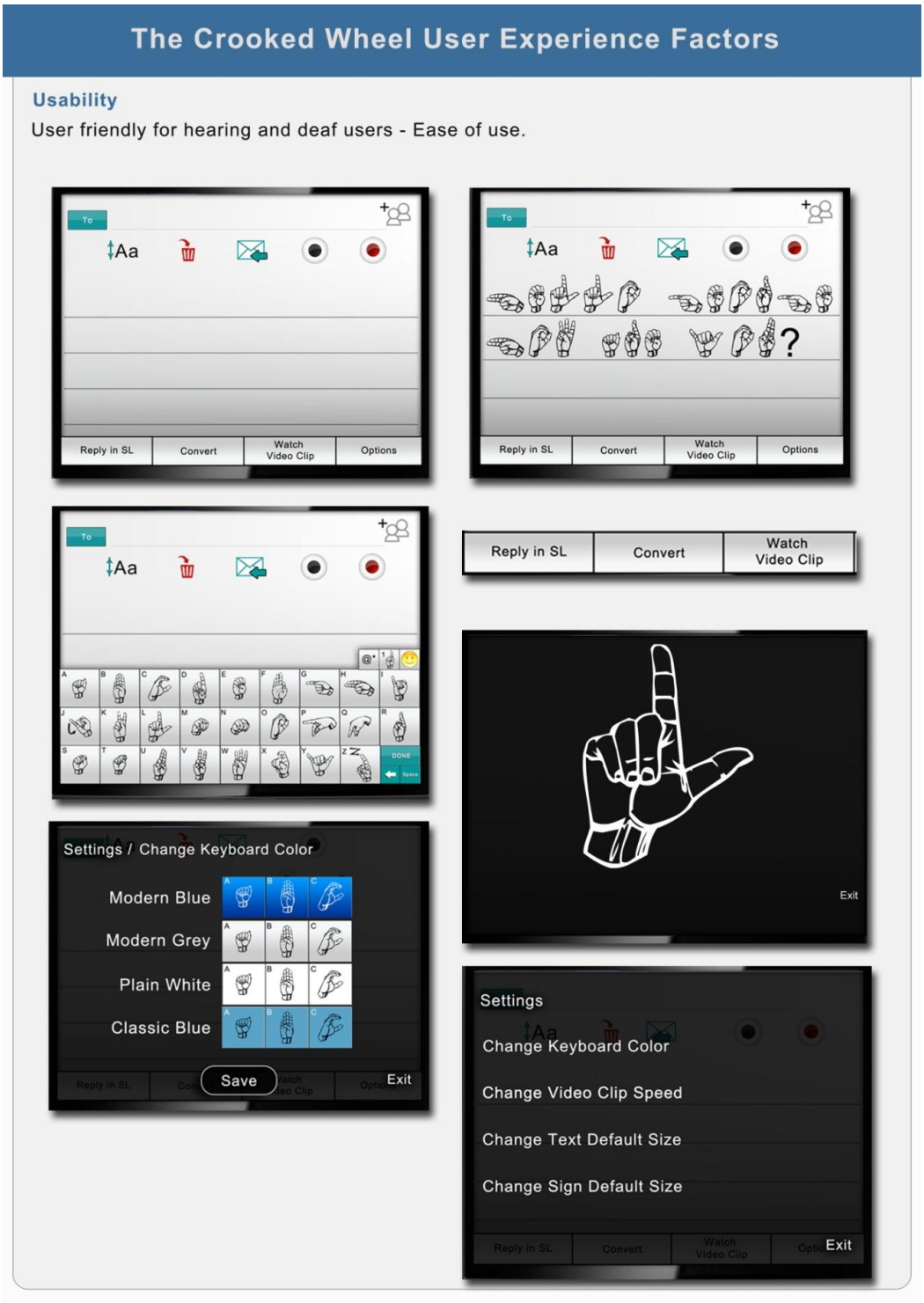


Figure 5.14: Proposed guideline 18

- **Usability** – User-friendly for hearing and deaf users - Effectiveness, efficiency and satisfaction and Ease of use.

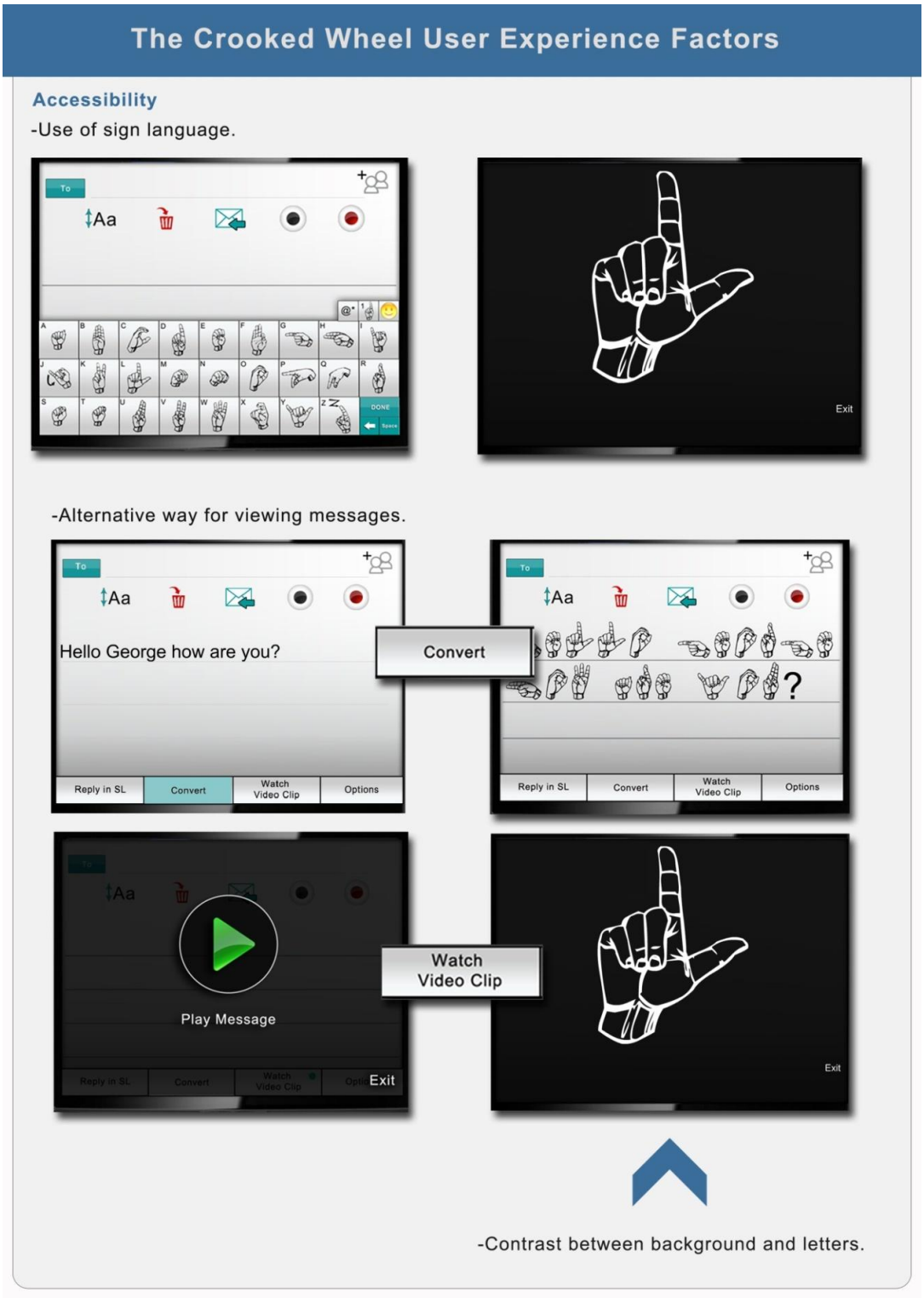


Figure 5.15: Proposed guideline 19

- **Accessibility -** Use of sign language - Contrast between background and letters - Use of simple English - Alternative way for viewing messages.

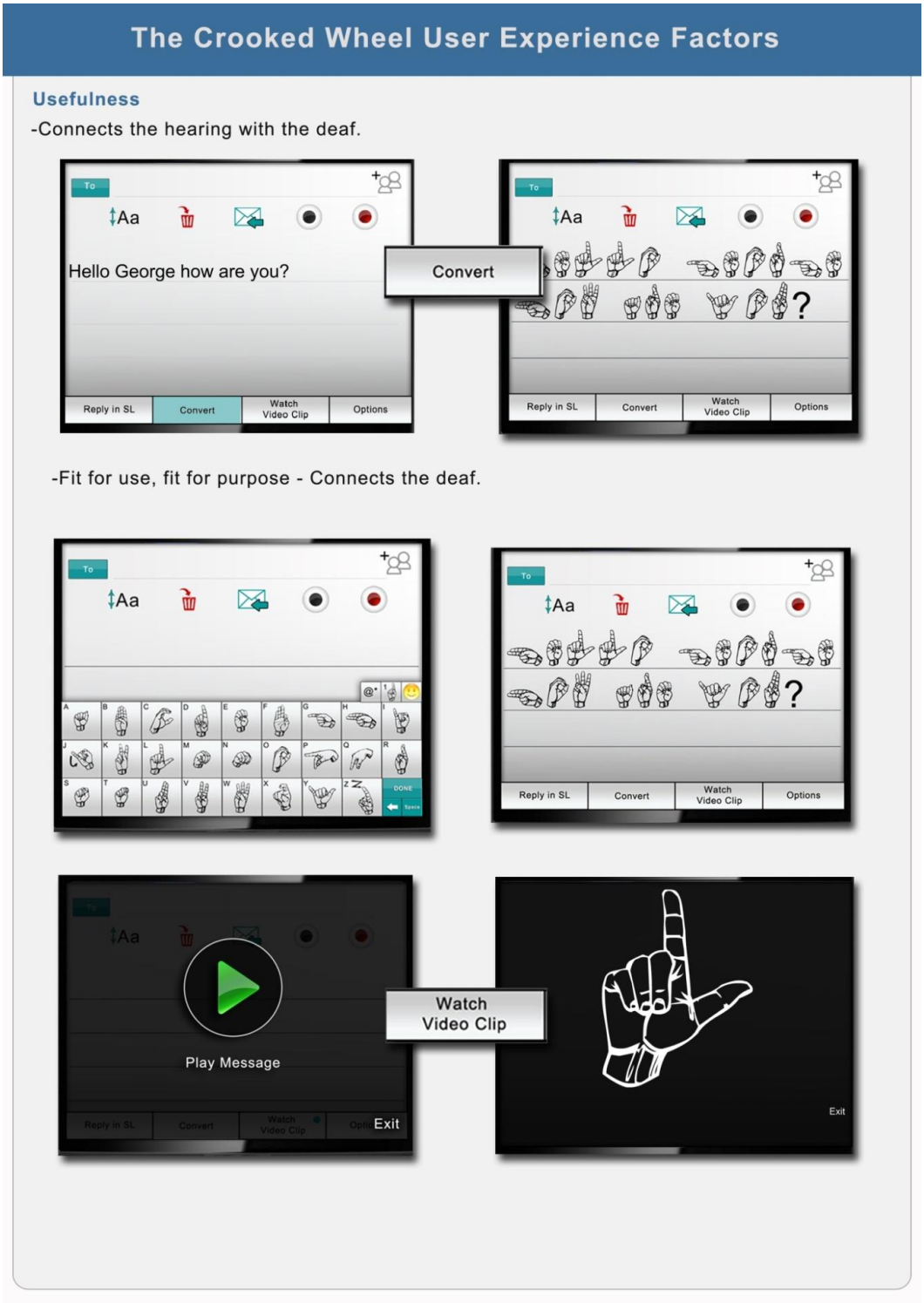


Figure 5.16: Proposed guideline 20

- **Usefulness -** Connects the hearing with the Deaf - Fit for use, fit for purpose - Connects the Deaf.

5.7 Summary

The aim of this chapter was to point out and make clear what research process was followed and applied to this research project. This chapter acted as a link to all the previous chapters. The goal of this chapter was to show the proposed guidelines in context. Therefore, the high fidelity prototype design of Signchat was introduced, demonstrating how the guidelines were applied to the design. Chapter 6 outlines the progress of the research process and presents the collected and analysed data.

Layout of Chapter 6

CHAPTER 6: Research Findings and Results

6.1 Introduction

The previous chapter described the research design and the methodology, and discussed topics regarding the research process that was adapted for this study. This chapter presents the findings of the study, in terms of the analysis and interpretation of the data obtained from the data collection process. The data collection instruments were designed to investigate the usability and accessibility of the guidelines applied to Signchat. The data collected from the case study are analysed and presented as follows:

- Participant's biographical data;
- Participant's warm-up comments;
- Usability testing;
- Post-test questionnaire results; and
- General comments.

6.2 Biographical Data Analysis

This questionnaire was used to gather the biographical detail of the participants involved in the usability testing. A total of ten participants were recruited for the biographical data collection. Participants were categorized into two groups, namely the English group (no knowledge of sign language) and the sign language group. The following demographic data were collected:

6.2.1Biographical data from group 1 (English group)

PARTICIPANTS	*Questions*														
	1	***2***	***3***	***4***	***5***	***6***	***7***	***8***	***9***						
	Age	Gender	Education status	Home language	Owner of Cell phone	For how long have you had a cell phone?	Level of cell phone experience	Family or deaf acquaint-ance	Use of cell phone						
									SMS	MMS	EMAILS	INTERNET	CALLS	APPS
P1	27	Female	Masters	English	Yes	13 years	Expert	No	*	*	*	*	*	
P2	23	Male	Masters	Afrikaans	Yes	10+years	Intermediate	No	*		*	*	*	
P3	39	Male	PHD	Afrikaans	Yes	10+years	Expert	No	*	*	*	*	*	*
P4	40	Female	PHD	Afrikaans	Yes	15+years	Intermediate	Yes	*				*	
P5	16	Female	Grade 11	English	Yes	5 years	Intermediate	No	*	*		*	*	*

Table 6.1: Biographical data from group 1 (English group)

Table 6.1 presents the biographical data collected from group 1. The first group consisted of five participants between the ages of sixteen and forty years old, three of which were female and two of which were male. Two of the participants had completed a PHD degree, two a masters degree and one had completed grade 11. Out of the five participants, the home language of three of them was Afrikaans and that of the rest was English.

Out of the five participants, only one had a deaf family member or acquaintance. All of the users were owners of a cell phone and had been using a cell phone for a period of between five and fifteen years. Three respondents rated their expertise regarding cell phones as intermediate and the remaining two as experts. All five participants used their cell phones for sending SMSes, three of them for MMS, three for emails, four for Internet, all five for phone calls and finally two for applications.

6.2.2 Biographical data from group 2 (Sign language group)

Questions										
PARTICIPANTS	1	2	3	4	5	6	7	8		9
	Age	Gender	Education status	Home Sign language	Age at which deafness occurred	Type of deafness	Level of deafness	Age of onset		How long have you been using sign language
								PRI-LINGUAL	POST-LINGUAL	
P1	46	Male	Step 7	SASL	Birth	Sensorieneural	Profound	*		40 Years
P2	46	Female	Standard 5	Xhosa	8 Years old	Sensorieneural	Mild	*		39 Years
P3	39	Female	Grade 10	Xhosa	Birth	Sensorieneural	Moderate	*		21 Years
P4	41	Female	Diploma	N/A	N/A	N/A	N/A	N/A	N/A	14 Years
P5	40	Female	Diploma	N/A	N/A	N/A	N/A	N/A	N/A	11 Years

Questions Continue												
PARTICIPANTS	10	11	12	13	14	15						
	Are your parents Deaf?	Have you received formal sign language training?	Owner of Cell phone	For how long have you had a cell phone?	Level of cell phone experience	Use of cell phone						
						SMS	MMS	EMAILS	INTERNET	CALLS	APPS
P1	No	No	Yes	6 Years	Intermediate	*					
P2	No	No	Yes	7 Years	Intermediate	*					
P3	No	Yes	Yes	11 Years	Intermediate	*				*	*
P4	No	Yes	Yes	12 Years	Expert	*				*	
P5	No	Yes	Yes	12 Years	Intermediate	*				*	

Table 6.2: Biographical data from group 2 (Sign language group)

Table 6.2 presents the biographical data collected from group 2. The second group consisted of five participants between the ages of thirty nine and forty six years old, four which were female and one male. Two of the participants had completed a diploma, one had completed Standard 5, one had completed Grade 10 and one had completed Step 7, which refers to a level of the sign language education system. Out of the five participants, two had Xhosa sign language as home language, and one used South African Sign Language (SASL). The remaining two had no home sign language as they were not deaf, but teachers that taught sign language. Two of the respondents were born deaf, one was deaf from the age of eight and the remaining two were the teachers who were not deaf. All three of the deaf participant's type of deafness was sensorieneural, meaning that the minute hair cells in the cochlea in the inner ear had sustained some damage.

In terms of the level of deafness one participant was profoundly deaf meaning completely deaf, the second participant was mildly deaf and the last participant was moderately deaf. For all three participants deafness was pre-lingual, which means that deafness occurred before they had learnt the English language. The period of time for which the participants had been using sign language varied between eleven and forty years. Three of them had at one point received formal sign language training. None of the three deaf participants or the two teachers had deaf parents.

All of the users were owners of a cell phone and had been using a cell phone for a period of between six and twelve years. Four respondents rated their expertise regarding cell phones as intermediate, and the remaining one as expert. All five participants used their cell phones for sending SMSes, three for phone calls and one for applications.

6.3 Participants' Warm-up Comments

Upon completion of the biographical data questionnaire, the users (both groups) were presented with screenshots of the Signchat mobile application. The participants were asked to comment on each screenshot. This was optional, and not all the participants left comments.

The warm-up section was a series of screenshots of the application (see table 6.3), which allowed the participants to become familiarized with the application before viewing the demo. Some of the comments and questions written by the participants during their viewing of the screenshots were answered when they viewed the demo. For example, for photo nine (refer to appendix M table M: 9) one participant requested demonstrations of the different sizes of text. This was displayed when the participant viewed the demo. One must keep in mind that the purpose of the warm-up was only to familiarize the user with environment, and not to test matters such as interface, navigation, usefulness, usability and accessibility. These elements were tested by viewing the demo and by answering the post-test questionnaire.

	**Participant 1:** Overall great screenshots. Might be worth having a caption explaining each screenshot.
	Participant 2: No comment
	Participant 3: No comment
	Participant 4: No Comment
	Participant 5: Cool logo

Table 6.3: Comments for photo 1

6.4 Post-test Questionnaire Results

After viewing the demo, the participants were presented with a post-test questionnaire. The questionnaire was rated according to the Likert scale, with five ratings which included strongly agree, agree, undecided, disagree and strongly disagree. The purpose of the questionnaire was to test and obtain the participants' opinions regarding the following:

- Interface;
- Navigation;

- Usefulness;
- Usability; and
- Accessibility.

The results of the questionnaire were analysed by means of the top-2-boxes and bottom-2-boxes response technique (Tullis and Albert, 2008). Top boxes represent the response options available to the participants as well as the number of respondents that participated in the questionnaire. Bottom boxes represent the responses as a percentage of all the participants. Results from both groups were analysed with the top-2-boxes and bottom-2-boxes response technique, allowing one to view the results from each group separately. In addition, results from both groups were combined and displayed in pie charts in order to represent the overall responses from all the participants.

6.4.1 Post-test questionnaire results for group 1 (English group)

Interface questions

1. The interface of the phone application was user-friendly.					
Response options	**Strongly agree**	**Agree**	**Undecided**	**Disagree**	**Strongly disagree**
Participant count	2	3			
Percentage	**40%**	**60%**			

Table 6.4: Results from question 1

Forty per cent of the participants strongly agreed while sixty per cent agreed that the application was user-friendly. It can therefore be concluded that the application is user-friendly.

2. I like using the interface of this phone application.					
Response options	**Strongly agree**	**Agree**	**Undecided**	**Disagree**	**Strongly disagree**
Participant count	4	1			
Percentage	**80%**	**20%**			

Table 6.5: Results from question 2

Eighty per cent of the participants strongly agreed while twenty per cent agreed that they liked using the application. It can therefore be concluded that the application is likeable.

3. I find the design consistent throughout the phone application design.					
Response options	**Strongly agree**	**Agree**	**Undecided**	**Disagree**	**Strongly disagree**
Participant count	3		1	1	
Percentage	**60%**		**20%**	**20%**	

Table 6.6: Results from question 3

Sixty per cent of the participants strongly agreed while twenty per cent were undecided and twenty per cent disagreed that the design of the application was consistent. It can therefore be concluded that the majority found the design consistent.

4. The phone application has the functions and features I expect it to have.					
Response options	**Strongly agree**	**Agree**	**Undecided**	**Disagree**	**Strongly disagree**
Participant count	4	1			
Percentage	**80%**	**20%**			

Table 6.7: Results from question 4

Eighty per cent of the participants strongly agreed while twenty per cent agreed that the application had all the features they expected from such an application. It can therefore be concluded that the application had all the necessary functions and features.

5. I find the colours of the phone application pleasant.					
Response options	**Strongly agree**	**Agree**	**Undecided**	**Disagree**	**Strongly disagree**
Participant count	5				
Percentage	**100%**				

Table 6.8: Results from question 5

Hundred per cent of the participants strongly agreed that the colors of application were pleasant. It can therefore be concluded that the colors used for the design of the application was successful.

6. Overall I am satisfied with the design of the phone application.					
Response options	**Strongly agree**	**Agree**	**Undecided**	**Disagree**	**Strongly disagree**
Participant count	3	2			
Percentage	**60%**	**40%**			

Table 6.9: Results from question 6

Sixty per cent of the participants strongly agreed while forty per cent agreed that they were satisfied with the design of the application. It can therefore be concluded that the design of the application was successful.

Navigation

7. I find the phone application easy to navigate.					
Response options	**Strongly agree**	**Agree**	**Undecided**	**Disagree**	**Strongly disagree**
Participant count	2	2	1		
Percentage	**40%**	**40%**	**20%**		

Table 6.10: Results from question 7

Forty per cent strongly agreed and forty per cent agreed while twenty per cent was undecided regarding the ease of navigation of the application. It can therefore be concluded that the navigation of the application was successful.

8. The phone application requires the fewest steps to accomplish what you want to do.					
Response options	**Strongly agree**	**Agree**	**Undecided**	**Disagree**	**Strongly disagree**
Participant count	4	1			
Percentage	**80%**	**20%**			

Table 6.11: Results from question 8

Eighty per cent of the participants strongly agreed while twenty per cent agreed that the phone application requires the fewest steps to accomplish what you want to do. It can therefore be concluded that the structure of the application was successful.

9. The placement of the functions (buttons) was appropriate.					
Response options	**Strongly agree**	**Agree**	**Undecided**	**Disagree**	**Strongly disagree**
Participant count	4			1	
Percentage	**80%**			**20%**	

Table 6.12: Results from question 9

Eighty per cent of the participants strongly agreed while twenty per cent disagreed that the placement of the functions were appropriate. It can therefore be concluded that the majority found the placement of the functions appropriate.

10. The functions placed on the home screen were important.					
Response options	**Strongly agree**	**Agree**	**Undecided**	**Disagree**	**Strongly disagree**
Participant count	4		1		
Percentage	**80%**		**20%**		

Table 6.13: Results from question 10

Eighty per cent of the participants strongly agreed while twenty per cent were undecided regarding the importance of the functions placed on the home screen. It can therefore be concluded that the majority found the functions placed on the home screen appropriate.

11. Do you agree with the use of icons instead of text on the home screen?		
Response options	**Yes**	**No**
Participant count	5	
Percentage	**100%**	

Table 6.14: Results from question 11

Hundred per cent of the participants agreed with the use of icons rather than text on the home screen.

12. Did you find yourself at any point confused or not knowing where you are and what to expect next?		
Response options	**Yes**	**No**
Participant count	3	2
Percentage	**60%**	**40%**

Table 6.15: Results from question 12

When asked if at any point they were confused or not knowing where they were and what to expect next, sixty per cent of the participants replied yes while forty per cent replied no.

Usefulness

13. Do you find this phone application useful?		
Response options	**Yes**	**No**
Participant count	5	
Percentage	**100%**	

Table 6.16: Results from question 13

Hundred per cent of the participants agreed that the application is useful. It can therefore be acknowledged without doubt that the application is useful.

14. Would you recommend this phone application to a friend?		
Response options	**Yes**	**No**
Participant count	5	
Percentage	**100%**	

Table 6.17: Results from question 14

Hundred per cent of the participants replied yes when they were asked if they would recommend this application to others.

15. Do you believe that you can benefit from this phone application?		
Response options	**Yes**	**No**
Participant count	5	
Percentage	**100%**	

Table 6.18: Results from question 15

Hundred per cent of the participants agreed that they can benefit from the application. The importance of the application can therefore be acknowledged without doubt.

16. I believe I can improve my communication skills with this phone application.					
Response options	**Strongly agree**	**Agree**	**Undecided**	**Disagree**	**Strongly disagree**
Participant count	4	1			
Percentage	**80%**	**20%**			

Table 6.19: Results from question 16

Eighty per cent of the participants strongly agreed while twenty per cent agreed that they can improve their communication skills with the application. It can therefore be concluded that the application has more to offer than only sending and viewing messages.

17. I believe I can communicate with hearing/deaf people with this phone application.					
Response options	**Strongly agree**	**Agree**	**Undecided**	**Disagree**	**Strongly disagree**
Participant count	5				
Percentage	**100%**				

Table 6.20: Results from question 17

Hundred per cent of the participants strongly agreed that the application can help deaf and hearing people to communicate over cell phones.

Usability

18. I am satisfied with how easy the phone application is to use.					
Response options	**Strongly agree**	**Agree**	**Undecided**	**Disagree**	**Strongly disagree**
Participant count	3	1	1		
Percentage	**60%**	**20%**	**20%**		

Table 6.21: Results from question 18

Sixty per cent of the participants strongly agreed while twenty per cent agreed and twenty per cent were undecided on how easy the application was to use. It can therefore be concluded that the majority found that the application was easy to use.

19. I felt comfortable using the phone application.					
Response options	**Strongly agree**	**Agree**	**Undecided**	**Disagree**	**Strongly disagree**
Participant count	4	1			
Percentage	**80%**	**20%**			

Table 6.22: Results from question 19

Eighty per cent of the participants strongly agreed while twenty per cent agreed that they felt comfortable using the application.

20. It was easy to find the information I needed.					
Response options	**Strongly agree**	**Agree**	**Undecided**	**Disagree**	**Strongly disagree**
Participant count	4	1			
Percentage	**80%**	**20%**			

Table 6.23: Results from question 20

Eighty per cent of the participants strongly agreed and twenty per cent agreed that it was easy to find the information they needed while using the application.

21. The information in the settings was easy to understand.					
Response options	**Strongly agree**	**Agree**	**Undecided**	**Disagree**	**Strongly disagree**
Participant count	4		1		
Percentage	**80%**		**20%**		

Table 6.24: Results from question 21

Eighty per cent of the participants strongly agreed and twenty per cent were undecided regarding how easy it was to understand the information in the settings. The majority found the information in the settings easy to understand.

22. The features on the home screen were easy to understand.					
Response options	**Strongly agree**	**Agree**	**Undecided**	**Disagree**	**Strongly disagree**
Participant count	2	3			
Percentage	**40%**	**60%**			

Table 6.25: Results from question 22

Forty per cent of the participants strongly agreed and the remaining sixty per cent agreed that the features on the home screen were easy to understand.

Accessibility

23. Did you find the level of English hard to understand?		
Response options	**Yes**	**No**
Participant count		5
Percentage		**100%**

Table 6.26: Results from question 23

Hundred per cent of the participants agreed that the level of English used in the application was not hard for them to understand.

24. Did you find the sign language keyboard easy to understand?		
Response options	**Yes**	**No**
Participant count	5	
Percentage	**100%**	

Table 6.27: Results from question 24

Hundred per cent of the participants agreed that the sign language keyboard was easy to understand.

25. Did you find the convert feature useful?		
Response options	**Yes**	**No**
Participant count	5	
Percentage	**100%**	

Table 6.28: Results from question 25

Hundred per cent of the participants agreed that the *convert* feature is useful.

26. Did you find the watch video clip feature useful?		
Response options	**Yes**	**No**
Participant count	5	
Percentage	**100%**	

Table 6.29: Results from question 26

Hundred per cent of the participants agreed that the *watch video clip* feature is useful.

27. Was the sign language message easy to distinguish from the background?		
Response options	**Yes**	**No**
Participant count	5	
Percentage	**100%**	

Table 6.30: Results from question 27

Hundred per cent of the participants agreed that the message was easy to distinguish from the background.

28. Was the sign language video clip message easy to distinguish from the background?		
Response options	**Yes**	**No**
Participant count	5	
Percentage	**100%**	

Table 6.31: Results from question 28

Hundred per cent of the participants agreed that the video clip message was easy to distinguish from the background.

29. Does this phone application meet your needs?		
Response options	**Yes**	**No**
Participant count	5	
Percentage	**100%**	

Table 6.32: Results from question 29

Hundred per cent of the participants agreed that the application satisfies and meets their needs.

6.4.2 Post-test questionnaire results for group 2 (sign language group)

Interface questions

1. The interface of the phone application was user-friendly.					
Response options	**Strongly agree**	**Agree**	**Undecided**	**Disagree**	**Strongly disagree**
Participant count	5				
Percentage	**100%**				

Table 6.33: Results from question 1

Hundred per cent of the participants strongly agreed that the application was user-friendly. It can therefore be concluded that the application is user-friendly.

2. I like using the interface of this phone application.					
Response options	**Strongly agree**	**Agree**	**Undecided**	**Disagree**	**Strongly disagree**
Participant count	5				
Percentage	**100%**				

Table 6.34: Results from question 2

Hundred per cent of the participants strongly agreed that the interface of the application was enjoyable to use. It can therefore be concluded that the interface design was successful.

3. I find the design consistent throughout the phone application design.					
Response options	**Strongly agree**	**Agree**	**Undecided**	**Disagree**	**Strongly disagree**
Participant count	1	4			
Percentage	**20%**	**80%**			

Table 6.35: Results from question 3

Twenty per cent of the participants strongly agreed while eighty agreed that the design of the application was consistent. It can therefore be concluded that the design of the application was consistent.

4. The phone application has the functions and features I expect it to have.					
Response options	**Strongly agree**	**Agree**	**Undecided**	**Disagree**	**Strongly disagree**
Participant count	2	3			
Percentage	**40%**	**60%**			

Table 6.36: Results from question 4

Forty per cent of the participants strongly agreed while sixty per cent agreed that the application had all the features they expected from such an application. It can therefore be concluded that the application had all the necessary functions and features.

5. I find the colours of the phone application pleasant.					
Response options	**Strongly agree**	**Agree**	**Undecided**	**Disagree**	**Strongly disagree**
Participant count	5				
Percentage	**100%**				

Table 6.37: Results from question 5

Hundred per cent of the participants strongly agreed that the colors of application were pleasant. It can therefore be concluded that the colors used for the design of the application was successful.

6. Overall I am satisfied with the design of the phone application.					
Response options	**Strongly agree**	**Agree**	**Undecided**	**Disagree**	**Strongly disagree**
Participant count	5				
Percentage	**100%**				

Table 6.38: Results from question 6

Hundred per cent of the participants strongly agreed that they were satisfied with the design of the application. It can therefore be concluded that the design of the application was successful.

Navigation

7. I find the phone application easy to navigate.					
Response options	**Strongly agree**	**Agree**	**Undecided**	**Disagree**	**Strongly disagree**
Participant count	4	1			
Percentage	**80%**	**20%**			

Table 6.39: Results from question 7

Eighty per cent strongly agreed while twenty per cent agreed regarding the ease of navigation of the application. It can therefore be concluded that the navigation of the application was successful.

8. The phone application requires the fewest steps to accomplish what you want to do.					
Response options	**Strongly agree**	**Agree**	**Undecided**	**Disagree**	**Strongly disagree**
Participant count	5				
Percentage	**100%**				

Table 6.40: Results from question 8

Hundred per cent of the participants strongly agreed that the phone application requires the fewest steps to accomplish what you want to do. It can therefore be concluded that the structure of the application was successful.

9. The placement of the functions (buttons) was appropriate.					
Response options	**Strongly agree**	**Agree**	**Undecided**	**Disagree**	**Strongly disagree**
Participant count	5				
Percentage	**100%**				

Table 6.41: Results from question 9

Hundred per cent of the participants strongly agreed that the placement of the functions were appropriate. It can therefore be concluded that the placement of the functions appropriate.

10. The functions placed on the home screen were important.					
Response options	**Strongly agree**	**Agree**	**Undecided**	**Disagree**	**Strongly disagree**
Participant count	5				
Percentage	**100%**				

Table 6.42: Results from question 10

Hundred per cent of the participants strongly agreed regarding the importance of the functions placed on the home screen. It can therefore be concluded that the functions placed on the home screen are important.

11. Do you agree with the use of icons instead of text on the home screen?		
Response options	**Yes**	**No**
Participant count	5	
Percentage	**100%**	

Table 6.43: Results from question 11

Hundred per cent of the participants agreed with the use of icons rather than text on the home screen.

12. Did you find yourself at any point confused or not knowing where you are and what to expect next?		
Response options	**Yes**	**No**
Participant count		5
Percentage		**100%**

Table 6.44: Results from question 12

When asked if at any point they were confused or not knowing where they were and what to expect next, hundred per cent of the participants replied no.

Usefulness

13. Do you find this phone application useful?		
Response options	**Yes**	**No**
Participant count	5	
Percentage	**100%**	

Table 6.45: Results from question 13

Hundred per cent of the participants agreed that the application is useful. It can therefore be acknowledged without doubt that the application is useful.

14. Would you recommend this phone application to a friend?		
Response options	**Yes**	**No**
Participant count	5	
Percentage	**100%**	

Table 6.46: Results from question 14

Hundred per cent of the participants replied yes when they were asked if they would recommend this application to others.

15. Do you believe that you can benefit from this phone application?		
Response options	**Yes**	**No**
Participant count	5	
Percentage	**100%**	

Table 6.47: Results from question 15

Hundred per cent of the participants agreed that they can benefit from the application. The importance of the application can therefore be acknowledged without doubt.

16. I believe I can improve my communication skills with this phone application.					
Response options	**Strongly agree**	**Agree**	**Undecided**	**Disagree**	**Strongly disagree**
Participant count	5				
Percentage	**100%**				

Table 6.48: Results from question 16

Hundred per cent of the participants strongly agreed that they can improve their communication skills with the application. It can therefore be concluded that the application has more to offer than only sending and viewing messages.

17. I believe I can communicate with hearing/deaf people with this phone application.					
Response options	**Strongly agree**	**Agree**	**Undecided**	**Disagree**	**Strongly disagree**
Participant count	5				
Percentage	**100%**				

Table 6.49: Results from question 17

Hundred per cent of the participants strongly agreed that the application can help deaf and hearing people to communicate over cell phones.

Usability

18. I am satisfied with how easy the phone application is to use.					
Response options	**Strongly agree**	**Agree**	**Undecided**	**Disagree**	**Strongly disagree**
Participant count	2	3			
Percentage	**40%**	**60%**			

Table 6.50: Results from question 18

Forty per cent of the participants strongly agreed while sixty per cent agreed on how easy the application was to use. It can therefore be concluded that the application is easy to use.

19. I felt comfortable using the phone application.					
Response options	**Strongly agree**	**Agree**	**Undecided**	**Disagree**	**Strongly disagree**
Participant count	5				
Percentage	**100%**				

Table 6.51: Results from question 19

Hundred per cent of the participants strongly agreed that they felt comfortable using the application.

20. It was easy to find the information I needed.					
Response options	**Strongly agree**	**Agree**	**Undecided**	**Disagree**	**Strongly disagree**
Participant count	5				
Percentage	**100%**				

Table 6.52: Results from question 20

Hundred per cent of the participants strongly agreed that it was easy to find the information they needed while using the application.

21. The information in the settings was easy to understand.					
Response options	**Strongly agree**	**Agree**	**Undecided**	**Disagree**	**Strongly disagree**
Participant count	5				
Percentage	**100%**				

Table 6.53: Results from question 21

Hundred per cent of the participants strongly agreed regarding how easy it was to understand the information in the settings.

22. The features on the home screen were easy to understand.					
Response options	**Strongly agree**	**Agree**	**Undecided**	**Disagree**	**Strongly disagree**
Participant count	4	1			
Percentage	**80%**	**20%**			

Table 6.54: Results from question 22

Eighty per cent of the participants strongly agreed and the remaining twenty agreed that the features on the home screen were easy to understand.

Accessibility

23. Did you find the level of English hard to understand?		
Response options	**Yes**	**No**
Participant count	3	2
Percentage	**60%**	**40%**

Table 6.55: Results from question 23

Sixty per cent of the participants replied yes and forty replied no, regarding the level of English used in the application and whether or not it was hard for them to understand it.

24. Did you find the sign language keyboard easy to understand?		
Response options	**Yes**	**No**
Participant count	5	
Percentage	**100%**	

Table 6.56: Results from question 24

Hundred per cent of the participants agreed that the sign language keyboard was easy to understand.

25. Did you find the convert feature useful?		
Response options	**Yes**	**No**
Participant count	5	
Percentage	**100%**	

Table 6.57: Results from question 25

Hundred per cent of the participants agreed that the *convert* feature is useful.

26. Did you find the watch video clip feature useful?		
Response options	**Yes**	**No**
Participant count	5	
Percentage	**100%**	

Table 6.58: Results from question 26

Hundred per cent of the participants agreed that the *watch video clip* feature is useful.

27. Was the sign language message easy to distinguish from the background?		
Response options	**Yes**	**No**
Participant count	5	
Percentage	**100%**	

Table 6.59: Results from question 27

Hundred per cent of the participants agreed that the message was easy to distinguish from the background.

28. Was the sign language video clip message easy to distinguish from the background?		
Response options	**Yes**	**No**
Participant count	5	
Percentage	**100%**	

Table 6.60: Results from question 28

Hundred per cent of the participants agreed that the video clip message was easy to distinguish from the background.

29. Does this phone application meet your needs?		
Response options	**Yes**	**No**
Participant count	5	
Percentage	**100%**	

Table 6.61: Results from question 29

Hundred per cent of the participants agreed that the application satisfies and meets their needs.

6.4.3 Post-test questionnaire results from both groups combined

In this section the results from the post-test questionnaire from both groups were combined and displayed in pie charts. Since Signchat is intended for both hearing impaired and hearing in this section the results are shown as one. Purpose of this section is to display the overall results and reveal if indeed Signchat satisfies both groups. The results were positive and reveal that Signchat does satisfy both groups. To view the pie charts refer to appendix N for further details.

6.5 General comments

This section lists general verbal comments that were provided by the participants during the usability testing. The comments are not linked to a specific participant, and are not presented in any specific order:

- I have never seen something like this on a phone;
- I like the fingerspelling keyboard;
- I like the emotions keyboard;
- It is like a conversation, it is a good way of communicating;
- I like the option for replying in sign language;
- I like that there are letters and signs on the keyboard;
- Change of speed is good for various users;
- Plain white looks good;
- Black and white is clear in sign language;
- It can help Deaf people to learn sign language as well;
- I don’t have computer skills but Signchat was easy to understand;
- Icons add video or image not easy to understand;
- English used is good;
- Like the blue keyboard, prefer using the blue keyboard at night time;
- The old Deaf do not understand the numbers on the keyboard;
- I like the play video message;
- Happy with the settings;
- After going through the application it was easy;

- I like the converting option makes it easy to understand;
- I like that I can choose a keyboard;
- Video clip feature is very helpful; and
- Add to send email feature as well.

6.6 Recommendations

The proposed guidelines were applied in the development of the prototype (Signchat). It was previously highlighted that the main concerns with deaf users relate to accessibility and interaction. In view of the results from the usability testing, it has been determined that the guidelines do indeed cater for the needs of Deaf people. The two major concerns, namely accessibility and Interaction between the end user and Signchat, were addressed successfully.

The guidelines used for the design of Signchat were mostly based on a literature study, in combination with the Guidelines for Telecoms Accessibility, User Interface Design Guidelines (Usability Heuristics by Jakob Nielsen), User Interaction Guidelines (Nielsen Norman Group, 2012), The Crooked Wheel User Experience Factors (compiled by researcher), “Web Content Accessibility Guidelines (WCAG) 2.0” and accessibility features used by major cell phone manufacturing companies. Refer to section 5.6 in chapter 5 for the final proposed guidelines. Based on the data and feedback collected from the participants, the following changes can be recommended in order to improve the Signchat application:

- Add an option to send and receive email;
- Change the add video or image icon; and
- Provide an extra text or sign size option.

6.7 Conclusions

Based on the feedback received from the participants and upon completion of the data analysis, it can be concluded that the implementation of the proposed guidelines in Signchat was successful. This was the case for all relevant variables, namely interface, navigation, usefulness, usability and accessibility. The data verify that the guidelines, applied to Signchat, do meet the needs of Deaf people.

Layout of Chapter 7

Chapter 7: Conclusion

7.1 Introduction

The purpose of this research study was to recommend a set of guidelines and then to apply them to the design of a mobile phone messaging application for deaf users. The application should take their needs into consideration and should present them with a user-friendly, modern design environment within which to function. It should provide them with the opportunity to integrate into the society, to socialize more and to communicate with other deaf or hearing people. It should in the process hopefully help to decrease the digital divide, while at the same time allowing them to improve their communication skills as well as their English. This final chapter provides a platform for summarizing the entire research study.

Section 7.2 provides an overview of the research. The research questions and objectives are presented and answered in section 7.3. Contributions made by the research are discussed in section 7.4. In section 7.5, the significance of research is discussed. Areas for future research are identified in section 7.6. The lessons learnt from this research experience are presented in section 7.7. Finally, a summary is presented in section 7.8.

7.2 Research Overview

The research began by reviewing the existing body of knowledge that relates to the area of interest. The literature review was discussed in chapters 2, 3 and 4. In particular, chapter 2 discussed Deafness and Sign Language and matters such as types of deafness and the different levels of deafness. Additionally, communication methods of Deaf people were discussed. These included a comparison between sign language and spoken language, as well as an overview of the different types of sign language. This was followed by an in-depth review of the South African sign language and sign writing.

In chapter 3, Accessible ICT to enhance communication and interaction was discussed, and the importance of accessibility to digital information was highlighted. Chapter 3 also investigated how Deaf people access information, the challenges with which they are

faced and the technologies that exist to support communication and interaction for deaf people. These include PCs, Text Phone Devices, Cell phones, Multimedia, Captioning, Transcripts, Speech to text (STT) and Hearing aids. Chapter 3 also discussed policies regarding ICT and disability. Such policies included ICT and people with hearing disability, South African ICT policy and people with disabilities. Chapter 3 ended with a discussion of ICT to support access to information and knowledge, ICT to support personal communication and interactions and finally ICT to support learning and teaching.

Topics such as user interface design, usability and UX factors and several guidelines were discussed in chapter 4. The purpose of chapter 4 was to introduce the guidelines that were used in the design of the Signchat application. The research design and methodology was presented in chapter 5. The research onion model was used to explain the methodology of this study. The participants and sampling were mentioned. In this chapter, HCI Research Disciplines were also discussed and the High Fidelity Prototype was presented.

Chapter 6 presented the research findings as well as an analysis of the data. Results were presented separately for the English group and sign language group. Combined results were also presented. The purpose was to present the opinion of both the groups, i.e. the English and the sign language group, since Signchat is intended for both. The data were analysed and recommendations were provided. Participants also provided feedback for improving Signchat.

7.3 Research Questions and Objectives

Based on the problem description and rationale in chapter 1, a primary research question and supporting sub-questions were derived. In this section, findings on the research questions and related objectives stated in Chapter 1 are discussed. The research process and methodology followed were critical in answering the primary and sub-questions. The research onion model was used as a platform, and this study identified the components of the research methodology. The research onion model

presented in Figure 7.1 is the adapted version that reflects the process applied for this study.

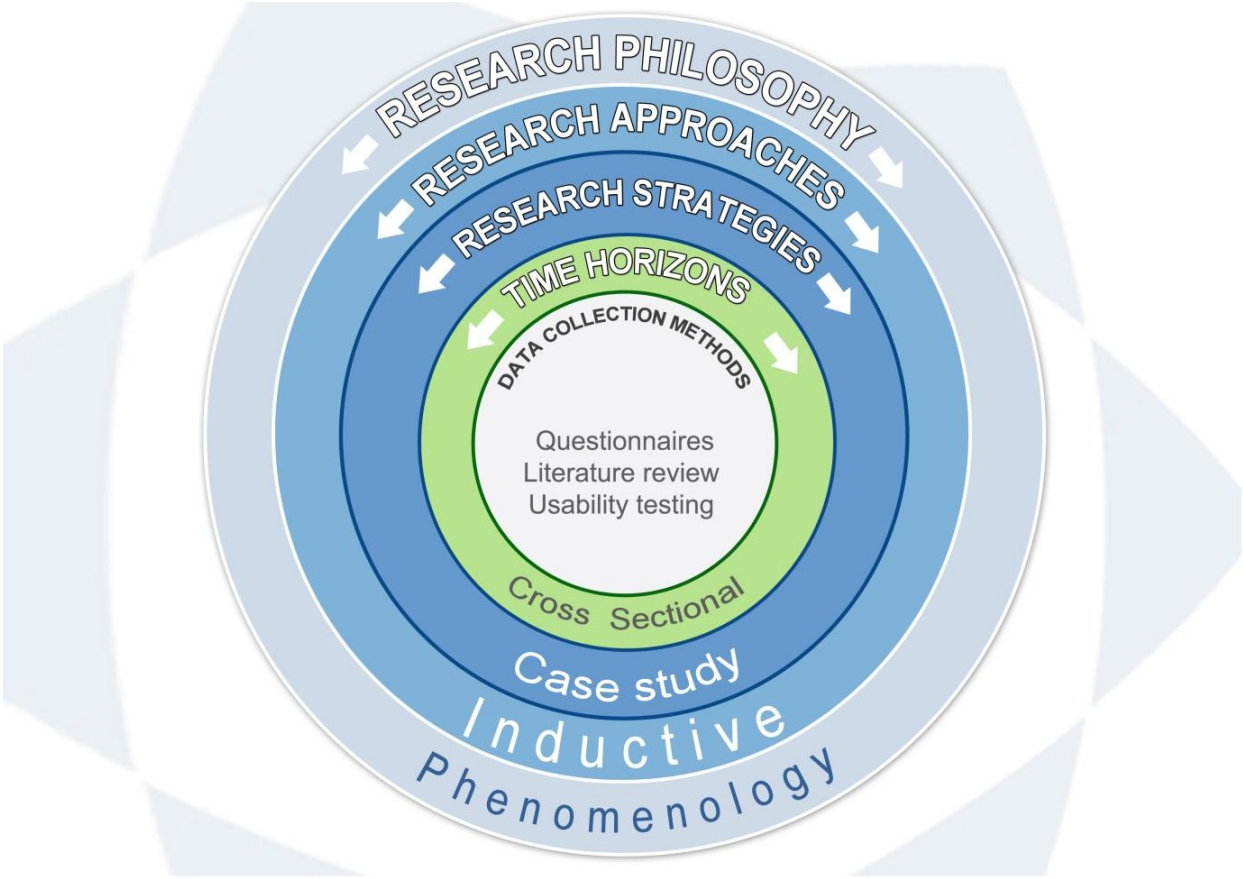


Figure 7.1: The process applied for this study (Adapted from Saunders *et al*, 2003)

7.3.1 Main research question

What are appropriate guidelines for the design of the user interface of a mobile application for deaf users?

7.3.2 Research question 1 and 4

1. **Which functionalities are currently available on a mobile device for use by deaf users?**

Corresponding research objective: *To define the current functionalities available on a mobile device for use by deaf users.*

4. **What are the typical means of communication and interaction for deaf users?**

Corresponding research objective*: To determine the most suited means of communication and interaction for deaf users.*

In-depth information regarding the research questions was gathered through a literature study. Data were collected through appropriate methods, and were analysed. The following features of a mobile messaging application for deaf users were identified:

- The text/signs must be clean and readable;
- High contrast display of text/signs;
- Large size of text ;
- Simple font;
- The text display area should be able to display a fair amount of text/signs;
- As less as possible delay in the process of translation;
- If interaction is intended to be frequent the design of wide structures is recommended for visual search;
- Multimedia tools are very important, especially video;
- Visual or vibrating alerts;
- Use of icons for navigation;
- Feedback response;
- Use of sign language;
- Use of simple English;
- Contrast between background and letters; and
- Alternative way for viewing messages.

With respect to the last component, Signchat provides three ways of viewing a message, i.e. in text, in sign and as sign in motion. Signchat also takes into consideration the age factor and experience of the deaf or hearing user, and allows the user to adjust the size of the text/signs and the speed of the sign display for his convenience.

7.3.3 Research question 2

2. What are the unique characteristics of deaf users?

Corresponding research objective: *To identify the unique characteristics of deaf users.*

In-depth information regarding the research question was gathered through a literature study. Deaf users are unique in that they:

- Generally have low literacy levels;
- Rarely achieve verbal language literacy;
- Are visual users and learners;
- Can function better in high contrast environments;
- Communicate through visual manual communication methods; and
- Are comparable with hearing users in visual tasks and environments.

7.3.4 Research question 3

3. **Which guidelines exist for the design of such applications?**

Corresponding research objective*: To determine the existing guidelines for the design of such applications.*

There are currently no guidelines that specifically focus on a messaging application for deaf people. The guidelines used for the design of Signchat were mostly based on a literature study, in combination with the following guidelines:

- Guidelines for Telecoms Accessibility;
- User Interface Design Guidelines (Usability Heuristics by Jakob Nielsen);
- User Interaction Guidelines (Nielsen Norman Group, 2012);
- The Crooked wheel User Experience Factors;
- The four basic principles of the “Web Content Accessibility Guidelines (WCAG) 2.0”; and
- Accessibility features regarding Deaf people that are used from major manufacturing companies such as Nokia, Apple, Samsung, Google android.

To reiterate, the proposed guidelines selected for the design of the high fidelity prototype are as follows (Figure 7.2).

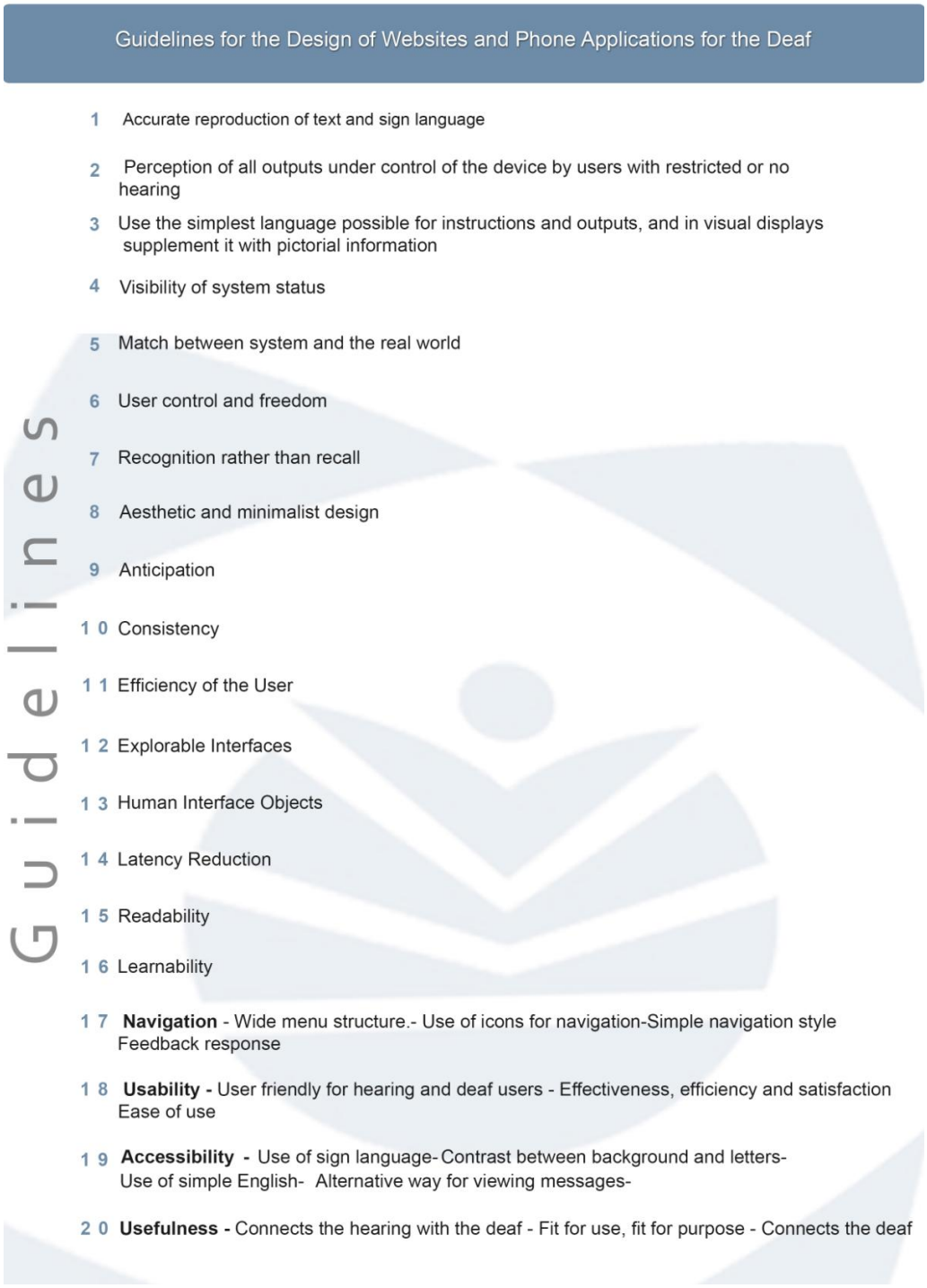


Figure 7.2: Proposed guidelines (compiled by researcher)

7.4 Contributions

The importance of developing these guidelines is highlighted throughout the dissertation. As noted throughout the dissertation, very limited information exists regarding ICT and the hearing impaired. It also highlights what a designer or developer must be aware of for a mobile application to be usable, understandable, user-friendly and effective for a deaf user.

7.5 Significance of Research

Signchat provides a unique application for the Deaf demographic, as no other similar mobile application exists. The data from the usability testing were summarized in chapter 6, and revealed the success of the application, as the results are very positive. From a design and functionality point of view, the application answers the needs of Deaf people. One must not neglect the human point of view and the value that the application has to offer the Deaf demographic.

As noted in the literature chapters, deaf people have low reading and writing skills. Signchat can therefore be perceived as a learning tool. It can help a deaf person to learn a spoken language, or even help a deaf person to learn sign language. Additionally, Signchat also allows a hearing person to learn sign language. Signchat also gives the Deaf demographic the opportunity to communicate amongst themselves as well as with the hearing demographic in their mother tongue, allowing them to integrate into society.

Since Deaf people have been neglected as a demographic they tend to be a closed, self-focused demographic. The purpose of the guidelines as well as Signchat was to help with the social development of the Deaf demographic by providing them an application that answers to the following important principles:

- Inclusion;
- Social Integration;
- Access to appropriate services;

- Self-respect and self-sufficiency; and
- Accessibility

Allowing them:

- To live independently and participate fully in all aspects of life;
- Access, on equal basis with others like hearing users, to communications technologies and systems;
- To exercise their right of freedom of expression and opinion; and
- Inclusion in this modern digital society.

The significance of this research is therefore that it contributes in its own way to help reduce the digital divide.

7.6 Future Research

Upon completion of this study, areas for possible future research were identified. These are mentioned below:

- Applying guidelines to other phone applications;
- Applying guidelines to computer applications;
- Developing heuristics for mobile applications that are intended for deaf users;
- Improving the existing guidelines (Signchat);
- Developing an operating system for Internet browsing for Deaf people;
- Developing devices for deaf people such as cameras and cell phones; and
- Develop devices that can help deaf users to participate in classrooms.

7.7 Lessons Learnt

It is important to mention additional lessons that were learnt during the course of this research study. Firstly, the specific research area is very limited and still has a long road ahead. The most important lesson learned from this study was the necessity of such an application and how much it can help the Deaf demographic. This fact is not only based on literature research but also from the actual response from the deaf participants used for the usability testing.

The reaction of the participants was very touching, as they thanked me for following this research path, highlighted the need for such an application and emphasized how much they are neglected as a demographic. Another interesting fact that has arisen from this study was that, despite the fact that deafness is hereditary, it can also be caused by the poor living conditions associated with poverty. Out of all the participants that were used for the usability testing, none of them had a deaf parent.

7.8 Summary

This chapter summarizes the research study. The introduction (section 7.1) was followed by a research overview in section 7.2. This outlined the discussions that were undertaken in each chapter and presented the primary research question and sub-questions of the study. Section 7.3 emphasized the unique contributions made by this research study, and in section 7.4 the significance of such research was highlighted. Eight possible areas for future research have been identified, and were discussed in section 7.5. In conclusion, section 7.6 pointed out some of the lessons that were learnt during the course of this research study.

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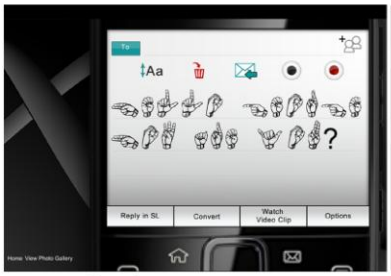
***Appendix* A** Snapshots of Signchat Photo gallery and Demo

1. Splash screen

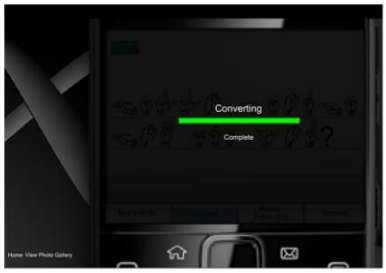
2. Gallery screen

3. Demo intro screen

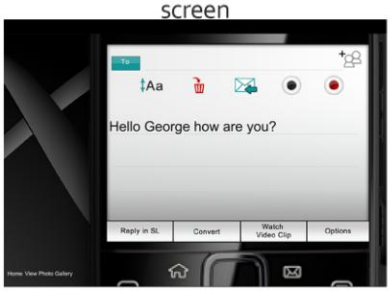


4. Sign language message screen

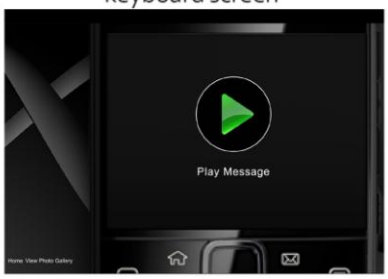
5. On-screen sign language keyboard screen



6. Converting message screen



7.Converted message screen



8.Play message screen

9. Playing message screen

10. Settings screen

11. Options screen

12. Keyboard settings screen

13. Video clip settings screen

14. Text settings screen

15. Sign size settings screen

***Appendix* B** Consent Form

Consent Form for Signchat

Please read and sign this form.

In this usability test:

- You will complete a biographical details form.
- You will be asked to perform certain tasks on Signchat.
- You will be asked to fill in a user satisfaction questionnaire.

Participation in this usability study is voluntary. All information will remain strictly confidential. The descriptions and findings may be used to help improve the Signchat mobile application. However, at no time will your name or any other identification be used. You can withdraw your consent to the experiment and stop participation at any time. The test is not to test you but the usability and features on Signchat mobile application.

If you have any questions after today, please contact George Yeratziotis at George.Yeratziotis@nmmu.ac.za.

I have read and understood the information on this form and had all of my questions answered

_____

_____

Participant's Signature

Date

_____

_____

Test moderator

Date

Appendix* C**: *Results from Hearing User **1

The biographical information, list of tasks and user satisfaction questionnaire is provided below.

Biographical Information

1. Name: *Participant H1*
2. Home language: *English*
3. Country: *South Africa*
4. Education status: *Currently Masters student*
5. Age: *27*
6. Gender:

Male		Female	**x**

7. Do you have a family member or friend that is deaf?

Yes		No	**x**

8. Do you have a mobile phone?

Yes	**x**	No	

9. For how long have you been using a mobile phone?

   13 Years

10. What do you use your mobile phone for?

SMS	**x**	MMS	**x**
Emails	**x**	Internet	**x**

Phone Calls	x

Applications (Word,Powepoint)	

11. How would you note the level of your mobile experience?

Beginner	

Intermediate	

Expert	x

List of Tasks

You will be provided with a flash presentation, in the flash presentation a photo gallery is provided were you can see several screenshots of the application. Additionally a demo of the phone application will also be provided to you.

Purpose of the flash presentation is so that you can explore the several features and functions of the phone application (Signchat). Main focus of the flash presentation is to help you understand how the application (Signchat) operates and what it has to offer to you. You will also be able to explore the several options that are provided to you in the application and see the overall design of the application.

The reason why we doing this is that you can get a feeling of how the application looks and works so that you can answer the user satisfaction questionnaire that will be provided to you after viewing the presentation.

I would like to note at this point that the presentation is interactive to one point. The interactivity is predefined for you. Meaning that the features and buttons are selectable and do prompt you to the relevant information when the link is pressed. Guidance is provided to you throughout the presentation. Meaning at one specific point to be able to continue information will be displayed to you informing you what to press next so that you can continue.

What to expect to see from the presentation:

- Consent form
- Usability test
    - Screenshots of phone application (Signchat)
    - Phone application Demo (Signchat)

- Questionnaire

Warm Up (Voluntary)

Task 1: Take a moment and have a look at the photo gallery and feel free to make any comments.

Photo **1:** Observations and comments

Overall great screenshots. Might be worth having a caption somewhere explaining or defining each screenshot.

Photo **2:** Observations and comments

Photo **3:** Observations and comments

Photo **4:** Observations and comments

Photo **5:** Observations and comments

Photo **6:** Observations and comments

Photo **7:** Observations and comments

Photo **8:** Observations and comments

Photo **9:** Observations and comments

Photo **10:** Observations and comments

Photo **11:** Observations and comments

Photo **12:** Observations and comments

Photo **13:** Observations and comments

Photo **14:** Observations and comments

Photo **15:** Observations and comments

Photo **16:** Observations and comments

Photo **17:** Observations and comments

Task 2: Once task 1 is complete continue to view the demo.

Task List for Demo

Feel free to make any comments or suggestions.

Task **1:** To view the demo of Signchat click on the View Demo link.

Task **2:** Click on the message icon on the mobile phone screen to continue.

Task **3:** Scroll over the several icons on the screen to see what they are (top area).

Task **4:** You will notice that the displayed message is in sign language, convert this message to English.

That was fun to watch.

Task **5:** Convert the message back to sign language.

Task **6:** Click the Reply in SL button to view the onscreen sign language keyboard.

Task **7:** Once task 6 is complete return to the main screen.

Because I did not use the on-screen keyboard, my initial reaction was to click on the "Back to inbox" icon and not on the "Done" button. Only after this did I notice the text on the left side of the screen.

Task **8:** You will notice that the sign language message is static, view the message in motion.

Task **9:** Once task 8 is complete return to the main screen.

Task **10:** View the several options of the application.

Task **11:** Click on the settings link and see what the application has to offer.

I tried to make and save changes in the settings option, however I was not able to.

Task **12:** Once task 12 is complete return to the main screen.

I clicked on the home button and thought that was what I was supposed to do until I saw the next question.

Task **13:** Select the Home button (left bottom) to return to the starting point.

Thank you for your participation!

User Satisfaction Questionnaire

Please provide your ratings for the following questions. The questions focus on your experience and opinions when using the Signchat phone application.

The questionnaire is divided in the following sections:

- Interface
- Navigation
- Usefulness
- Usability
- Accessibility

Name: *Participant H1*

Interface

1. The interface of the phone application was user friendly.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

2. I like using the interface of this phone application.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

3. I find the design consistence throughout the phone application design.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

4. The phone application has the functions and features I expect it to have.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

5. I find the colours of the phone application pleasant.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

6. Overall I am satisfied with the design of the phone application.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

Navigation

7. I find the phone application easy to navigate.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

8. The phone application requires the fewest steps to accomplish what you want to do.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

9. The placement of the functions (buttons) was appropriate.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

10. The functions placed on the home screen were important.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

11. Do you agree with the use of icons instead of text on the home screen?

Yes	**x**	No	

12. Did you find yourself at any point confused or not knowing where you are and what to expect next?

Yes		No	**x**

Usefulness

13. Do you find this phone application useful?

Yes	**x**	No	

14. Would you recommend this phone application to a friend?

Yes	**x**	No	

15. Do you believe that you can benefit from this phone application?

Yes	**x**	No	

16. I believe I can improve my communication skills with this phone application.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

17. I believe I can communicate with hearing/Deaf people with this phone application.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

Usability

18. I am satisfied with how easy the phone application is to use.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

19. I felt comfortable using the phone application.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

20. It was easy to find the information I needed.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

21. The information in the settings was easy to understand.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

22. The features on the home screen were easy to understand.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

Accessibility

23. Did you find the level of English hard to understand?

Yes		No	**x**

24. Did you find the sign language keyboard easy to understand?

Yes	**x**	No	

25. Did you find the convert feature useful?

Yes	**x**	No	

26. Did you find the watch video clip feature useful?

Yes	**x**	No	

27. Was the sign language message easy to distinguish from the background?

Yes	**x**	No	

28. Was the sign language video clip message easy to distinguish from the background?

Yes	**x**	No	

29. Does this phone application meet your needs?

Yes	**x**	No	

Appendix* D**: *Results from Hearing User **2

The biographical information, list of tasks and user satisfaction questionnaire is provided below.

Biographical Information

1. Name: *Participant H2*
2. Home language: *Afrikaans*
3. Country: *South Africa*
4. Education status: *Currently Masters student*
5. Age: *23*
6. Gender:

Male	**x**

Female	

7. Do you have a family member or friend that is deaf?

Yes	

No	**x**

8. Do you have a mobile phone?

Yes	**x**

No	

9. For how long have you been using a mobile phone?

   +- *10 Years*

10. What do you use your mobile phone for?

SMS	**x**

MMS	

Emails	**x**

Internet	**x**

Phone Calls	**x**		Applications (Word,Powepoint)		

11. How would you note the level of your mobile experience?

Beginner			Intermediate	**x**		Expert	

List of Tasks

You will be provided with a flash presentation, in the flash presentation a photo gallery is provided were you can see several screenshots of the application. Additionally a demo of the phone application will also be provided to you.

Purpose of the flash presentation is so that you can explore the several features and functions of the phone application (Signchat). Main focus of the flash presentation is to help you understand how the application (Signchat) operates and what it has to offer to you. You will also be able to explore the several options that are provided to you in the application and see the overall design of the application.

The reason why we doing this is that you can get a feeling of how the application looks and works so that you can answer the user satisfaction questionnaire that will be provided to you after viewing the presentation.

I would like to note at this point that the presentation is interactive to one point. The interactivity is predefined for you. Meaning that the features and buttons are selectable and do prompt you to the relevant information when the link is pressed. Guidance is provided to you throughout the presentation. Meaning at one specific point to be able to continue information will be displayed to you informing you what to press next so that you can continue.

What to expect to see from the presentation:

- Consent form
- Usability test
    - Screenshots of phone application (Signchat)
    - Phone application Demo (Signchat)

- Questionnaire

Warm Up

Task 1: Take a moment and have a look at the photo gallery and feel free to make any comments.

Photo **1:** Observations and comments

Photo **2:** Observations and comments

Video and camera icon not clear

Photo **3:** Observations and comments

Photo **4:** Observations and comments

Photo **5:** Observations and comments

Delete and inbox icon not clear

Photo **6:** Observations and comments

Photo **7:** Observations and comments

Photo **8:** Observations and comments

Photo **9:** Observations and comments

Photo **10:** Observations and comments

Photo **11:** Observations and comments

Photo **12:** Observations and comments

Photo **13:** Observations and comments

Photo **14:** Observations and comments

Photo **15:** Observations and comments

Photo **16:** Observations and comments

Photo **17:** Observations and comments

Task 2: Once task 1 is complete continue to view the demo.

Task List for Demo

Feel free to make any comments or suggestions.

Task **1:** To view the demo of Signchat click on the View Demo link.

Task **2:** Click on the message icon on the mobile phone screen to continue.

Task **3:** Scroll over the several icons on the screen to see what they are (top area).

Refer to previous comments on icons in top bar.

Task **4:** You will notice that the displayed message is in sign language, convert this message to English.

Perhaps button should read convert to English" or "convert to sign".

Task **5:** Convert the message back to sign language.

Task **6:** Click the Reply in SL button to view the onscreen sign language keyboard.

It may be better to format the keyboard to querty layout.

Task **7:** Once task 6 is complete return to the main screen.

The button should be within the application.

Task **8:** You will notice that the sign language message is static, view the message in motion.

Don't know if the space for should be shown. Perhaps it could be left out.

Task **9:** Once task 8 is complete return to the main screen.

Task **10:** View the several options of the application.

Exit should the button be similar to save.

Task **11:** Click on the settings link and see what the application has to offer.

Task **12:** Once task 12 is complete return to the main screen.

Task **13:** Select the Home button (left bottom) to return to the starting point.

Thank you for your participation!

User Satisfaction Questionnaire

Please provide your ratings for the following questions. The questions focus on your experience and opinions when using the Signchat phone application.

The questionnaire is divided in the following sections:

- Interface
- Navigation
- Usefulness
- Usability
- Accessibility

Name: *Participant H2*

Interface

1. The interface of the phone application was user friendly.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
	x			

2. I like using the interface of this phone application.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

3. I find the design consistence throughout the phone application design.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
			x	

4. The phone application has the functions and features I expect it to have.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
	x			

5. I find the colours of the phone application pleasant.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

6. Overall I am satisfied with the design of the phone application.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
	x			

Navigation

7. I find the phone application easy to navigate.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
		x		

8. The phone application requires the fewest steps to accomplish what you want to do.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
	x			

9. The placement of the functions (buttons) was appropriate.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
			x	

10. The functions placed on the home screen were important.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
		x		

11. Do you agree with the use of icons instead of text on the home screen?

Yes	**x**	No	

12. Did you find yourself at any point confused or not knowing where you are and what to expect next?

Yes	**x**	No	

Usefulness

13. Do you find this phone application useful?

Yes	**x**	No	

14. Would you recommend this phone application to a friend?

Yes	**x**	No	

15. Do you believe that you can benefit from this phone application?

Yes	**x**	No	

16. I believe I can improve my communication skills with this phone application.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
	x			

17. I believe I can communicate with hearing/Deaf people with this phone application.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

Usability

18. I am satisfied with how easy the phone application is to use.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
		x		

19. I felt comfortable using the phone application.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
	x			

20. It was easy to find the information I needed.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

21. The information in the settings was easy to understand.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
		x		

22. The features on the home screen were easy to understand.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
	x			

Accessibility

23. Did you find the level of English hard to understand?

Yes		No	**x**

24. Did you find the sign language keyboard easy to understand?

Yes	**x**	No	

25. Did you find the convert feature useful?

Yes	**x**	No	

26. Did you find the watch video clip feature useful?

Yes	**x**	No	

27. Was the sign language message easy to distinguish from the background?

Yes	**x**	No	

28. Was the sign language video clip message easy to distinguish from the background?

Yes	**x**	No	

29. Does this phone application meet your needs?

Yes	**x**	No	

Appendix* E**: *Results from Hearing User **3

The biographical information, list of tasks and user satisfaction questionnaire is provided below.

Biographical Information

1. Name: *Participant H3*
2. Home language: *Afrikaans*
3. Country: *South Africa*
4. Education status: *PHD*
5. Age: *39*
6. Gender:

Male	**x**

Female	

7. Do you have a family member or friend that is deaf?

Yes	

No	**x**

8. Do you have a mobile phone?

Yes	**x**

No	

9. For how long have you been using a mobile phone?

   10+ Years

10. What do you use your mobile phone for?

SMS	**x**

MMS	**x**

Emails	**x**

Internet	**x**

Phone Calls	**x**		Applications (Word,Powepoint)	**x**	

11. How would you note the level of your mobile experience?

Beginner			Intermediate			Expert	**x**

List of Tasks

You will be provided with a flash presentation, in the flash presentation a photo gallery is provided were you can see several screenshots of the application. Additionally a demo of the phone application will also be provided to you.

Purpose of the flash presentation is so that you can explore the several features and functions of the phone application (Signchat). Main focus of the flash presentation is to help you understand how the application (Signchat) operates and what it has to offer to you. You will also be able to explore the several options that are provided to you in the application and see the overall design of the application.

The reason why we doing this is that you can get a feeling of how the application looks and works so that you can answer the user satisfaction questionnaire that will be provided to you after viewing the presentation.

I would like to note at this point that the presentation is interactive to one point. The interactivity is predefined for you. Meaning that the features and buttons are selectable and do prompt you to the relevant information when the link is pressed. Guidance is provided to you throughout the presentation. Meaning at one specific point to be able to continue information will be displayed to you informing you what to press next so that you can continue.

What to expect to see from the presentation:

- Consent form
- Usability test
    - Screenshots of phone application (Signchat)
    - Phone application Demo (Signchat)

- Questionnaire

Warm Up

Task 1: Take a moment and have a look at the photo gallery and feel free to make any comments.

Photo **1:** Observations and comments

Photo **2:** Observations and comments

Photo **3:** Observations and comments

Photo **4:** Observations and comments

Photo **5:** Observations and comments

Photo **6:** Observations and comments

Photo **7:** Observations and comments

I definitely prefer classic blue

Photo **8:** Observations and comments

Obvious what it will do

Photo **9:** Observations and comments

Same as 8

Photo **10:** Observations and comments

Same as 8

Photo **11:** Observations and comments

Looks like photo 13 to me

Photo **12:** Observations and comments

Contrast is very overpowering

Photo **13:** Observations and comments

Photo **14:** Observations and comments

Most readable to me

Photo **15:** Observations and comments

Photo **16:** Observations and comments

Photo 17: Observations and comments

Task 2: Once task 1 is complete continue to view the demo.

Task List for Demo

Feel free to make any comments or suggestions.

Task **1:** To view the demo of Signchat click on the View Demo link.

Task **2:** Click on the message icon on the mobile phone screen to continue.

Task **3:** Scroll over the several icons on the screen to see what they are (top area).

First 3 I guessed correct. Add image, Add video I had to read what they do.

Task **4:** You will notice that the displayed message is in sign language, convert this message to English.

Very intuitive (made sense)

Task **5:** Convert the message back to sign language.

Easy

Task **6:** Click the Reply in SL button to view the onscreen sign language keyboard.

Easy

Task **7:** Once task 6 is complete return to the main screen.

Easy

Task **8:** You will notice that the sign language message is static, view the message in motion.

Spelled out, I like the bigger images.

Task **9:** Once task 8 is complete return to the main screen.

Easy

Task **10:** View the several options of the application.

Easy

Task **11:** Click on the settings link and see what the application has to offer.

Easy

Task **12:** Once task 12 is complete return to the main screen.

Easy

Task **13:** Select the Home button (left bottom) to return to the starting point.

Thank you for your participation!

User Satisfaction Questionnaire

Please provide your ratings for the following questions. The questions focus on your experience and opinions when using the Signchat phone application.

The questionnaire is divided in the following sections:

- Interface
- Navigation
- Usefulness
- Usability
- Accessibility

Name: Participant H3

Interface

1. The interface of the phone application was user friendly.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

2. I like using the interface of this phone application.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree

x				

3. I find the design consistence throughout the phone application design.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

4. The phone application has the functions and features I expect it to have.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

5. I find the colours of the phone application pleasant.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

6. Overall I am satisfied with the design of the phone application.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

Navigation

7. I find the phone application easy to navigate.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

8. The phone application requires the fewest steps to accomplish what you want to do.

Strongly	Agree	Undecided	Disagree	Strongly

Agree				Disagree
x				

9. The placement of the functions (buttons) was appropriate.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

10. The functions placed on the home screen were important.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

11. Do you agree with the use of icons instead of text on the home screen?

Yes	**x**	No	

12. Did you find yourself at any point confused or not knowing where you are and what to expect next?

Yes		No	**x**

Usefulness

13. Do you find this phone application useful?

Yes	**x**	No	

14. Would you recommend this phone application to a friend?

Yes	**x**	No	

15. Do you believe that you can benefit from this phone application?

Yes	**x**	No	

16. I believe I can improve my communication skills with this phone application.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

17. I believe I can communicate with hearing/Deaf people with this phone application.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

Usability

18. I am satisfied with how easy the phone application is to use.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

19. I felt comfortable using the phone application.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

20. It was easy to find the information I needed.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

21. The information in the settings was easy to understand.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree

x				

22. The features on the home screen were easy to understand.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
	x			

Accessibility

23. Did you find the level of English hard to understand?

Yes		No	**x**

24. Did you find the sign language keyboard easy to understand?

Yes	**x**	No	

25. Did you find the convert feature useful?

Yes	**x**	No	

26. Did you find the watch video clip feature useful?

Yes	**x**	No	

27. Was the sign language message easy to distinguish from the background?

Yes	**x**	No	

28. Was the sign language video clip message easy to distinguish from the background?

Yes	**x**	No	

29. Does this phone application meet your needs?

Yes	**x**	No	

Appendix* F**: *Results from Hearing User **4

The biographical information, list of tasks and user satisfaction questionnaire is provided below.

Biographical Information

1. Name: *Participant H4*
2. Home language: *Afrikaans*
3. Country: South *Africa*
4. Education status: *PHD*
5. Age: *40*
6. Gender:

Male		Female	**x**

7. Do you have a family member or friend that is deaf?

Yes	**x**	No	

8. Do you have a mobile phone?

Yes	**x**	No	

9. For how long have you been using a mobile phone?

   15+ Years

10. What do you use your mobile phone for?

SMS	**x**	MMS	

Emails	

Internet	

Phone Calls	x

Applications (Word,Powepoint)	

11. How would you note the level of your mobile experience?

Beginner	

Intermediate	x

Expert	

List of Tasks

You will be provided with a flash presentation, in the flash presentation a photo gallery is provided were you can see several screenshots of the application. Additionally a demo of the phone application will also be provided to you.

Purpose of the flash presentation is so that you can explore the several features and functions of the phone application (Signchat). Main focus of the flash presentation is to help you understand how the application (Signchat) operates and what it has to offer to you. You will also be able to explore the several options that are provided to you in the application and see the overall design of the application.

The reason why we doing this is that you can get a feeling of how the application looks and works so that you can answer the user satisfaction questionnaire that will be provided to you after viewing the presentation.

I would like to note at this point that the presentation is interactive to one point. The interactivity is predefined for you. Meaning that the features and buttons are selectable and do prompt you to the relevant information when the link is pressed. Guidance is provided to you throughout the presentation. Meaning at one specific point to be able to continue information will be displayed to you informing you what to press next so that you can continue.

What to expect to see from the presentation:

- Consent form
- Usability test
    - Screenshots of phone application (Signchat)
    - Phone application Demo (Signchat)

- Questionnaire

Warm Up

Task 1: Take a moment and have a look at the photo gallery and feel free to make any comments.

Photo **1:** Observations and comments

Photo **2:** Observations and comments

Button task activity not instantly recognized

Photo **3:** Observations and comments

Recognizable sigh language offered to user in addition to very clear task function of icons

Photo **4:** Observations and comments

Curious of how played message will transfer knowledge message without sound

Photo **5:** Observations and comments

Not sure what this menu relates to and how it is invoked

Photo **6:** Observations and comments

Takes time to read the options and interoperate purpose of each

Photo **7:** Observations and comments

Good display of color examples

Photo **8:** Observations and comments

Picture would speed recognition

Photo **9:** Observations and comments

Picture would speed recognition

Photo **10:** Observations and comments

Demonstration needed

Photo **11:** Observations and comments

Not sure what done represents

Photo **12:** Observations and comments

Assume color change applied to sign keyboard

Photo **13:** Observations and comments

No focus, too much info

Photo **14:** Observations and comments

Color makes sign unclear

Photo **15:** Observations and comments

Why incomplete rows

Photo **16:** Observations and comments

Clear

Photo **17:** Observations and comments

Clear

Task 2: Once task 1 is complete continue to view the demo.

Task List for Demo

Feel free to make any comments or suggestions.

Task **1:** To view the demo of Signchat click on the View Demo link.

Purpose clear, message received

Task **2:** Click on the message icon on the mobile phone screen to continue.

Ask to reply but I have not read the message ,is this the message in sign language?

Task **3:** Scroll over the several icons on the screen to see what they are (top area).

Task **4:** You will notice that the displayed message is in sign language, convert this message to English.

Like this functionality, for a person that is not 100% clued up with sign language

Task **5:** Convert the message back to sign language.

Like the option of conversion and vice versa

Task **6:** Click the Reply in SL button to view the onscreen sign language keyboard.

Function clear

Task **7:** Once task 6 is complete return to the main screen.

How? Done works!

Task **8:** You will notice that the sign language message is static, view the message in motion.

How? With watch video clip? Unsure!

Task **9:** Once task 8 is complete return to the main screen.

Exit to return

Task **10:** View the several options of the application.

Unsure what the options are that 13 referred to. Is it buttons on bottom icons on top? Now I see it options button! Right bottom corner!

Task **11:** Click on the settings link and see what the application has to offer.

I like!! But what is the current color size etc.

Task **12:** Once task 12 is complete return to the main screen.

Recognize the screen I return to and its function

Task **13:** Select the Home button (left bottom) to return to the starting point.

Thank you for your participation!

User Satisfaction Questionnaire

Please provide your ratings for the following questions. The questions focus on your experience and opinions when using the Signchat phone application.

The questionnaire is divided in the following sections:

- Interface
- Navigation

- Usefulness
- Usability
- Accessibility

Name: Participant H4

Interface

1. The interface of the phone application was user friendly.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
	x			

2. I like using the interface of this phone application.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
	x			

3. I find the design consistence throughout the phone application design.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
		x		

4. The phone application has the functions and features I expect it to have.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

5. I find the colours of the phone application pleasant.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

6. Overall I am satisfied with the design of the phone application.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
	x			

Navigation

7. I find the phone application easy to navigate.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
	x			

8. The phone application requires the fewest steps to accomplish what you want to do.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

9. The placement of the functions (buttons) was appropriate.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

10. The functions placed on the home screen were important.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

11. Do you agree with the use of icons instead of text on the home screen?

Yes	**x**

No	

12. Did you find yourself at any point confused or not knowing where you are and what to expect next?

Yes	x

No	

Usefulness

13. Do you find this phone application useful?

Yes	x

No	

14. Would you recommend this phone application to a friend?

Yes	x

No	

15. Do you believe that you can benefit from this phone application?

Yes	x

No	

16. I believe I can improve my communication skills with this phone application.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

17. I believe I can communicate with hearing/Deaf people with this phone application.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

Usability

18. I am satisfied with how easy the phone application is to use.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
	x			

19. I felt comfortable using the phone application.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

20. It was easy to find the information I needed.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
	x			

21. The information in the settings was easy to understand.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

22. The features on the home screen were easy to understand.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

Accessibility

23. Did you find the level of English hard to understand?

Yes	

No	**x**

24. Did you find the sign language keyboard easy to understand?

Yes	**x**

No	

25. Did you find the convert feature useful?

Yes	x		No	

26. Did you find the watch video clip feature useful?

Yes	x		No	

27. Was the sign language message easy to distinguish from the background?

Yes	x		No	

28. Was the sign language video clip message easy to distinguish from the background?

Yes	x		No	

29. Does this phone application meet your needs?

Yes	x		No	

Appendix* G**: *Results from Hearing User* ***5

The biographical information, list of tasks and user satisfaction questionnaire is provided below.

Biographical Information

1. Name: *Participant H5*
2. Home language: *English*
3. Country: *South Africa*
4. Education status: *Grade 11*
5. Age: *16*
6. Gender:

Male	

Female	**x**

7. Do you have a family member or friend that is deaf?

Yes	

No	**x**

8. Do you have a mobile phone?

Yes	**x**

No	

9. For how long have you been using a mobile phone?

   5 Years

10. What do you use your mobile phone for?

SMS	**x**

MMS	**x**

Emails	

Internet	**x**

Phone Calls	**x**

Applications (Word,Powepoint)	**x**

11. How would you note the level of your mobile experience?

Beginner	

Intermediate	**x**

Expert	

List of Tasks

You will be provided with a flash presentation, in the flash presentation a photo gallery is provided were you can see several screenshots of the application. Additionally a demo of the phone application will also be provided to you.

Purpose of the flash presentation is so that you can explore the several features and functions of the phone application (Signchat). Main focus of the flash presentation is to help you understand how the application (Signchat) operates and what it has to offer to you. You will also be able to explore the several options that are provided to you in the application and see the overall design of the application.

The reason why we doing this is that you can get a feeling of how the application looks and works so that you can answer the user satisfaction questionnaire that will be provided to you after viewing the presentation.

I would like to note at this point that the presentation is interactive to one point. The interactivity is predefined for you. Meaning that the features and buttons are selectable and do prompt you to the relevant information when the link is pressed. Guidance is provided to you throughout the presentation. Meaning at one specific point to be able to continue information will be displayed to you informing you what to press next so that you can continue.

What to expect to see from the presentation:

- Consent form
- Usability test
    - Screenshots of phone application (Signchat)
    - Phone application Demo (Signchat)

- Questionnaire

Warm Up

Task 1: Take a moment and have a look at the photo gallery and feel free to make any comments.

Photo **1:** Observations and comments

Cool logo

Photo **2:** Observations and comments

Text on options at the bottom of cell phone screen a bit unclear

Photo **3:** Observations and comments

Not all hand signals are clear

Photo **4:** Observations and comments

Like the effect of dark but slightly transparent background

Photo **5:** Observations and comments

Text is legible but slightly blurry

Photo **6:** Observations and comments

Settings heading should be bold/larger. Light dark slightly transparent background

Photo **7:** Observations and comments

Like that it shows the route taken (where we were previously etc.)

Photo **8:** Observations and comments

Should have adjustable bar to increase or decrease speed like volume bar

Photo **9:** Observations and comments

Demonstration of sizes should be shown

Photo **10:** Observations and comments

Demonstration of sizes should be shown

Photo **11:** Observations and comments

Hand signals more clear rather use icon instead of text for space button

Photo **12:** Observations and comments

Should be more of a contrast between colors to make the signs easier to see

Photo **13:** Observations and comments

Plain but very clear and easy to read

Photo **14:** Observations and comments

Most effective color co-ordination and the most legible

Photo **15:** Observations and comments

Clear and obvious

Photo **16:** Observations and comments

Clear and obvious

Photo **17:** Observations and comments

No comment

Task 2: Once task 1 is complete continue to view the demo.

Task List for Demo

Feel free to make any comments or suggestions.

Task **1:** To view the demo of Signchat click on the View Demo link.

Effective start! The way the phone appears after the logo

Task **2:** Click on the message icon on the mobile phone screen to continue.

Bright, clear, very legible.

Task **3:** Scroll over the several icons on the screen to see what they are (top area).

Aa makes it appear as though it is changing from caps to small the other way. Add images and video icons don't illustrate their functions.

Task **4:** You will notice that the displayed message is in sign language, convert this message to English.

Very easy to convert (no confusion) and converted quickly.

Task **5:** Convert the message back to sign language.

Easy and quick

Task **6:** Click the Reply in SL button to view the onscreen sign language keyboard.

I like the fact that the keyboard is in alphabetical order

Task **7:** Once task 6 is complete return to the main screen.

Was unsure if it was the main screen

Task **8:** You will notice that the sign language message is static, view the message in motion.

Very effective

Task **9:** Once task 8 is complete return to the main screen.

Should have said main instead of exit

Task **10:** View the several options of the application.

Very clear

Task **11:** Click on the settings link and see what the application has to offer.

"Settings" is now clear that it is a heading

Task **12:** Once task 12 is complete return to the main screen.

Good that speed is demonstrated, bar no longer necessary. Good that size differences are shown, should use back instead of exit.

Task **13:** Select the Home button (left bottom) to return to the starting point.

Home option should be more visible

Thank you for your participation!

User Satisfaction Questionnaire

Please provide your ratings for the following questions. The questions focus on your experience and opinions when using the Signchat phone application.

The questionnaire is divided in the following sections:

- Interface
- Navigation
- Usefulness
- Usability
- Accessibility

Name: *Participant H5*

Interface

1. The interface of the phone application was user friendly.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
	x			

2. I like using the interface of this phone application.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

3. I find the design consistence throughout the phone application design.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

4. The phone application has the functions and features I expect it to have.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

5. I find the colours of the phone application pleasant.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

6. Overall I am satisfied with the design of the phone application.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

Navigation

7. I find the phone application easy to navigate.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
	x			

8. The phone application requires the fewest steps to accomplish what you want to do.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

9. The placement of the functions (buttons) was appropriate.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

10. The functions placed on the home screen were important.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

11. Do you agree with the use of icons instead of text on the home screen?

Yes	**x**	No	

12. Did you find yourself at any point confused or not knowing where you are and what to expect next?

Yes	**x**	No	

Usefulness

13. Do you find this phone application useful?

Yes	**x**	No	

14. Would you recommend this phone application to a friend?

Yes	**x**	No	

15. Do you believe that you can benefit from this phone application?

Yes	**x**	No	

16. I believe I can improve my communication skills with this phone application.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

17. I believe I can communicate with hearing/Deaf people with this phone application.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

Usability

18. I am satisfied with how easy the phone application is to use.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

19. I felt comfortable using the phone application.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

20. It was easy to find the information I needed.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

21. The information in the settings was easy to understand.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

22. The features on the home screen were easy to understand.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
	x			

Accessibility

23. Did you find the level of English hard to understand?

Yes		No	x

24. Did you find the sign language keyboard easy to understand?

Yes	x	No	

25. Did you find the convert feature useful?

Yes	x	No	

26. Did you find the watch video clip feature useful?

Yes	x	No	

27. Was the sign language message easy to distinguish from the background?

Yes	x	No	

28. Was the sign language video clip message easy to distinguish from the background?

Yes	x	No	

29. Does this phone application meet your needs?

Yes	x	No	

Appendix* H**: *Results from Deaf User **1

The biographical information, list of tasks and user satisfaction questionnaire is provided below.

Biographical Information

1. Name: *Participant D1*
2. Home Sign language: *South African Sign Language (SASL)*
3. Country: South Africa
4. Education status: *Step 7 (Deaf education system)*
5. Age: *46*
6. Gender:

Male	**x**

Female	

7. Age deafness occurred?

   Born Deaf

8. Type of deafness?

Conductive	

Sensorieneural	**x**

Mixed	

9. Level of deafness?

Mild	

Moderate	

Severe	

Profound	**x**

10. Age of onset?

Pre-lingual deafness	**x**

Post-lingual deafness	

11. How long have you been using sign language?

.From birth

12. Are your parents Deaf?

Yes	

No	**x**

Only one of them	

13. Have you received formal sign language training?

Yes	

No	**x**

14. Do you have a mobile phone?

Yes	**x**

No	

15. For how long have you been using a mobile phone?

From 2006

16. What do you use your mobile phone for?

SMS	**x**

MMS	

Emails	

Internet	

Phone Calls	

Applications (Word,Powepoint)	

17. How would you note the level of your mobile experience?

Beginner		Intermediate	**x**	Expert	

List of Tasks

You will be provided with a flash presentation, in the flash presentation a photo gallery is provided were you can see several screenshots of the application. Additionally a demo of the phone application will also be provided to you.

Purpose of the flash presentation is so that you can explore the several features and functions of the phone application (Signchat). Main focus of the flash presentation is to help you understand how the application (Signchat) operates and what it has to offer to you. You will also be able to explore the several options that are provided to you in the application and see the overall design of the application.

The reason why we doing this is that you can get a feeling of how the application looks and works so that you can answer the user satisfaction questionnaire that will be provided to you after viewing the presentation.

I would like to note at this point that the presentation is interactive to one point. The interactivity is predefined for you. Meaning that the features and buttons are selectable and do prompt you to the relevant information when the link is pressed. Guidance is provided to you throughout the presentation. Meaning at one specific point to be able to continue information will be displayed to you informing you what to press next so that you can continue.

What to expect to see from the presentation:

- Consent form
- Usability test
    - Screenshots of phone application (Signchat)
    - Phone application Demo (Signchat)

- Questionnaire

Warm Up

Task 1: Take a moment and have a look at the photo gallery and feel free to make any comments.

Photo **1:** Observations and comments

Good

Photo **2:** Observations and comments

Good

Photo **3:** Observations and comments

Good

Photo **4:** Observations and comments

Good

Photo **5:** Observations and comments

Good

Photo **6:** Observations and comments

Good

Photo **7:** Observations and comments

Good

Photo **8:** Observations and comments

Good

Photo **9:** Observations and comments

Good

Photo **10:** Observations and comments

Good

Photo **11:** Observations and comments

Good

Photo **12:** Observations and comments

Good

Photo **13:** Observations and comments

Good

Photo **14:** Observations and comments

Good

Photo **15:** Observations and comments

Good

Photo **16:** Observations and comments

Good

Photo **17:** Observations and comments

Good

Task 2: Once task 1 is complete continue to view the demo.

Task List for Demo

Feel free to make any comments or suggestions.

Task **1:** To view the demo of Signchat click on the View Demo link.

Task **2:** Click on the message icon on the mobile phone screen to continue.

Task **3:** Scroll over the several icons on the screen to see what they are (top area).

Yes I understand

Task **4:** You will notice that the displayed message is in sign language, convert this message to English.

Useful

Task **5:** Convert the message back to sign language.

Task **6:** Click the Reply in SL button to view the onscreen sign language keyboard.

Likes that letters are combined with sign language

Task **7:** Once task 6 is complete return to the main screen.

Task **8:** You will notice that the sign language message is static, view the message in motion.

I like

Task **9:** Once task 8 is complete return to the main screen.

Task **10:** View the several options of the application.

I understand

Task **11:** Click on the settings link and see what the application has to offer.

I like plain white keyboard

Task **12:** Once task 12 is complete return to the main screen.

Task **13:** Select the Home button (left bottom) to return to the starting point.

Thank you for your participation!

User Satisfaction Questionnaire

Please provide your ratings for the following questions. The questions focus on your experience and opinions when using the Signchat phone application.

The questionnaire is divided in the following sections:

- Interface
- Navigation
- Usefulness
- Usability
- Accessibility

Name: Participant D1

Interface

1. The interface of the phone application was user friendly.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

2. I like using the interface of this phone application.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

3. I find the design consistence throughout the phone application design.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

4. The phone application has the functions and features I expect it to have.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

5. I find the colours of the phone application pleasant.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

6. Overall I am satisfied with the design of the phone application.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

Navigation

7. I find the phone application easy to navigate.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

8. The phone application requires the fewest steps to accomplish what you want to do.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

9. The placement of the functions (buttons) was appropriate.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

10. The functions placed on the home screen were important.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

11. Do you agree with the use of icons instead of text on the home screen?

Yes	**x**

No	

12. Did you find yourself at any point confused or not knowing where you are and what to expect next?

Yes	

No	**x**

Usefulness

13. Do you find this phone application useful?

Yes	x

No	

14. Would you recommend this phone application to a friend?

Yes	x

No	

15. Do you believe that you can benefit from this phone application?

Yes	x

No	

16. I believe I can improve my communication skills with this phone application.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

17. I believe I can communicate with hearing/Deaf people with this phone application.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

Usability

18. I am satisfied with how easy the phone application is to use.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

19. I felt comfortable using the phone application.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

20. It was easy to find the information I needed.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

21. The information in the settings was easy to understand.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

22. The features on the home screen were easy to understand.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

Accessibility

23. Did you find the level of English hard to understand?

Yes		No	**x**

24. Did you find the sign language keyboard easy to understand?

Yes	**x**	No	

25. Did you find the convert feature useful?

Yes	**x**	No	

26. Did you find the watch video clip feature useful?

Yes	**x**	No	

27. Was the sign language message easy to distinguish from the background?

Yes	**x**	No	

28. Was the sign language video clip message easy to distinguish from the background?

Yes	**x**	No	

29. Does this phone application meet your needs?

Yes	**x**	No	

Appendix* I**: *Results from Deaf User **2

The biographical information, list of tasks and user satisfaction questionnaire is provided below.

Biographical Information

1. Name: *Participant D2*
2. Home Sign language: *Xhosa Sign Language*
3. Country: *South Africa*
4. Education status: *Step 5*
5. Age: *46*
6. Gender:

Male		Female	**x**

7. Age deafness occurred?

   8 years old

8. Type of deafness?

Conductive		Sensorieneural	**x**	Mixed	

9. Level of deafness?

Mild	**x**	Moderate	

Severe		Profound	

10. Age of onset?

Pre-lingual deafness	**x**

Post-lingual deafness	

11. How long have you been using sign language?

From 1973

12. Are your parents Deaf?

Yes	

No	**x**

Only one of them	

13. Have you received formal sign language training?

Yes	

No	**x**

14. Do you have a mobile phone?

Yes	**x**

No	

15. For how long have you been using a mobile phone?

From 2005

16. What do you use your mobile phone for?

SMS	**x**

MMS	

Emails	

Internet	

Phone Calls	

Applications (Word,Powepoint)	

17. How would you note the level of your mobile experience?

Beginner		Intermediate	**x**	Expert	

List of Tasks

You will be provided with a flash presentation, in the flash presentation a photo gallery is provided were you can see several screenshots of the application. Additionally a demo of the phone application will also be provided to you.

Purpose of the flash presentation is so that you can explore the several features and functions of the phone application (Signchat). Main focus of the flash presentation is to help you understand how the application (Signchat) operates and what it has to offer to you. You will also be able to explore the several options that are provided to you in the application and see the overall design of the application.

The reason why we doing this is that you can get a feeling of how the application looks and works so that you can answer the user satisfaction questionnaire that will be provided to you after viewing the presentation.

I would like to note at this point that the presentation is interactive to one point. The interactivity is predefined for you. Meaning that the features and buttons are selectable and do prompt you to the relevant information when the link is pressed. Guidance is provided to you throughout the presentation. Meaning at one specific point to be able to continue information will be displayed to you informing you what to press next so that you can continue.

What to expect to see from the presentation:

- Consent form
- Usability test
    - Screenshots of phone application (Signchat)
    - Phone application Demo (Signchat)

- Questionnaire

Warm Up

Task 1: Take a moment and have a look at the photo gallery and feel free to make any comments.

Photo **1:** Observations and comments

Good

Photo **2:** Observations and comments

Good

Photo **3:** Observations and comments

Good

Photo **4:** Observations and comments

Good

Photo **5:** Observations and comments

Good

Photo **6:** Observations and comments

Good

Photo **7:** Observations and comments

Good

Photo **8:** Observations and comments

Good

Photo **9:** Observations and comments

Good

Photo **10:** Observations and comments

Good

Photo **11:** Observations and comments

Good

Photo **12:** Observations and comments

Good

Photo **13:** Observations and comments

Good

Photo **14:** Observations and comments

Good

Photo **15:** Observations and comments

Good

Photo **16:** Observations and comments

Good

Photo **17:** Observations and comments

Good

Task 2: Once task 1 is complete continue to view the demo.

Task List for Demo

Feel free to make any comments or suggestions.

Task **1:** To view the demo of Signchat click on the View Demo link.

Task **2:** Click on the message icon on the mobile phone screen to continue.

Task **3:** Scroll over the several icons on the screen to see what they are (top area).

Task **4:** You will notice that the displayed message is in sign language, convert this message to English.

Task **5:** Convert the message back to sign language.

Task **6:** Click the Reply in SL button to view the onscreen sign language keyboard.

Task **7:** Once task 6 is complete return to the main screen.

Task **8:** You will notice that the sign language message is static, view the message in motion.

Task **9:** Once task 8 is complete return to the main screen.

Task **10:** View the several options of the application.

Task **11:** Click on the settings link and see what the application has to offer.

Task **12:** Once task 12 is complete return to the main screen.

Task **13:** Select the Home button (left bottom) to return to the starting point.

Thank you for your participation!

User Satisfaction Questionnaire

Please provide your ratings for the following questions. The questions focus on your experience and opinions when using the Signchat phone application.

The questionnaire is divided in the following sections:

- Interface
- Navigation
- Usefulness
- Usability
- Accessibility

Name: Participant D2

Interface

1. The interface of the phone application was user friendly.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

2. I like using the interface of this phone application.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

3. I find the design consistence throughout the phone application design.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
	x			

4. The phone application has the functions and features I expect it to have.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

5. I find the colours of the phone application pleasant.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

6. Overall I am satisfied with the design of the phone application.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

Navigation

7. I find the phone application easy to navigate.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
	x			

8. The phone application requires the fewest steps to accomplish what you want to do.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

9. The placement of the functions (buttons) was appropriate.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

10. The functions placed on the home screen were important.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

11. Do you agree with the use of icons instead of text on the home screen?

Yes	**x**	No	

12. Did you find yourself at any point confused or not knowing where you are and what to expect next?

Yes		No	**x**

Usefulness

13. Do you find this phone application useful?

Yes	**x**	No	

14. Would you recommend this phone application to a friend?

Yes	**x**	No	

15. Do you believe that you can benefit from this phone application?

Yes	**x**	No	

16. I believe I can improve my communication skills with this phone application.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

17. I believe I can communicate with hearing/Deaf people with this phone application.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

Usability

18. I am satisfied with how easy the phone application is to use.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

19. I felt comfortable using the phone application.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

20. It was easy to find the information I needed.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

21. The information in the settings was easy to understand.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

22. The features on the home screen were easy to understand.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
	x			

Accessibility

23. Did you find the level of English hard to understand?

Yes		No	**x**

24. Did you find the sign language keyboard easy to understand?

Yes	**x**	No	

25. Did you find the convert feature useful?

Yes	**x**	No	

26. Did you find the watch video clip feature useful?

Yes	**x**	No	

27. Was the sign language message easy to distinguish from the background?

Yes	**x**	No	

28. Was the sign language video clip message easy to distinguish from the background?

Yes	**x**	No	

29. Does this phone application meet your needs?

Yes	**x**	No	

Appendix* J:** *Results from Deaf User* ***3

The biographical information, list of tasks and user satisfaction questionnaire is provided below.

Biographical Information

1. Name: *Participant D3*
2. Home Sign language: *Xhosa*
3. Country: *South Africa*
4. Education status: *Grade 10*
5. Age: *39*
6. Gender:

Male		Female	**x**

7. Age deafness occurred?

   From birth

8. Type of deafness?

Conductive		Sensorieneural	**x**	Mixed	

9. Level of deafness?

Mild		Moderate	**x**

Severe		Profound	

10. Age of onset?

Pre-lingual deafness	**x**

Post-lingual deafness	

11. How long have you been using sign language?

Since 1991

12. Are your parents Deaf?

Yes	

No	**x**

Only one of them	

13. Have you received formal sign language training?

Yes	**x**

No	

14. Do you have a mobile phone?

Yes	**x**

No	

15. For how long have you been using a mobile phone?

Since 2001

16. What do you use your mobile phone for?

SMS	**x**

MMS	

Emails	

Internet	

Phone Calls	**x**

Applications (Word,Powepoint)	**x**

17. How would you note the level of your mobile experience?

Beginner		Intermediate		Expert	

List of Tasks

You will be provided with a flash presentation, in the flash presentation a photo gallery is provided were you can see several screenshots of the application. Additionally a demo of the phone application will also be provided to you.

Purpose of the flash presentation is so that you can explore the several features and functions of the phone application (Signchat). Main focus of the flash presentation is to help you understand how the application (Signchat) operates and what it has to offer to you. You will also be able to explore the several options that are provided to you in the application and see the overall design of the application.

The reason why we doing this is that you can get a feeling of how the application looks and works so that you can answer the user satisfaction questionnaire that will be provided to you after viewing the presentation.

I would like to note at this point that the presentation is interactive to one point. The interactivity is predefined for you. Meaning that the features and buttons are selectable and do prompt you to the relevant information when the link is pressed. Guidance is provided to you throughout the presentation. Meaning at one specific point to be able to continue information will be displayed to you informing you what to press next so that you can continue.

What to expect to see from the presentation:

- Consent form
- Usability test
    - Screenshots of phone application (Signchat)
    - Phone application Demo (Signchat)

- Questionnaire

Warm Up

Task 1: Take a moment and have a look at the photo gallery and feel free to make any comments.

Photo **1:** Observations and comments

Good

Photo **2:** Observations and comments

Good

Photo **3:** Observations and comments

Good

Photo **4:** Observations and comments

Good

Photo **5:** Observations and comments

Good

Photo **6:** Observations and comments

Good

Photo **7:** Observations and comments

Good

Photo **8:** Observations and comments

Good

Photo **9:** Observations and comments

Good

Photo **10:** Observations and comments

Good

Photo **11:** Observations and comments

Good

Photo **12:** Observations and comments

Good

Photo **13:** Observations and comments

Good

Photo **14:** Observations and comments

Good

Photo **15:** Observations and comments

Good

Photo **16:** Observations and comments

Good

Photo **17:** Observations and comments

Good

Task 2: Once task 1 is complete continue to view the demo.

Task List for Demo

Feel free to make any comments or suggestions.

Task **1:** To view the demo of Signchat click on the View Demo link.

Task **2:** Click on the message icon on the mobile phone screen to continue.

Task **3:** Scroll over the several icons on the screen to see what they are (top area).

Task **4:** You will notice that the displayed message is in sign language, convert this message to English.

Task **5:** Convert the message back to sign language.

Task **6:** Click the Reply in SL button to view the onscreen sign language keyboard.

Task **7:** Once task 6 is complete return to the main screen.

Task **8:** You will notice that the sign language message is static, view the message in motion.

Task **9:** Once task 8 is complete return to the main screen.

Task **10:** View the several options of the application.

Task **11:** Click on the settings link and see what the application has to offer.

Task **12:** Once task 12 is complete return to the main screen.

Task **13:** Select the Home button (left bottom) to return to the starting point.

Thank you for your participation!

User Satisfaction Questionnaire

Please provide your ratings for the following questions. The questions focus on your experience and opinions when using the Signchat phone application.

The questionnaire is divided in the following sections:

- Interface
- Navigation
- Usefulness
- Usability
- Accessibility

Name: *Participant D3*

Interface

1. The interface of the phone application was user friendly.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

2. I like using the interface of this phone application.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

3. I find the design consistence throughout the phone application design.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
	x			

4. The phone application has the functions and features I expect it to have.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
	x			

5. I find the colours of the phone application pleasant.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

6. Overall I am satisfied with the design of the phone application.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

Navigation

7. I find the phone application easy to navigate.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

8. The phone application requires the fewest steps to accomplish what you want to do.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

9. The placement of the functions (buttons) was appropriate.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

10. The functions placed on the home screen were important.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

11. Do you agree with the use of icons instead of text on the home screen?

Yes	**x**	No	

12. Did you find yourself at any point confused or not knowing where you are and what to expect next?

Yes		No	**x**

Usefulness

13. Do you find this phone application useful?

Yes	**x**	No	

14. Would you recommend this phone application to a friend?

Yes	**x**	No	

15. Do you believe that you can benefit from this phone application?

Yes	**x**	No	

16. I believe I can improve my communication skills with this phone application.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

17. I believe I can communicate with hearing/Deaf people with this phone application.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

Usability

18. I am satisfied with how easy the phone application is to use.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
	x			

19. I felt comfortable using the phone application.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

20. It was easy to find the information I needed.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

21. The information in the settings was easy to understand.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

22. The features on the home screen were easy to understand.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

Accessibility

23. Did you find the level of English hard to understand?

Yes	**x**	No	

24. Did you find the sign language keyboard easy to understand?

Yes	**x**	No	

25. Did you find the convert feature useful?

Yes	**x**	No	

26. Did you find the watch video clip feature useful?

Yes	**x**	No	

27. Was the sign language message easy to distinguish from the background?

Yes	**x**	No	

28. Was the sign language video clip message easy to distinguish from the background?

Yes	**x**	No	

29. Does this phone application meet your needs?

Yes	**x**	No	

Appendix* K**: *Results from Deaf User **4

The biographical information, list of tasks and user satisfaction questionnaire is provided below.

Biographical Information

1. Name: *Participant D4*
2. Home Sign language: *Interpreter*
3. Country: *South Africa*
4. Education status: *Diploma*
5. Age: *41*
6. Gender:

Male		Female	**x**

7. Age deafness occurred?

   N/A

8. Type of deafness? ***N/A***

Conductive		Sensorieneural		Mixed	

9. Level of deafness? ***N/A***

Mild		Moderate			
Severe		Profound			

10. Age of onset? ***N/A***

Pre-lingual deafness		Post-lingual deafness	

11. How long have you been using sign language?

14 years

12. Are your parents Deaf?

Yes		No	**x**	Only one of them	

13. Have you received formal sign language training?

Yes	**x**	No	

14. Do you have a mobile phone?

Yes	**x**	No	

15. For how long have you been using a mobile phone?

Since 2000

16. What do you use your mobile phone for?

SMS	**x**	MMS	

Emails		Internet	

Phone Calls	**x**	Applications (Word,Powepoint)	

17. How would you note the level of your mobile experience?

Beginner		Intermediate		Expert	**x**

List of Tasks

You will be provided with a flash presentation, in the flash presentation a photo gallery is provided were you can see several screenshots of the application. Additionally a demo of the phone application will also be provided to you.

Purpose of the flash presentation is so that you can explore the several features and functions of the phone application (Signchat). Main focus of the flash presentation is to help you understand how the application (Signchat) operates and what it has to offer to you. You will also be able to explore the several options that are provided to you in the application and see the overall design of the application.

The reason why we doing this is that you can get a feeling of how the application looks and works so that you can answer the user satisfaction questionnaire that will be provided to you after viewing the presentation.

I would like to note at this point that the presentation is interactive to one point. The interactivity is predefined for you. Meaning that the features and buttons are selectable and do prompt you to the relevant information when the link is pressed. Guidance is provided to you throughout the presentation. Meaning at one specific point to be able to continue information will be displayed to you informing you what to press next so that you can continue.

What to expect to see from the presentation:

- Consent form
- Usability test
    - Screenshots of phone application (Signchat)
    - Phone application Demo (Signchat)

- Questionnaire

Warm Up

Task 1: Take a moment and have a look at the photo gallery and feel free to make any comments.

Photo **1:** Observations and comments

Good

Photo **2:** Observations and comments

Good

Photo **3:** Observations and comments

Good

Photo **4:** Observations and comments

Good

Photo **5:** Observations and comments

Good

Photo **6:** Observations and comments

Good

Photo **7:** Observations and comments

Good

Photo **8:** Observations and comments

Good

Photo **9:** Observations and comments

Good

Photo **10:** Observations and comments

Good

Photo **11:** Observations and comments

Good

Photo **12:** Observations and comments

Good

Photo **13:** Observations and comments

Good

Photo **14:** Observations and comments

Good

Photo **15:** Observations and comments

Good

Photo **16:** Observations and comments

Good

Photo **17:** Observations and comments

Good

Task 2: Once task 1 is complete continue to view the demo.

Task List for Demo

Feel free to make any comments or suggestions.

Task **1:** To view the demo of Signchat click on the View Demo link.

Task **2:** Click on the message icon on the mobile phone screen to continue.

Task **3:** Scroll over the several icons on the screen to see what they are (top area).

Task **4:** You will notice that the displayed message is in sign language, convert this message to English.

Task **5:** Convert the message back to sign language.

Task **6:** Click the Reply in SL button to view the onscreen sign language keyboard.

Task **7:** Once task 6 is complete return to the main screen.

Task **8:** You will notice that the sign language message is static, view the message in motion.

Task **9:** Once task 8 is complete return to the main screen.

Task **10:** View the several options of the application.

Task **11:** Click on the settings link and see what the application has to offer.

Task **12:** Once task 12 is complete return to the main screen.

Task **13:** Select the Home button (left bottom) to return to the starting point.

Thank you for your participation!

User Satisfaction Questionnaire

Please provide your ratings for the following questions. The questions focus on your experience and opinions when using the Signchat phone application.

The questionnaire is divided in the following sections:

- Interface
- Navigation
- Usefulness
- Usability
- Accessibility

Name: Participant D4

Interface

1. The interface of the phone application was user friendly.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

2. I like using the interface of this phone application.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

3. I find the design consistence throughout the phone application design.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
	x			

4. The phone application has the functions and features I expect it to have.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
	x			

5. I find the colours of the phone application pleasant.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

6. Overall I am satisfied with the design of the phone application.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

Navigation

7. I find the phone application easy to navigate.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

8. The phone application requires the fewest steps to accomplish what you want to do.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

9. The placement of the functions (buttons) was appropriate.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

10. The functions placed on the home screen were important.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

11. Do you agree with the use of icons instead of text on the home screen?

Yes	**x**	No	

12. Did you find yourself at any point confused or not knowing where you are and what to expect next?

Yes		No	**x**

Usefulness

13. Do you find this phone application useful?

Yes	**x**	No	

14. Would you recommend this phone application to a friend?

Yes	**x**	No	

15. Do you believe that you can benefit from this phone application?

Yes	**x**	No	

16. I believe I can improve my communication skills with this phone application.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

17. I believe I can communicate with hearing/Deaf people with this phone application.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

Usability

18. I am satisfied with how easy the phone application is to use.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
	x			

19. I felt comfortable using the phone application.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

20. It was easy to find the information I needed.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

21. The information in the settings was easy to understand.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

22. The features on the home screen were easy to understand.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

Accessibility

23. Did you find the level of English hard to understand?

Yes		No	**x**

24. Did you find the sign language keyboard easy to understand?

Yes	**x**	No	

25. Did you find the convert feature useful?

Yes	**x**	No	

26. Did you find the watch video clip feature useful?

Yes	**x**	No	

27. Was the sign language message easy to distinguish from the background?

Yes	**x**	No	

28. Was the sign language video clip message easy to distinguish from the background?

Yes	**x**	No	

29. Does this phone application meet your needs?

Yes	**x**	No	

Appendix* L**: *Results from Deaf User* ***5

The biographical information, list of tasks and user satisfaction questionnaire is provided below.

Biographical Information

1. Name: *Participant D5*
2. Home Sign language: *Interpreter*
3. Country: *South Africa*
4. Education status: *Diploma*
5. Age: *40*
6. Gender:

Male		Female	**x**

7. Age deafness occurred?

   N/A

8. Type of deafness? **N/A**

Conductive		Sensorieneural		Mixed	

9. Level of deafness? **N/A**

Mild		Moderate	

Severe		Profound	

10. Age of onset? **N/A**

Pre-lingual deafness		Post-lingual deafness	

11. How long have you been using sign language?

-+ 11 years

12. Are your parents Deaf?

Yes		No	x	Only one of them	

13. Have you received formal sign language training?

Yes	x	No	

14. Do you have a mobile phone?

Yes	x	No	

15. For how long have you been using a mobile phone?

Since 2000

16. What do you use your mobile phone for?

SMS	x	MMS	

Emails		Internet	

Phone Calls	x	Applications (Word,Powepoint)	

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Photo **6:** Observations and comments

Good

Photo **7:** Observations and comments

Good

Photo **8:** Observations and comments

Good

Photo **9:** Observations and comments

Good

Photo **10:** Observations and comments

Good

Photo **11:** Observations and comments

Good

Photo **12:** Observations and comments

Good

Photo **13:** Observations and comments

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Photo **14:** Observations and comments

Good

Photo **15:** Observations and comments

Good

Photo **16:** Observations and comments

Good

Photo **17:** Observations and comments

Good

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Thank you for your participation!

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- Accessibility

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x				

2. I like using the interface of this phone application.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

3. I find the design consistence throughout the phone application design.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
	x			

4. The phone application has the functions and features I expect it to have.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
	x			

5. I find the colours of the phone application pleasant.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

6. Overall I am satisfied with the design of the phone application.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

Navigation

7. I find the phone application easy to navigate.

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x				

8. The phone application requires the fewest steps to accomplish what you want to do.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

9. The placement of the functions (buttons) was appropriate.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

10. The functions placed on the home screen were important.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

11. Do you agree with the use of icons instead of text on the home screen?

Yes	**x**		No	

12. Did you find yourself at any point confused or not knowing where you are and what to expect next?

Yes			No	**x**

Usefulness

13. Do you find this phone application useful?

Yes	**x**		No	

14. Would you recommend this phone application to a friend?

Yes	**x**		No	

15. Do you believe that you can benefit from this phone application?

Yes	x

No	

16. I believe I can improve my communication skills with this phone application.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

17. I believe I can communicate with hearing/Deaf people with this phone application.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

Usability

18. I am satisfied with how easy the phone application is to use.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
	x			

19. I felt comfortable using the phone application.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

20. It was easy to find the information I needed.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

21. The information in the settings was easy to understand.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

22. The features on the home screen were easy to understand.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
x				

Accessibility

23. Did you find the level of English hard to understand?

Yes		No	**x**

24. Did you find the sign language keyboard easy to understand?

Yes	**x**	No	

25. Did you find the convert feature useful?

Yes	**x**	No	

26. Did you find the watch video clip feature useful?

Yes	**x**	No	

27. Was the sign language message easy to distinguish from the background?

Yes	**x**	No	

28. Was the sign language video clip message easy to distinguish from the background?

Yes	**x**	No	

29. Does this phone application meet your needs?

Yes	**x**

No	