GUIDELINES FOR AND EVALUATION OF THE DESIGN OF TECHNOLOGY-SUPPORTED LESSONS TO TEACH BASIC PROGRAMMING PRINCIPLES TO DEAF AND HARD OF HEARING LEARNERS: A CASE STUDY OF A SCHOOL FOR THE DEAF

Ulza Wassermann

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By

Ulza Wassermann

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, to be awarded at the Nelson Mandela University

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Supervisor: Prof Darelle van Greunen

Declaration

I, Ulza Wassermann, 21403080898, hereby declare that the dissertation for Masters in Information Technology is my own work and that it has not previously been submitted for assessment or completion of any postgraduate qualification to another University or for another qualification.

Ulza Wassermann

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Researcher's publications related to this research project

Breed, E. A., Goosen, L., Havenga, M., Lubbe, E. E. S., Mentz, E., Serfontein, C. P., & Wassermann, U. (2013). Empowering IT & CAT Teachers. (in E. Mentz, Ed.). Stellenbosch: SUN MeDIA MeTRO.

Buitendag, A. A. K., Wassermann, U., & Pretorius, C. M. (2013). Utilising living lab principles to model and create a collaborative education environment - The CAT schools programme. In 2013 IST-Africa Conference and Exhibition, IST-Africa 2013. Nairobi, Kenya.

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Jacobs, S., Barnard, R., Brenkman, R., Gibson, K., Labuschagne, E., MacMillan, P., Wassermann, U. (2016). Computers, part of your life - Grade 10; A Textbook for Computer Applications Technology (2nd ed.). Pretoria: Study Opportunities.

Jacobs, S., Barnard, R., Gibson, K., Labuschagne, E., MacMillan, P., Miller, P., Wassermann, U. (2013). Computers, part of your life - Grade 12; A textbook for Computer Applications Technology. Pretoria: Study Opportunities.

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ABSTRACT

Deaf and Hard of Hearing (DHH) learners are part of a diverse population with unique learning challenges, strengths and needs. Learning material should be developed specifically for them to provide for their needs and capitalise on their strengths. These materials should include visual material and strategies as well as sign language. Furthermore, DHH learners have the same capacity for learning as hearing learners. However, in South Africa, DHH learners do not have adequate access to training in computer-related subjects, and therefore no material exists that has been developed specifically for DHH learners who want to learn a programming language. This research provides guidelines on the way technology-supported lessons can be designed to teach basic programming principles using the programming language Scratch, to DHH learners. Provision was made for the South African context where limited technology is available at most schools for DHH learners, but where most educators have access to Microsoft Office applications – specifically MS PowerPoint. Two goals were pursued. The primary goal of this research project was to determine the user experience (UX) of the participants (both learners and educators) during and after using and attending the technology-supported lessons. This was achieved through a case study. Four UX evaluation elements were evaluated in this project. They were: usability, accessibility, emotional user reaction, and hedonic aspects. Questionnaires, semi-structured interviews as well as participant-observation were used to determine the UX of participants. The UX evaluation provided sufficient evidence to claim that UX of participants was satisfactory, and therefore the guidelines that were developed to create technology-supported lessons to teach basic programming principles to DHH learners were appropriate.

The secondary goal was to develop guidelines for the design of technology-supported lessons to teach programming to DHH learners, and to apply these guidelines to develop a high-fidelity, fully functional prototype – a set of technology-supported lessons. This was achieved through a prototype construction research strategy. The lessons consisted of two vocabulary lessons and one programming lesson. The words that were taught in the vocabulary lesson were either terms appearing in the interface of Scratch, or words needed in the explanation of programming principles and Scratch context. The programming lesson (a PowerPoint slide show) was a guide for the educator to present the content in a logical way, and not to leave out important information. It used multimedia techniques (colour, pictures, animation) to explain programming concepts, and to display the tasks to be completed to the learners, so that they could remember the sequence of the steps. Practical strategies have been included in the guidelines to address the learning challenges DHH experience in the following areas: Comprehension skills, application of knowledge and knowledge organisation, relational and individual-item orientations, metacognition, memory, distractibility. The guidelines referred to techniques and principles that can be followed to design the interface and navigation tools of a technology-supported lesson; enhance communication with DHH learners, and provide support for them to work independently; specify the educator's role and attitude when facilitating or presenting programming lessons and to structure a programming lesson.

Keywords

Hearing impairment

Learning challenges

User Experiences

Design guidelines

Programming

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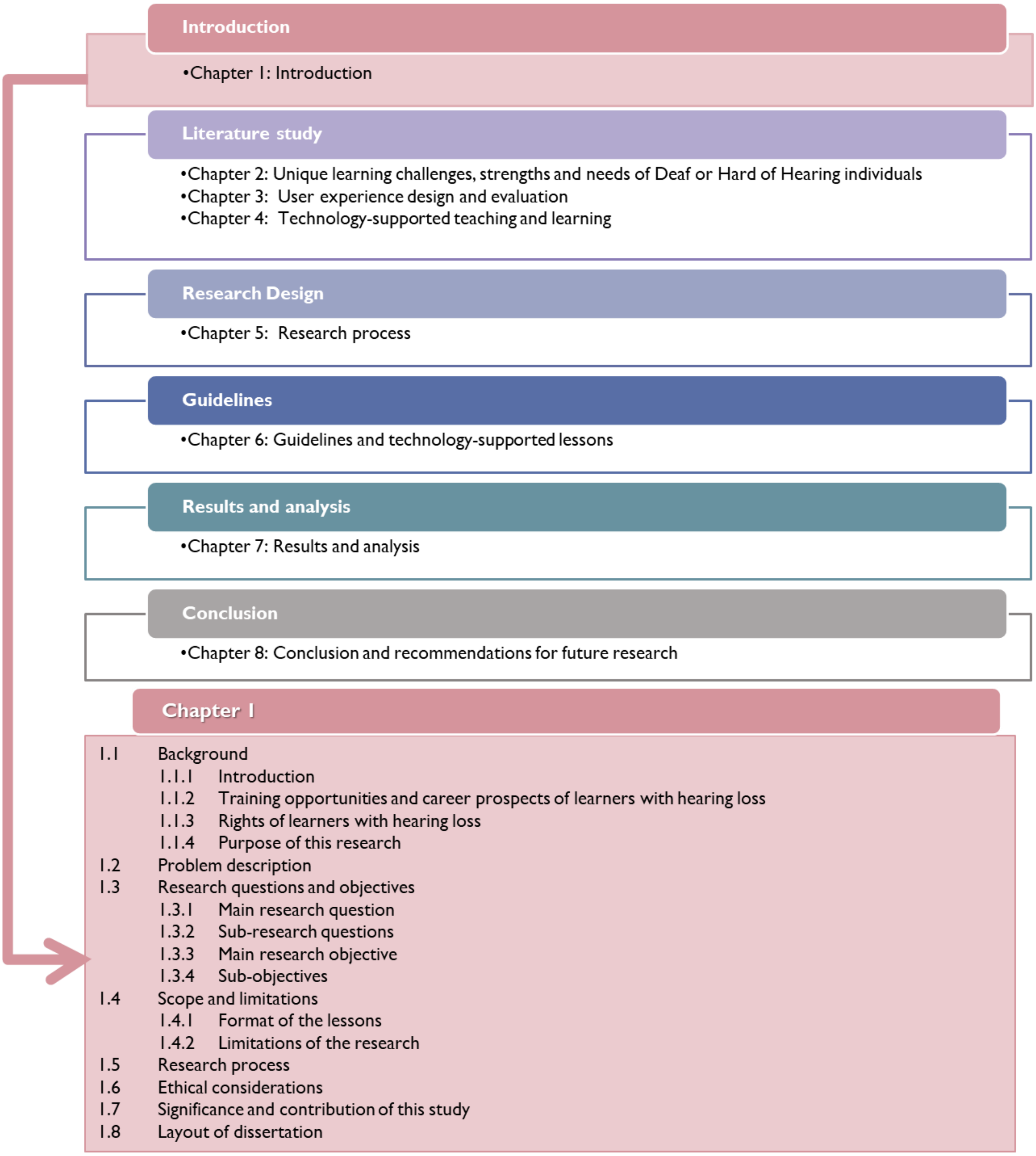
List of acronyms and abbreviations

ASL	American Sign Language
Auslan	Australian Sign Language
CAPS	Curriculum and Assessment Policy Statements
CART	Communication Access Realtime Translation
CAT	Computer Applications Technology
CC	Closed captioning
CODA	Child of Deaf Adults
DBE	Department of Basic Education
dBHL	Decibels hearing level
DeafSA	The Deaf Federation of South Africa
DHH	Deaf and Hard of Hearing
DoE	Department of Education
GDE	Gauteng Department of Education
HCD	Human Centred Design
HCI	Human computer interaction
ISO	International Organisation for Standardisation
IT	Information Technology
LoLT	Language of learning and teaching
MV	Cytomegalovirus
NCPPDSA	National Council for Persons with Physical Disabilities in SA
NCS	National Senior Certificate
NID	National Institute for the Deaf
NMU	Nelson Mandela University
OC	Open captioning
PC	Personal computers
SADA	South African Disability Alliance
SASL	South African Sign Language
SLED	Sign Language Education and Development
TVET	Technical and Vocational Education and Training
UWC	University of Western Cape
UX	User experience
UXD	User experience design
WCAG	W3C Web Content Accessibility Guidelines

WFD	World Federation of the Deaf
WPRDP	White Paper on the Rights of Persons with Disabilities
WWW	World Wide Web

Chapter 1

Introduction



1.1 Background

1.1.1 Introduction

This chapter sets out the background to the research project by discussing the training opportunities, career prospects of, and rights of learners who have hearing loss in South Africa. Salient terminology used pertaining to persons who have hearing loss is discussed in greater detail in Chapter 2. In this study, the term Deaf and Hard of Hearing (DHH) is used, since this description best fits the population in the school for the Deaf where the project was completed. When appropriate, the term 'people / learners with hearing loss' is also used.

1.1.2 Training opportunities and career prospects of learners with hearing loss

Results from the 2011 South African census indicate that 2,9% of persons aged five years and older in South Africa had mild difficulty in hearing, and 0,7% had severe difficulty (Statistics South Africa, 2014). It is also clear from statistics provided in the census report that many people with hearing loss do not attend any educational institutions, which will inevitably limit their career prospects – see Figure 1.1.

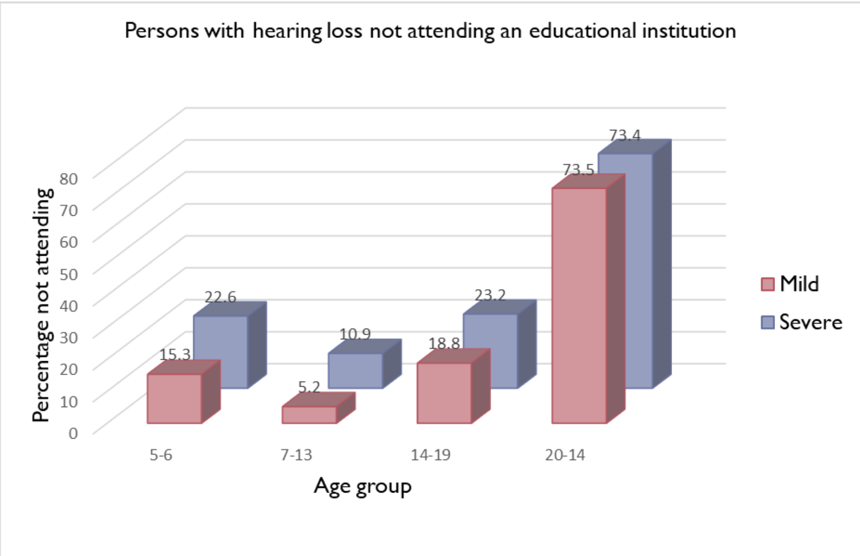


Figure 1.1: Created using data from Census 2011

According to reports issued by the Deaf Education directorate of The Deaf Federation of South Africa (DeafSA), there are numerous issues regarding training opportunities and career prospects for learners with hearing loss. Some of these are:

- In 2015, only 13 schools in South Africa enrolled students to write the Grade 12 National Senior Certificate (NCS) examinations. Of the 84 learners who wrote the examination, only 42 passed. This represents a 50% pass rate, which is 20.7% below the national pass rate for 2015 (Swift, 2016).

- The types of passes achieved by the 42 learners are displayed in the graph in Figure 1.2. This indicates the significant need for access by learners who indeed passed Grade 12, to Technical and Vocational Education and Training (TVET), Higher Certificate and Diploma studies (Swift, 2016).

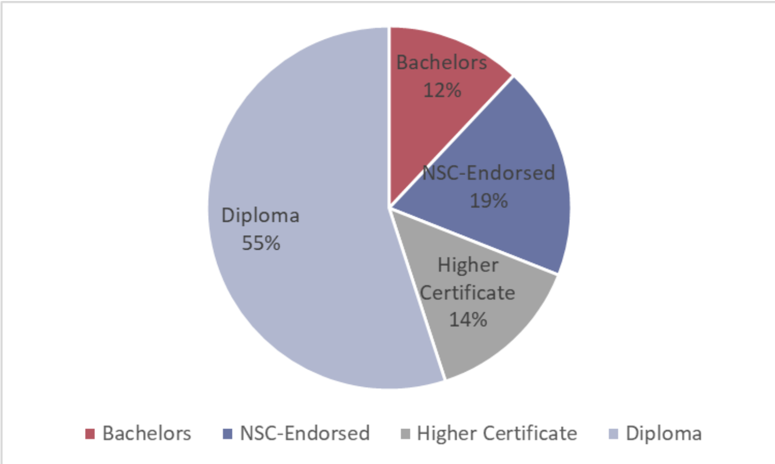


Figure 1.2: Deaf matric rate by pass type: 2016

- The level of academic education at schools for the Deaf is a concern in light of the paucity of learners in Grade 12, as well as their high failure rate (Swift, 2016).
- There is a lack of access to TVET colleges for Deaf school leavers who did not pass Grade 12, or who have achieved only an endorsed matric (Swift, 2016).
- No subject-specific information has been provided in the 2016 report, but in the Matric results of 2014, Computer Applications Technology (CAT) was offered by 13 schools for the Deaf in South Africa, with a total of only 54 learners. No school offered Information Technology (IT) (Swift, 2015). It has been confirmed by the Director, Deaf Education: DeafSA, that no school offered IT on Grade 12 level in 2016 either (personal communication, January 25, 2017). It is clear that DHH learners in South Africa do not have adequate access to training in computer-related subjects.

A number of reasons for this lack in academic performance in South African Schools for the Deaf are offered (Swift, 2016) – these include:

- Not all educators are able to use South African Sign Language (SASL) fluently in the classroom.
- Deaf learners attend mixed classes with blind learners, and educators teach only orally.
- There is a lack of subject-specific sign language vocabulary.

- A general perception exists that academia is not within the capabilities of DHH learners.

It is clear that the current state of education for learners with hearing loss is preventing them from becoming contributing members of society. Swift (2016) calls for research to gain insight into the specific challenges facing Deaf learners and Deaf school leavers.

1.1.3 Rights of learners with hearing loss

According to the World Federation of the Deaf (WFD), "Deaf people have the same right to education and full access to quality education. The right to education is clearly and explicitly stated in the new Convention on the Rights of Persons with Disabilities" (WFD, 2016, "Background", par. 1). This convention has been signed by South Africa in 2007[1], and states, amongst others, that:

- States should provide resources to facilitate the learning of sign language and ensure that education is delivered in environments that maximise academic and social development.
- Educators who are qualified in sign language should be employed.
- The linguistic identity of the Deaf community must be promoted.

The convention further states that, "Deaf children are born with the same basic capacities for learning and language as all children; they can and should reach their full potential with appropriate, visual, quality educational programmes and support" (WFD, 2016, "Background", par. 4).

The convention further emphasises the fact that Deaf people are visual beings; that they learn best through the use of visual material, and that sign language and visual strategies should be made available to them as a birth right.

The *White Paper on the Rights of Persons with Disabilities* was approved by the cabinet of South Africa on the 9th December 2015 (Department of Social Development, 2015). This document also refers to the fact that:

- Education to Deaf and hearing-impaired learners should be delivered in appropriate languages and modes, and the environment should maximise academic and social development.

[1] The signing of the *Convention on the Rights of Persons with Disabilities* was confirmed by the Manager: Public Education & Awareness; Hearing Impairment/Deaf Affairs (personal communication, 2016, July 27).

- Educators (also educators with disabilities), who are qualified in SASL, should be employed and trained. Training should include “disability awareness and the use of appropriate augmentative and alternative modes, means and formats of communication, educational techniques and materials to support persons with disabilities” (Department of Social Development, 2015, p. 84).

In South Africa, some progress has been made to comply with these guidelines. In 2015, the Department of Basic Education (DBE) included South Africa Sign Language (SASL) in the curriculum in all schools for the Deaf.

However, even though learners with hearing loss are legally protected and provided for in South Africa, the reality is that there is still a lack of learning material and trained educators in SASL. A non-profit organisation called Sign Language Education and Development (SLED) has been active in South Africa since 2001 to promote SASL. SLED delivers training to educators in schools for the Deaf, and also provides learning material to assist educators to create meaningful SASL lessons. These materials include, amongst others, illustrated signed stories, games, puzzles, and literature DVD’s with accompanying reading books. However, on their official website they mention that there is a “dearth of material and trained educators in SASL” (SLED, 2015b, “WHY SIGN LANGUAGE”, par. 1).

1.1.4 Purpose of this research

The purpose of this research project is to:

- Develop a set of guidelines for the development of technology-supported lessons to teach programming principles to DHH learners at a school for the Deaf,
- Apply these guidelines to develop a high-fidelity, fully functional prototype – a set of technology-supported lessons, and then
- To present the lessons and evaluate the user experience (UX) of the DHH learners and educators who were involved, during and after the learners completed the lessons.

1.2 Problem description

In this research project, it has been identified that:

- There is a lack of guidelines for educators to create their own learning material which takes the unique learning challenges and strengths, and subsequent needs of DHH learners into account.
- No learning material exists that has been developed specifically for DHH learners who want to learn a programming language.

The problem statement for this research project can therefore be formulated as:

What are the appropriate guidelines for the development of technology-supported lessons to teach basic programming principles to Deaf and Hard of Hearing learners?

1.3 Research questions and objectives

The main and sub-research questions and objectives are as follows:

1.3.1 Main research question

What are the appropriate guidelines for the development of technology-supported lessons to teach basic programming principles to Deaf and Hard of Hearing learners?

1.3.2 Sub-research questions

1. What are the unique learning challenges and strengths, and subsequent needs of Deaf and Hard of Hearing learners?
2. How can technology be implemented to support lessons to teach basic programming principles to Deaf and Hard of Hearing learners?
3. To what extent did Deaf and Hard of Hearing learners and their educators have a satisfactory user experience during and after completing technology-supported lessons to teach basic programming principles?

1.3.3 Main research objective

The primary objective of this research project is to determine whether the set of guidelines that has been designed during the course of this research to develop technology-supported lessons to teach basic programming principles to Deaf and Hard of Hearing learners is appropriate.

1.3.4 Sub-objectives

1. To identify the unique learning challenges and strengths, and subsequent needs of Deaf and Hard of Hearing learners.

2. To create guidelines for the design of technology-supported lessons to teach basic programming principles to Deaf and Hard of Hearing learners.
3. To evaluate the user experience of the learners and educators after completing the lessons.

1.4 Scope and limitations

In order to appreciate the references in the literature review chapters, to the way in which the theoretical principles were applied practically, it is necessary to describe the format of the lessons which were developed.

1.4.1 Format of the lessons

The set of technology-supported lessons that was developed by applying the guidelines, entails the following:

1. Two vocabulary lessons – MS PowerPoint presentations.
2. An introduction, which is a video clip (in mp4 format), explaining to learners how to use the vocabulary lessons. The explanation is signed in South African Sign Language (SASL).
3. One programming lesson – an MS PowerPoint presentation.

The words to be included in the vocabulary lessons were identified by:

- The educator teaching South African Sign Language (SASL) and English, who was also the one who presented the programming lesson.
- The educator teaching Computer Applications Technology (CAT), as well as
- The researcher who is a subject expert in teaching and developing learning material to teach Scratch[2].

The words that were taught in the vocabulary lesson were either terms appearing in the interface of Scratch, or words needed in the explanation of programming principles and Scratch context.

Examples of words that appear in the interface of Scratch are: Event; Stage; Backdrop, and Costume. Examples of words that were needed to teach programming principles and Scratch content are Actor; Instructions; Group; Bump, and Ditch. Some words appear are used in both contexts, for example the word Repeat.

The two vocabulary lessons were presented as two different stories. Each story consisted of short sentences in familiar contexts – for example, one story described a camping trip since all the learners went on such a trip the previous year, while the other story described a

[2] Scratch is a project of the Lifelong Kindergarten Group at the MIT Media Lab. See http://scratch.mit.edu

concert, since the school's Sign Choir regularly performs with well-known actors. Each sentence in the story contained one new word. The learners had to learn to read the word, recognise the SASL sign, as well as understand the meaning of the word. A more detailed description of the layout of these lessons is presented in Chapter 6 of this study.

In order to assist learners to learn the new words, each new word was represented in a number of ways:

- Written, using the SASL fingerspelling font,
- Used in an Afrikaans sentence (the language in which the group of participants learned to read and write).
- Used in an English sentence.
- Represented using a picture or animation.
- As a single SASL sign for the new word.
- Used in a SASL sentence (same content as the Afrikaans and English sentences), containing the new word as a sign.

Learners received the vocabulary lessons on flash disks so they could view them at home. The lessons were also used in some of the regular SASL classes, and they was installed on all computers to which learners had access.

The educator who presented the programming lesson was not familiar with the programming language Scratch, even though she does have some background knowledge of programming. The MS PowerPoint slide show for the programming lesson therefore served two purposes:

1. To be a guide for the educator to present the content in a logical way, and not to leave out important information.
2. To use multimedia techniques (colour, pictures, animation) to
    - explain programming concepts, and to
    - display the tasks to be completed to learners to assist them in remembering the order of steps.

1.4.2 Limitations of the research

Only learners from one school for the Deaf were involved in the research project.

Learners received assistance in completing the vocabulary lessons, and they had the opportunity to work on the lessons independently – either at home or during class time. However, no formal assessment was done to determine whether the learners did master all the vocabulary before the programming lesson was presented.

The programming lessons contained questions that learners had to answer in class during the lesson (formative assessment). However, no formal summative assessment was done to evaluate the knowledge and skills of learners after completing one programming lesson. At the end of the programming lesson, the learners received complete programs with limited instructions that they could copy, and their interaction with the programming language and one another was observed. Informal observations were done by the researcher, and in the semi-structured interview with the two educators they had the opportunity to express their opinions on the level of skills they observed during the programming lesson.

Therefore, the focus was on the UX of the learners – which included usability, accessibility, emotional user reaction and hedonic aspects (see Chapter 3).

1.5 Research process

The research process of this research project followed the so-called 'onion model' suggested by Saunders et al. (2003) and Saunders et al. (2009). This is demonstrated in Figure 1.3.

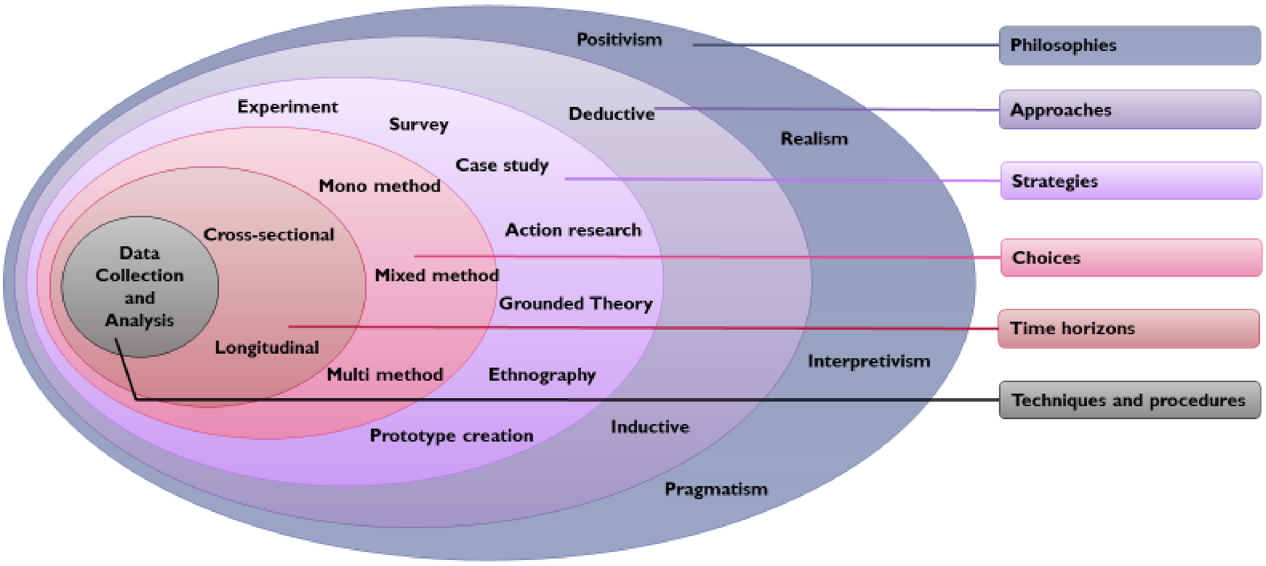


Figure 1.3: Research process indicated as an 'onion model'.
(Saunders, Lewis, & Thornhill, 2003; Saunders, Lewis, & Thornhill, 2009)

The different stages (or layers) in this research project were as follows:

The research philosophy that guided this research project is Interpretivism, where "the central endeavour in the context of the interpretive paradigm is to understand the subjective world of human experience" (Cohen, Manion, & Morrison, 2011, p. 16).

An inductive research approach was followed. "Data was explored and theories developed that can be related to relevant literature" (Saunders, Lewis, & Thornhill, 2009, p. 61).

Two research strategies were used in this research project. The secondary strategy was the construction of a prototype (two vocabulary lessons, and one programming lesson). The primary strategy was a case study in which the UX of the DHH learners, as well as the educators who were involved, was measured with regards to the vocabulary and programming lessons.

For data collection and analysis, a sub-category of the mixed-methods approach was used, where qualitative data is reported using descriptive statistics (quantitative analysis), as well as a number of narratives (qualitative analysis).

The time horizon was cross-sectional – since it "produces a 'snapshot' of a population at a particular point in time" (Cohen et al., 2011, p. 267).

Qualitative data collection methods were used, which included questionnaires (for the learners), semi-structured interviews (with the CAT and SASL educators), and participant-observation (done by the researcher during the programming lesson).

1.6 Ethical considerations

Research conducted in academic institutions has to comply with sets of ethical requirements. These requirements govern and guide the practices of researchers. If the research is conducted in an ethically sound manner, it enhances the quality of research and contributes to its trustworthiness (Rule & John, 2011).

In this study, ethical approval had to be obtained from two institutions, namely the Nelson Mandela University: Research Ethics Committee (Human), as well as the Gauteng Department of Education (GDE). In all documentation, the privacy and anonymity of the participants were emphasised. It is also a requirement of the GDE that the name of the school for the Deaf where the research project was completed, may not be mentioned in any documentation which forms part of the dissertation.

1.7 Significance and contribution of this study

As explained in Chapter 4, a number of researchers have reported on projects where e-learning projects for people with hearing loss have been created. However, most of these projects focussed on teaching sign language, or on improving reading comprehension. The lessons were also implemented purely as e-learning, usually using specialised software and technology.

The present research includes specific reference to the South African context where limited technology is available at most schools for DHH learners. Emphasis is placed on the importance of educator involvement in the learning process – therefore *technology-supported* learning, that may provide guidance to educators to teach basic programming principles.

The research also hopes to contribute to the field of UX evaluation, since there are no specific evaluation criteria available to evaluate the UX of DHH learners.

1.8 Layout of dissertation

This dissertation is divided into six categories and contains eight chapters. Figure 1.4 illustrates how the chapters are structured and how they fit into the different categories.

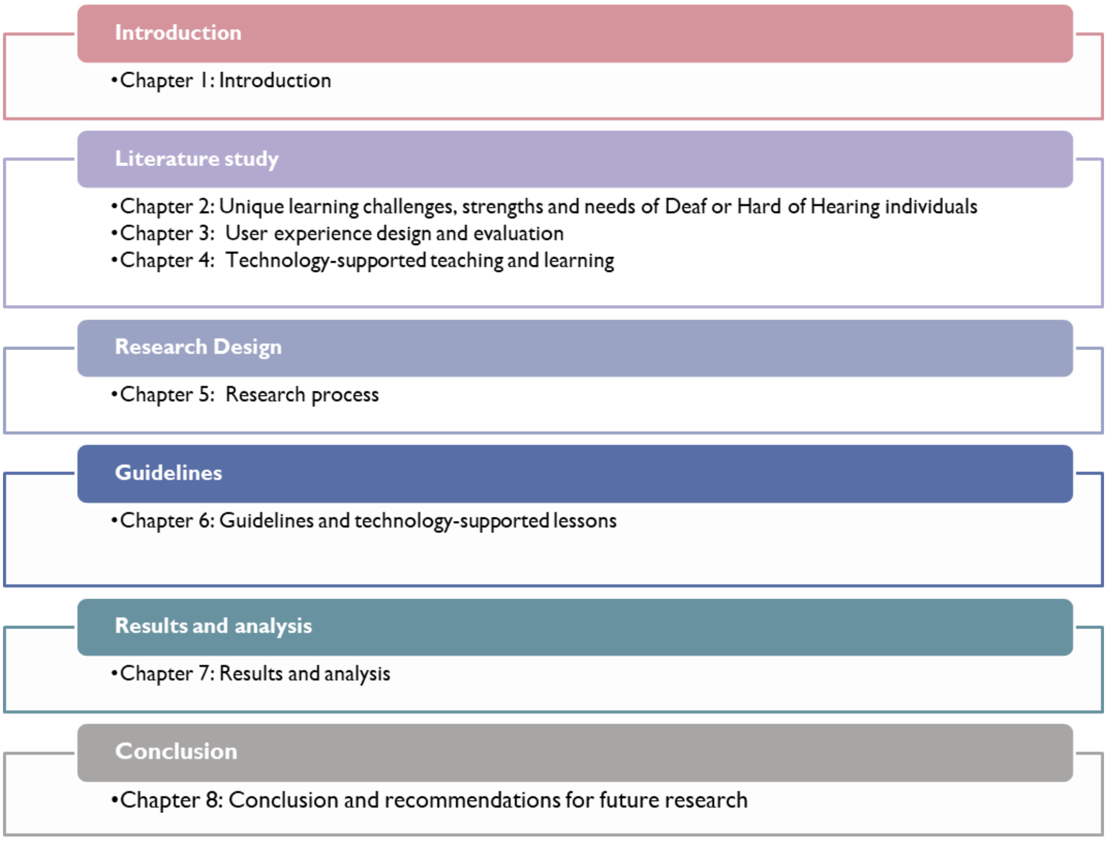


Figure 1.4: Layout of dissertation

Chapter 1 provides background information on the training of individuals with hearing loss in South Africa, and highlights some concerns, especially the lack of training in programming skills at school level (Grades 10 – 12). It also discusses the rights of learners with hearing loss as far as education is concerned, and formulates the problem statement for this research project. It further sets out the research questions, the scope and limitations, a brief overview of the research process, the ethical considerations and significance and contribution of the study.

Chapters 2, 3 and 4 are the literature review chapters, which, *inter alia*, provide information on exemplary studies, while comparing and contrasting different researchers' views, in order show how this study relates to previous studies and to highlight gaps with regard to the South African context.

Chapter 2 is the first literature review chapter, and here the need for a different approach in designing learning material for DHH learners is explained by providing background to hearing loss as well as communication options to emphasise the complexity and diversity of individuals with hearing loss. A number of challenges in learning and consequent learning needs are then discussed, and practical strategies to deal with these learning needs are suggested, as gleaned from various research projects. These strategies have been incorporated in the set of guidelines (that is provided in Chapter 6).

Chapter 3 is the second literature review chapter. It discusses the diversity of the field of UX, applies a reductive approach to UX to obtain the UX model which were used in this research project. The four UX elements that were used to evaluate the UX of the participants in this research project are identified and motivated. User experience design (UXD) is illustrated as an iterative process, and UXD guidelines for accessibility and usability are listed. Finally, evidence that is necessary to evaluate each of the UX evaluation elements, the evaluation methods, and evaluation instruments are discussed.

Chapter 4 is the third literature review chapter. The purpose of this chapter is to present practical guidelines to design learning and teaching media for DHH learners. These practical guidelines were used with the mitigation strategies presented in Chapter 2, and the UXD guidelines presented in Chapter 3, to create the guidelines for programming lessons.

Chapter 5 describes the process that was followed to turn the research questions into a research project.

Chapter 6 presents the guidelines that were used to create the technology-supported lessons to teach basic programming principles to DHH learners, as well as the lessons them self.

The focus of Chapter 7 is to present and analyse the results obtained from the data collection instruments. Evidence is provided to prove that the participants' UX for each of the UX elements identified in Chapter 3 was satisfactory.

Chapter 8 is the conclusion of the research project. Here, solutions to the problem statement and research questions are presented, together with limitations of the study, the significance and contributions of the study, lessons learnt and suggestions for future research.

The next chapter is the first of the three literature review chapters.

Chapter 2

Unique learning challenges, strengths and needs of Deaf and Hard of Hearing individuals

Introduction

- Chapter 1: Introduction

Literature study

- Chapter 2: Unique learning challenges, strengths and needs of Deaf or Hard of Hearing individuals
- Chapter 3: User experience design and evaluation
- Chapter 4: Technology-supported teaching and learning

Research Design

- Chapter 5: Research process

Guidelines

- Chapter 6: Guidelines and technology-supported lessons

Results and analysis

- Chapter 7: Results and analysis

Conclusion

- Chapter 8: Conclusion and recommendations for future research

Chapter 2

2.1 Introduction

This research project includes three literature review chapters. The present chapter is the first of these, and it presents the unique learning challenges and strengths of Deaf and Hard of Hearing (DHH) learners, and their subsequent learning needs. This review provides information that, together with the user experience design (UXD) guidelines (Chapter 3), as well as the literature review on the use of technology to support lessons to DHH learners (Chapter 4), supports the decisions that have been made pertaining to the design elements that have been included in the vocabulary as well as the programming lessons.

This chapter addresses sub-research question 1:

> *What are the unique learning challenges and strengths, and subsequent needs of Deaf and Hard of Hearing learners?*

The chapter also provides strategies that can be implemented to support the learning needs of DHH learners. Some of these mitigation strategies include the use of technology; therefore this chapter also partly addresses sub-research question 2:

> *How can technology be implemented to support lessons to teach basic programming principles to Deaf and Hard of Hearing learners?*

The review starts by providing a motivation for a different approach when designing learning material for learners who are DHH. It refers to the large number of people who are DHH, requirements of international organisations, the significant differences between learners who are DHH (and those who are not), as well as the diversity of DHH people.

Contextual background to hearing loss follows, and this section explains the different terminologies used to refer to people with hearing loss, different components of hearing loss, communication options for DHH people, and a brief overview of the communication options in South African schools.

Various challenges regarding learning for learners with hearing loss are then discussed, and a number of practical strategies to mitigate these challenges are suggested. These strategies have been incorporated in the design guidelines of the lessons. These guidelines are provided in Chapter 6, with an indication of the learning need that may be addressed by each guideline.

Finally, visuospatial memory as a strength of learners with hearing loss and the practical implications thereof when developing learning material is discussed.

2.2 The need for a different approach in design

Learners who are DHH do not receive the same education opportunities as learners without disabilities. This is the view of The World Federation of the Deaf (WFD), an international, non-governmental organisation that strives to promote and protect the right of Deaf people to life-long education. They advocate that Deaf learners have the same right to education and full access to quality education as all other learners. However, studies conducted by the WFD indicate that the literacy achievement of Deaf people is far below the level of the average of the population. They take the position that Deaf learners have the same capacities as other children, and should therefore receive appropriate education, which includes a strong language base (WFD, 2016). Other researchers also advocate that Deaf children have the same potential as other children for language development, but their communication needs are often not met – simply because a fully accessible (i.e., visually based) language is not present in their environment and because the language that is in their environment (i.e., auditory based) is not fully accessible (Kuntze, Golos, & Enns, 2014).

From a review of reports from various researchers, it is clear that DHH learners have distinguishing characteristics such as reduced literacy and slower academic progress, reduced social and emotional development, reduced empathy and a level of nervousness in novel situations, delayed language development, and limited or delayed spoken language (Korte, Potter, & Nielsen, 2015). According to Marschark, Spencer, Adams and Sapere (2011), there are also language and cognitive differences between DHH and hearing learners – and even among DHH learners themselves (Marschark, Spencer, Adams, & Sapere, 2011).

These differences are significant enough to suggest that the type of learning material used and the way DHH learners are taught should be modified. Marschark et al. (2011) add that it is not sufficient simply to remove communication barriers – the needs and cognitive strengths of DHH learners should be matched. Some researchers also suggest that interpreted lectures are not efficient, since they are structured by hearing educators for hearing learners, and may not match the knowledge and learning styles of DHH learners (Marschark et al., 2011). Therefore, there is a need to modify our teaching approaches, for example, to capitalise on the strengths of deaf children as visual learners (Kuntze et al., 2014).

Al-Osaimi, Alfedaghi and Alsumait (2009) specifically worked with the design of e-learning interfaces for DHH learners. They are convinced that it is a requirement that e-learning interfaces should be designed specifically for DHH learners, otherwise they face many difficulties. The authors also propose that these specially designed interfaces will enhance the learning experience of DHH learners (Al-Osaimi, AlFedaghi, & Alsumait, 2009).

Apart from research that provides sufficient proof that DHH learners' learning material should be designed specifically for them because of their unique needs, the significant number of people who are affected by hearing loss adds to this motivation. According to Phonak – a company that supplies hearing aids – up to 1.1 billion people around the world would have been affected by hearing loss in 2015. That is almost 16% of the world's population. The majority of these people are of school or working age, and increasingly young people experience hearing loss, mainly because of excessive noise levels and listening to loud music (Phonak, n.d.). Results from the 2011 South African census indicated that 2,9% of persons aged 5 years and older in South Africa had mild difficulty in hearing and 0,7% had severe difficulty (Statistics South Africa, 2014).

In South Africa, the statistics regarding DHH learners who complete Grade 12 further adds to the conviction that additional interventions are needed for learners with hearing loss. Only 45% of the 38 comprehensive/high schools for DHH learners in South Africa offered learners the opportunity to complete Grade 12 in 2014, with two provinces not even having a single school offering Grade 12 (Swift, 2015). Without a National Senior Certificate (NCS), learners are prevented from engaging in further study other than vocational studies in Technical and Vocational Education and Training (TVET) colleges.

Therefore, taking the large numbers of people having hearing loss into consideration, together with the requirements of organisations such as the WFD and the differences in learning between DHH and hearing learners, it is clearly extremely important to comprehend the unique learning needs of DHH learners before attempting to design instructional materials.

2.3 Background to hearing loss

2.3.1 Relevant terminology

According to information supplied on the official website of Gallaudet University, the World Federation of the Deaf voted in 1991 to use the terms *deaf* and *hard of hearing* to describe people in the deaf community. They also state that these terms are accepted and used by most organisations involved with the deaf community. The term *hearing impaired* is often found in articles relating to deaf matters; however, it seems as if it is not a preferred term, since it seems to focus on what people cannot do. Terminology such as *deaf and dumb*, or *deaf-mute* are not considered to be acceptable (Gallaudet, n.d.).

In South Africa, the South African Disability Alliance (SADA) confirmed the definitions to be used with reference to the communities of people who are Deaf, Hard of Hearing, or Hearing Impaired or deaf (SADA, 2016). These definitions are in line with the criteria set by the White

Paper on the Rights of Persons with Disabilities (WPRDP approved by Cabinet on 09/12/2015), as well as the United Nations Convention on the Rights of Persons with Disabilities (signed by South Africa in 2007). These definitions will be provided to the Department of Social Development, and will be used in all official documents issued by the Government. Figure 2.1 provides an overview of the terminology and definitions.

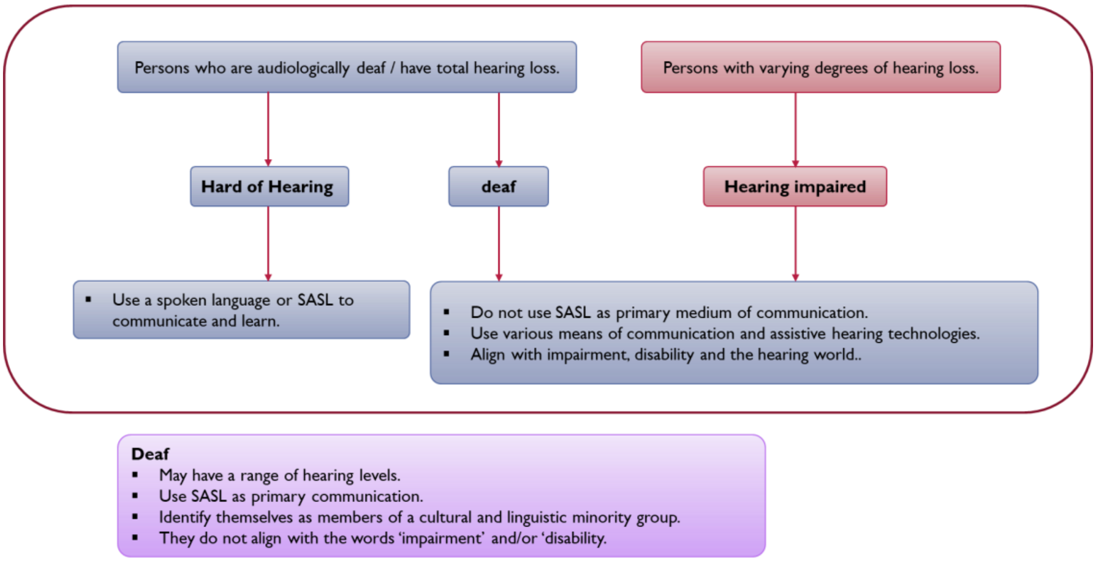


Figure 2.1: *Terminology and definitions related to persons with hearing difficulties. Diagram created using information from (Gallaudet, n.d.), (NCPPDSA, 2015) and (SADA, 2016)*

In South Africa, different terms are used when naming schools who provide education to learners with hearing loss. Some include the word 'Deaf' – for example *Ekurhuleni School for the Deaf*. Others use the term hearing impaired, such as *Sonitus School for the Hearing Impaired*. In this dissertation, various terms are used, depending on the terminology used in the literature. In general, 'learners who are Deaf and Hard and Hearing (DHH)' is used.

2.3.2 Defining and describing hearing loss

In this section, different components of hearing loss are discussed, namely the different levels of hearing loss, the age of onset, the type of hearing loss and the cause of hearing loss. Learners who are in the same classroom may have different profiles when these components are considered. By reviewing these components, the complexity of having to develop learning material for learners with hearing loss is emphasised.

2.3.2.1 Level of hearing loss

The levels of hearing are measured in decibels hearing level (or dBHL). Hearing loss is described as a measurement of the softest level a person can hear. According to the official website of Cochlear (a company that supplies cochlear implant technology), there are five levels of hearing:

Table 2.1: Description of hearing loss (Cochlear, n.d.)

Level of hearing	Description
Normal hearing	Can hear sounds down to 20 dBHL.
Mild hearing loss	Hearing loss in the better ear between 25 - 39 dBHL. One has difficulty following speech in noisy situations.
Moderate hearing loss	Hearing loss in the better ear between 40 - 69 dBHL One has difficulty following speech without a hearing aid.
Severe hearing loss	Hearing loss in the better ear between 70 – 89 dBHL. Require powerful hearing aids or an implant.
Profound hearing loss	Hearing loss in the better ear from 90 dBHL. One needs to rely mainly on lip-reading and/or sign language, or an implant.

2.3.2.2 Types of hearing loss

The type of hearing loss implies different kinds of hearing difficulty and different types of support and intervention that should be offered to a learner (Storbeck, 2005). Table 2.2 provides an overview of different types of hearing loss.

Table 2.2: Types of hearing loss (MED-EL, n.d.)

Type of hearing loss	Description
Conductive	Any problem in the outer or middle ear that prevents sound from being conducted properly is known as conductive hearing loss. Conductive hearing losses are usually mild or moderate in degree, ranging from 25 to 65 decibels.
Sensorineural	Sensorineural hearing loss results from missing or damaged sensory cells (hair cells) in the cochlea and is usually permanent. Also known as 'nerve deafness', sensorineural hearing loss can be mild, moderate, severe or profound.
Mixed hearing loss	A mixed hearing loss is a combination of a sensorineural and conductive hearing loss. It results from problems in both the inner and outer or middle ear. Treatment options may include medication, surgery, or hearing aids.

Neural hearing loss	A problem that results from the absence of or damage to the auditory nerve can cause a neural hearing loss. Neural hearing loss is usually profound and permanent. Hearing aids and cochlear implants cannot help, because the nerve is not able to pass on sound information to the brain.

2.3.2.3 Age of onset and cause of hearing loss

The age of onset and the cause of hearing loss have an impact on the linguistic and cognitive development of the child, on family relations and subsequently on the needs and types of support and intervention that a hearing-impaired learner may need. Two age categories are identified (Storbeck, 2005):

- Pre-lingually: Before language was developed – usually before two years of age. The child did not have adequate access to any spoken language. However, it may be the case that parents were able to expose the child to a signed language. These children are usually educated in a school for the Deaf. Deafness could either be from birth, or acquired by maternal illness such as German measles or a herpes virus – cytomegalovirus (MV); genetic deafness; birth complications and/or premature birth.
- Post-lingually: After language development. The child has a spoken language base for learning and communicating. These children can possibly continue in his/her present school with additional support strategies put in place. Post-lingual deafness is primarily caused by ear infections (otitis media) and meningitis.

2.3.3 Communication options

According to Lynas (2005), controversy surrounds the choice of method used to teach learners who are hearing impaired to communicate. Three of the major communication options for people who are hearing impaired mentioned by her are discussed here. However, communication methods are not limited to these three examples:

2.3.3.1 Total communication (TC)

TC uses signs from a sign language of a specific country, and replaces each word of the spoken language by a sign, while retaining the word order of the spoken language. It is supposed to provide access to the verbal language through signs, and also makes use of whatever level of hearing the child may have (Lynas, 2005).

2.3.3.2 Sign-bilingualism

According to the sign-bilingual approach, a child should be taught a sign language as soon as total hearing loss has been diagnosed. A written language should then be taught as a second language. According to supporters of this approach, a child with total hearing loss (deaf) will acquire sign language with the same ease as a hearing child acquires a spoken language. It is further argued that deaf learners who are able to sign will be able to perform in the same way as a hearing child when they start formal education, provided that trained signing educators are available (Lynas, 2005).

2.3.3.3 Auditory–oral

People who support this approach are of the opinion that it is desirable and – due to advances in technology – possible for even severely and profoundly deaf children to talk and understand a spoken language. They argue that verbal communication is the principal medium of social exchange, and that the negative consequences of deafness can be minimised if the child can talk, and interpret language to some extent. They claim that hearing loss can be detected very early, and due to the availability of smart hearing aids and cochlear implants, children can be taught to acquire language within their first five years (Lynas, 2005).

However, each of these approaches have their own advantages, disadvantages and challenges. For example, in third-world countries, many children are only diagnosed late in life, and miss language development which should have taken place from birth to the age of two. The auditory-oral approach, for example, will not be suitable for these children. Teachers will then have to teach the deaf child a sign language before the curriculum as required by the state can be taught (Hart & Ahmed, 2013).

2.3.4 Communication in South African schools

There are numerous organisations in South Africa that apply themselves towards improving education for hearing impaired children. One of them is called *Sign Language and Education* (SLED). They are: “a Deaf non-profit organisation that is committed to providing the Deaf child of South Africa with an equal and democratic right to literacy, learning and access to information through the promotion of South African Sign Language (SASL)” (SLED, 2015a, “SIGN LANGUGAE EDUCATION AND DEVELOPMENT (SLED)”, par. 1).

According to SLED,

> South African Sign Language is the most basic human right of the Deaf Community. It has become widely recognised and protected in various legislative and governmental policies (and is even acknowledged as a language equal in status to the 11 official languages in the country). (SLED, 2015a, “WHY SIGN LANGUAGE”, par. 1).

The Curriculum and Assessment Policy Statements (CAPS) for SASL Grades R-12 were completed and approved as policy in July 2014 (DBE, 2014). The South African Schools Act (84 of 1996) recognises SASL as a language of learning and teaching (LOLT). Based on the CAPS, SLED has developed learning material, and also provide training for educators in SASL.

According to the White Paper on the Rights of Persons with Disabilities which was approved by the Cabinet on the 9th of December 2015, the Constitution of the Republic of South Africa, 1996, provides for the recognition of SASL as the first language of Deaf South Africans. The White Paper further mentions that “Persons with disabilities must have access to inclusive learning opportunities throughout their lives where they learn with peers without disabilities in barrier-free settings” (Department of Social Development, 2015, p. 83). It further refers to specific measures which should be taken for Deaf learners, which include:

- Facilitating the learning of South African Sign Language and the promotion of the linguistic identity of the Deaf community and
- Ensuring that the education of persons, and in particular children, who are blind, deaf, hearing impaired, non-speaking autistic or deaf-blind is delivered in the most appropriate languages and modes and means of communication for the individual, and in environments which maximize academic and social development. (Department of Social Development, 2015, p. 84).

2.4 Learning challenges and needs

Even though many research projects have been conducted to support the teaching and learning of DHH children, and their mental capabilities are generally at the same level as those of hearing people, DHH people still demonstrate worse reading, writing and mathematical abilities when compared to those of hearing people (Drigas, Kouremenos, Kouremenos, & Vrettaros, 2005).

Marschark et al. (2011) examined the possible sources of academic underachievement of DHH children. They mention a number of areas in which DHH learners differ from hearing learners, and they suggest a few interventions. They stress the fact that not much research has been done to provide evidence with regard to the effectiveness of particular interventions. However, they are of the opinion that it is important to understand the differences between DHH and hearing learners and that it is not sufficient to only remove the communication barriers for DHH learners, and then teach them in the same way as hearing learners. There is a need to match teaching methods and materials to the strengths and the needs of DHH learners, and "teach to" (Marschark et al., 2011, p.18) the differences between DHH learners and hearing learners (Marschark et al., 2011).

It is interesting to note that, according to Marschark et al. (2011), DHH learners in general learn less than their peers in mainstream classrooms regardless of the mode of instruction (spoken language, sign language or a combination of the two). According to the authors, the research on the foundations of learning by DHH learners should be the starting point to increase understanding of the way in which the learning of DHH learners can be supported. Therefore, in the remaining part of this chapter, the learning needs and the cognitive strengths of learners with hearing loss are discussed. Some recommendations for interventions and strategies are also suggested. However, it is not a comprehensive list, and the more complete guidelines for creating technology-supported lesson for DHH learners are presented and discussed in Chapter 6.

The challenges pertaining to learning, and the learning needs of DHH learners are discussed next.

2.4.1 Comprehension skills

Hearing loss creates inescapable learning problems that usually result in delayed language acquisition and, consequently, delayed development of academic skills (Pollack, 1997). One of the most significant difficulties faced by DHH students are comprehension skills (Bueno, Fernández del Castillo, Garcia, & Borrego, 2007). The reading skills of many DHH children are several years behind those of hearing children (van Staden, 2013). DHH Learners have difficulty with acquiring reading as well as writing skills (Korte et al., 2015), and the average DHH adult reaches the written literacy level of a hearing learner in Grade 5 (H. F. Blair, 2013).

Numerous research projects and reports have focused on developing e-learning material for DHH learners and students, or adapting existing material to be accessible to them. Some of the projects claim that the techniques and interventions they offer do indeed improve reading comprehension (Al-Osaimi, AlFedaghi, & Alsumait, 2009; Bueno, Fernández del Castillo, Garcia, & Borrego, 2007; Giannakos & Jaccheri, 2014; Hart & Ahmed, 2013; Lang & Steely, 2003; Mich, Pianta, & Mana, 2013; Nikolaraizi & Vekiri, 2012; Luckner, Bowen, & Carter, 2001).

Efforts aimed at improving reading comprehension make up a vast field of research. In this research project, lesson presentation was supported by technology. Some of the strategies mentioned in the projects discussed were implemented in the technology-supported lessons, but this research project by no means claims that a comprehensive or in-depth study of reading comprehension has been implemented.

Strategies to deal with comprehension skills

- Include media such as sign language videos, concept maps and pictures in learning material (Nikolaraizi & Vekiri, 2012).
- Use simplified text supplemented with pictures (Mich, Pianta, & Mana, 2013).
- Use animations to reinforce and demonstrate important content (Lang & Steely, 2003).
- Use big screens, projectors and other visual aids to assist communication (Giannakos & Jaccheri, 2014).
- Involve a local person who can sign in the sign language used by the children one designs for (Hart & Ahmed, 2013).
- "Provide deaf learners with prior information about new vocabulary used in written texts" (Skrebneva, 2010, p. 120).
- "Interpreters and instructors need to work together in advance to reduce potential difficulties in communication – the interpreters need to have some knowledge in the field – e.g. programming" (Giannakos & Jaccheri, 2014, p. 6).

2.4.2 Application of knowledge and knowledge organisation

DHH learners are less likely to apply existing knowledge to new situations where it might be useful or necessary. This occurs in situations where they have to apply conceptual knowledge – for example, knowing that a horse can be part of two categories (it is part of the category of four-legged things, and it is also an animal). DHH learners also tend not to apply procedural knowledge, for example realising that they can use a stick that is one foot long in the same way as using a ruler to measure out six feet of rope. Therefore, DHH learners have difficulty in making connections between what they are learning and what they already know, or between one concept and another (Marschark et al., 2011).

Lang, Stinson, Basile, Kavanaugh and Liu (1999) reported that deaf adolescents are highly dependent learners, which means that they rely heavily on organisation and structure in the instructional environment (Lang, Stinson, Kavanagh, Liu, & Basile, 1999).

Strategies to deal with knowledge and knowledge organisation

- Use minds-on activities and materials that focus on active learning principles that engage students cognitively to ensure greater understanding and comprehension and enhance concept mastery (Drigas et al., 2005; Easterbrooks & Stephenson, 2006).
- "Use concept maps and other diagrams to depict relations among various concepts and the possibility of their being members of different categories at the same time" (Marschark et al., 2011, p. 20).

- "Use games or other targeted activities aimed at demonstrating similarities and differences among concepts at different levels: lexical; perceptual; practical; taxonomic; and so on" (Marschark et al., 2011, p. 20).
- Keep in mind that the ability to understand is influenced by "prior knowledge or previous experiences" (Skrebneva, 2010, p. 120).
- Use colour to organise information (Brokop, 2008).

2.4.3 Relational and individual-item orientations

According to Marschark et al. (2011), learners with hearing loss have difficulty performing tasks that require them to combine two or more dimensions, for example, sorting cards according to colours and numbers. They also tend to read word-by-word, as opposed to hearing learners, who look for relationships among words while they read in 'chunks'.

Strategies to deal with relational and individual-item orientations

- Teachers of DHH learners should provide richer background information when presenting new concepts than they normally would for hearing students.
- They will also frequently need to be explicit in relating new information to what students already know rather than depending on them to make appropriate inferences.

(Marschark et al., 2011)

2.4.4 Metacognition

DHH learners tend to overestimate the extent to which they monitor their own comprehension and learning (Borgna, Convertino, Marschark, Morrison, & Rizzolo, 2010). This results in them not realising that they need to have information repeated or elaborated on, or that they should ask questions. They also look to educators and peers for explanations of text rather than trying to determine the meaning themselves (Marschark et al., 2011).

It is important to develop metacognitive skills, since this may lead amongst others to learners:

- Developing skills to engage in their own correction and remediation strategies;
- Understanding what an educator wants in class;
- Recognising alternative problem-solving strategies used by peers, and
- Becoming more independent and willing to explore

Strategies to improve metacognition

- Teachers need to provide explicit guidance when explaining to learners what should be done, and why (Marschark et al., 2011).
- They need to repeat comments made and questions asked by other learners (Skrebneva, 2010).

- High expectations should be set, and learning material should be properly scaffolded (Marschark et al., 2011). "Scaffolding techniques include adding visual prompts, graphic organizers, and lower-level reading materials" (Easterbrooks & Stephenson, 2006, p. 394).

2.4.5 Memory

When DHH persons participate in memory-related activities such as remembering items in a specific order, they do not perform as well as hearing persons of the same age. However, people who learn sign language as first language, and even hearing-impaired individuals who use sign language, have better visuospatial[3] memory than hearing individuals. They have, for example, superior abilities to manipulate and generate mental images, such as to rotate images mentally and to predict the final image (Marschark et al., 2011).

Strategies to mitigate memory problems

- Use visuospatial arrangements rather than sequential arrangements.
- Help students to recognise when particular tasks require different approaches to remembering and provide them with the necessary tools (Marschark et al., 2011).
- Use high levels of visualization and visual aids to improve learners' visual memory (Skrebneva, 2010; Drigas et al., 2005).

2.4.6 Distractibility

Learners who are hearing-impaired have a greater sensitivity to visual signals in the peripheral visual fields. This may be the reason why they are easily distracted and often fail to pay full attention to the language of educators and even peers, which can significantly slow their progress in learning (Marschark et al., 2011).

Korte et al. (2015) found that the Deaf children who were involved in the design of an application to teach sign language were able to notice even the smallest changes to the layout of the screen. During the design process, this ability can be utilised in a positive way to ensure that the interface of an application adheres to design standards. The fact that the learners tend to get distracted by small changes suggests that attention to detail is very important in the design of any electronic learning material to minimise distraction (Korte et al., 2015).

Strategies to reduce distractibility

- Teachers need to guide DHH learners' visual attention to important events and information (Marschark et al., 2011).

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[3] This refers to the ability to comprehend and conceptualise visual representations and spatial relationships in learning and performing a task *(http://medical-dictionary.thefreedictionary.com/visuospatial).*

- They should ensure that the interface of electronic learning material is uniform (Korte et al., 2015).

2.4.7 Additional learning problems

Children who are DHH often display additional disabilities. According to Pollack (1997), the three most reported disabilities are learning disabilities, intellectual disabilities, and emotional/behavioural disabilities. These lead to a consistent lack of language learning, attention problems, retention difficulties, and delayed acquisition of academic skills (Pollack, 1997).

Common behavioural and academic characteristics of DHH students with learning disabilities are frequently cited: “memory problems, visual perception problems, attention problems, inconsistent performance, poor organizational skills, discrepancies between achievement and potential, behaviour problems, and unusual learning styles” (Soukup & Feinstein, 2007, p. 56).

The combination of other disabilities with diminished hearing significantly adds to the complexity of educating learners with hearing loss. The scope of the present research project does not include providing for other disabilities, but taking cognizance of these other disabilities reinforces the notion that special care needs to be taken when learning material is developed for learners with hearing loss.

2.5 Visuospatial memory as a strength

Native signers and other deaf individuals who use sign language (to a lesser extent) have better visuospatial memory and may exceed hearing individuals in their ability to generate and manipulate mental images (Marschark et al., 2011). A study by Emmeroy, Kosslyn and Bellugi (1992) also indicated that both deaf and hearing American Sign Language (ASL) signers have “an enhanced ability to generate relatively complex images and to detect mirror image reversals” (Emmorey, Kosslyn, & Bellugi, 1992, p. 139). As noted above, according to Korte et al. (2015), DHH people have sensitive visual attention in their peripheral vision, enhanced attention to small visual changes, and a capacity for visual learning. In their project where DHH children were involved in the design process of an application, the children were able to notice even minor changes in the design, such as the addition of a button to a screen, or a minor change to the background immediately (Korte et al., 2015) .

Practical implications of enhanced visuospatial memory

- Use visuospatial arrangements rather than sequential arrangements (Marschark et al., 2011).
- Pay attention to detail – keep the position of buttons in the interface and colours the same so that learners are not distracted (Korte et al., 2015).

2.6 Conclusion

Even though DHH learners deserve the same quality education, and have a number of abilities similar to those of hearing learners, their literacy levels (reading, writing and mathematical abilities) are far below the average of the population. It was also found that there are cognitive differences between DHH and hearing learners, and even between DHH learners themselves. One possible contributor to these inequalities is the fact that a visually-based language is not always available to DH learners. However, it is not sufficient to simply remove communication barriers, because the diversity among, and learning needs of the DHH population offers justification that learning material should be specially developed for DHH learners in order to provide for their needs and to capitalise on their strengths.

Various research projects have identified the learning needs of DHH learners, and have suggested practical strategies and interventions to address these needs. In the present research project, practical strategies have been included to address the learning challenges DHH experience in the following areas: Comprehension skills, application of knowledge and knowledge organisation, relational and individual-item orientations, metacognition, memory, distractibility.

DHH learners often also experience other learning problems such as learning disabilities, intellectual learning disabilities, and emotional/behavioural disabilities. However, addressing these disabilities does not fall within the scope of this research project.

Since one of the strengths of DHH learners is that they have very good visuospatial memory, and the ability to generate and manipulate mental images, it can be suggested that visual strategies should be included and emphasised when learning material for DHH leaners is developed.

2.7 Summary

In this chapter, a few the unique learning challenges, strengths, and subsequent needs of DHH learners have been identified and discussed. Visuospatial memory as a strength of DHH learners was highlighted. Possible practical strategies to mitigate the challenges and to utilise visuospatial memory when designing learning material for DHH learners have been identified. These mitigation strategies were incorporated in the guidelines which have been developed to create two vocabulary lessons and one programming lesson to teach basic programming skills to DHH learners (Chapter 6).

The next chapter – Chapter 3 – is the second literature review chapter of this research project. Chapter 3 presents the user experience design (UXD) guidelines that have also been included in the guidelines, as well as the UX evaluation elements, questions and methods that were used to design the evaluation instruments.

Chapter 3

User experience design and evaluation

Introduction

- Chapter 1: Introduction

Literature study

- Chapter 2: Unique learning challenges, strengths and needs of Deaf or Hard of Hearing individuals
- Chapter 3: User experience design and evaluation
- Chapter 4: Technology-supported teaching and learning

Research Design

- Chapter 5: Research process

Guidelines

- Chapter 6: Guidelines and technology-supported lessons

Results and analysis

- Chapter 7: Results and analysis

Conclusion

- Chapter 8: Conclusion and recommendations for future research

Chapter 3

3.1 Introduction

This is the second literature review chapter of this research project. The purpose of this chapter is to explain user experience design (UXD) as an iterative process, to provide UXD guidelines, as well as user experience (UX) elements, questions and methods that were needed to design UX evaluation instruments.

In the previous chapter, the unique learning challenges, strengths and learning needs of learners who are Deaf and Hard of Hearing (DHH) were identified. Strategies that can be implemented to support these learning needs were suggested. These mitigation strategies form part of the user research component of the user experience design (UXD) process.

The UXD guidelines that are presented in section 3.5.4 also form part of the user research component of the user experience design (UXD) process. These UXD guidelines, as well as the mitigation strategies presented in Chapter 2, partly address sub-research question 2:

> *How can technology be implemented to support lessons to teach basic programming principles to Deaf and Hard of Hearing learners?*

The chapter sets out by discussing the diversity of the field of UX by providing information on various fields studying UX and some definitions. The reductive approach to UX is then discussed, presenting the UX model that were used in this research project. Three UX components are identified which were used to establish the four UX elements against which UX was evaluated in this research project.

UXD is explored as an iterative process, and UXD guidelines for accessibility and usability are listed. Finally, evidence that is needed to evaluate each of the UX evaluation elements, the evaluation methods, and evaluation instruments are discussed.

3.2 Development of UX and definitions

UX is a term used in the field of human computer interaction (HCI) as well as interaction design (Hassenzahl & Tractinsky, 2006).

In this section, the diversity of the field of UX is demonstrated by discussing some of the fields which study UX, and a number of salient definitions are explored.

The International Organization for Standardisation (ISO) 9241-210:2010 standard on Ergonomics of human-system interaction – Part 210: Human-centred design for interactive systems, defines UX as follows:

> A person's perceptions and responses resulting from the use and/or anticipated use of a product, system or service.

- User experience includes all the users' emotions, beliefs, preferences, perceptions, physical and psychological responses, behaviours and accomplishments that occur before, during and after use.
- User experience is a consequence of brand image, presentation, functionality, system performance, interactive behaviour and assistive capabilities of the interactive system, the user's internal and physical state resulting from prior experiences, attitudes, skills and personality, and the context of use.
- Usability, when interpreted from the perspective of the users' personal goals, can include the kind of perceptual and emotional aspects typically associated with user experience. Usability criteria can be used to assess aspects of user experience.

(International Organization for Standardization, 2015, "Terms and definitions", par. 15).

Initially, the term UX was only used with reference to human-computer interactions. However, researchers and academics have come to realise that modern technology fulfils more than simply instrumental needs – it has to be acknowledged that technology use is a "subjective, situated, complex and dynamic encounter" (Hassenzahl & Tractinsky, 2006, p. 95). Therefore, the concept of UX is also used to refer to any specific human-design interaction, ranging from a digital device, to a sales process, to an entire conference (Knemeyer & Svoboda, 2004), and it includes subjective attributes in a design space that used to be mainly concerned with ease-of-use (Ardito, Costabile, Lanzilotto, & Montinaro, 2007).

Hazzenzahl and Tractinsky (2006) are of the opinion that the growing interest in UX is driven by three stakeholders:

- Commercial vendors – because interactive machinery is part of our daily lives, and since technology allows designers to create more than products without usability problems, the business climate has changed.
- Designers – they appreciate new design opportunities.
- Scientific community – they show an interest in the way in which the affective system can influence cognition.

The authors also state that UX is about “designing for pleasure rather than for absence of pain” (Hassenzahl & Tractinsky, 2006, p. 95), thereby contributing to our quality of life. However, according to Roto (2007), from a business perspective, commercial vendors regard the understanding of both pragmatic and hedonic user needs as the key in providing good systems for customers – and thereby in business success (Roto, 2007).

Apart from the different perspectives provided by the different stakeholders (commercial, design and scientific), different researchers also propose different definitions of, and statements on UX, depending on, for example, whether the term is used by researchers in an academic field, or by practitioners in a business environment. The concept can also be approached from different viewpoints, “ranging from a psychological to a business perspective, and from quality centric to value centric” – and there is no single definition that suits all perspectives (Roto, Law, Vermeeren, & Hoonhout, 2010, p. 2).

From the various definitions of UX, the influence of the different stakeholders (commercial, designers and the scientific community) can be gleaned. Some of the definitions and statements on UX are:

- “A momentary, primarily evaluative feeling (good-bad) while interacting with a product or service” (Hassenzahl, 2008, p. 12).
- “The quality of experience a person has when interacting with a specific design” (Knemeyer & Svoboda, 2004, “User Experience - UX”, par. 1).
- The entire set of effects that is elicited by the interaction between a user and a product, including the degree to which all our senses are gratified (aesthetic experience), the meanings we attach to the product (experience of meaning), and the feelings and emotions that are elicited (emotional experience). (Hekkert, 2006, p. 160).
- “How the product behaves and is used in the real world” (Garrett, 2002, p. 10).
- UX is about how a product works on the outside, where a person comes into contact with it and has to work with it. “Every product that is used by someone has a user experience: newspapers, ketchup bottles, reclining armchairs, cardigan sweaters” (Garrett, 2002, p. 10).
- “’User experience’ encompasses all aspects of the end-user's interaction with the company, its services, and its products” (Norman & Nielsen, 1998, “The Definition of User Experience (UX) ”, par. 1).

As can be gleaned from the above, many definitions only refer to the use of a specific product. In the context of this research project, which relies heavily on the interactions between people (for example, between the educator who presents the programming lesson and the DHH learners, and between the DHH learners themselves), the following two definitions are more suitable, since they include reference to aspects such as the context of the experience and the people involved:

- UX is a consequence of a user's internal state (predispositions, expectations, needs, motivation, mood, etc.), the characteristics of the designed system (e.g. complexity, purpose, usability, functionality, etc.) and the context (or the environment) within which the interaction occurs (e.g. organisational/social setting, meaningfulness of the activity, voluntariness of use, etc.). (Hassenzahl & Tractinsky, 2006, p. 95).
- "UX = sum of a series of interactions. User experience (UX) represents the perception left in someone's mind following a series of interactions between people, devices, and events – or any combination thereof" (All about UX, n.d., "User experience definitions", par. 25).

UX is still a relatively new field of research. Designers are increasingly concerning themselves with designing systems that meet UX goals, for example that they should be satisfying to use, enjoyable, fun, entertaining, helpful, motivating, aesthetically pleasing, supportive of creativity, rewarding and emotionally fulfilling (Preece, Rogers, & Sharp, 2002). However, no official guidelines could be found in literature that refers to the UX goals or aspects that need to be evaluated for technology-supported lessons for DHH learners.

In the next section, the approach to UX that was followed in this research project is explained.

3.3 UX approach in this research project

Blythe, Hassenzahl, Law and Vermeeren (2007) provide different approaches to UX. In this research project, a *reductive approach* is followed, where the aim is to "simplify the complexity of experience for the sake of description and operationalisation (i.e., to measure individual elements that play some role in UX)" (Mark Blythe, Hassenzahl, Law, & Vermeeren, 2007, p. 1). This approach differs from the holistic approach, which "aims to integrate various aspects of UX, including emotions, affect, aesthetics, hedonism, experiences, developing a big picture or an overarching framework of this area" (Mark Blythe, Hassenzahl, Law, & Vermeeren, 2007, p. 1).

In the remainder of this section, a number of UX models are discussed, and it will be demonstrated how these models can be combined to be more suitable to the environment of technology-assisted lessons for DHH learners. Thereafter follows a motivation as to why specific individual elements of UX can be identified for purposes of evaluating them.

A range of UX models and frameworks have been developed by the academic community. These models address the key issues of UX: its subjective, highly situated and dynamic nature, as well as the pragmatic and hedonic factors leading to UX (Väänänen-Vainio-Mattila, Roto, & Hassenzahl, 2008). However, all these models have at least one thing in common: they focus on well-being and not performance as an outcome of human-product interaction (Hassenzahl, 2008).

The main model that is followed in the approach towards UX in this research project is that of Mahlke (2007). She follows a reductive approach, and conceptualises UX as "a phenomenon" (Mahlke, 2007, p. 26) that contains three components: *instrumental quality perceptions*, *non-instrumental quality perceptions*, as well as *emotional user reactions*. She also emphasises that these components have to be integrated in order to fully understand a user's experience with an interactive system (Mahlke, 2007).Another popular model is *The 7 factors that influence UX* (Kellingley, 2016) - Figure 3.1. This model identifies the following UX goals of a product as important: the product must be Useful; Usable; Findable; Credible; Desirable; Accessible and Valuable.

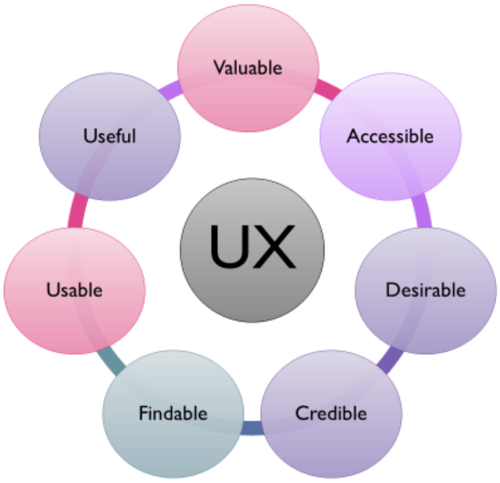


Figure 3.1: The 7 factors that influence UX.
Re-drawn by researcher from (Kellingley, 2016)

However, as far as interactive products are concerned, it is not feasible to apply all of the usability goals and UX goals to every product that is developed. The context in which it is used, the task at hand, and who the intended users are should be taken into account (Preece et al., 2002). Therefore, in this section, an explanation is offered regarding concepts relevant to various approaches to, and aspects of the three basic components of UX (instrumental quality perceptions, non-instrumental quality perceptions and emotional user reactions). These are combined to form a UX model for this research project. This model is used to explain and motivate the elements that are used to evaluate the UX of learners when they completed both the vocabulary and programming lessons.

The diagram of the UX model is provided in Figure 3.2, and in sections 3.4.2 to 3.4.4 the detail of the different components of the model is discussed.

3.4 UX model for this research project

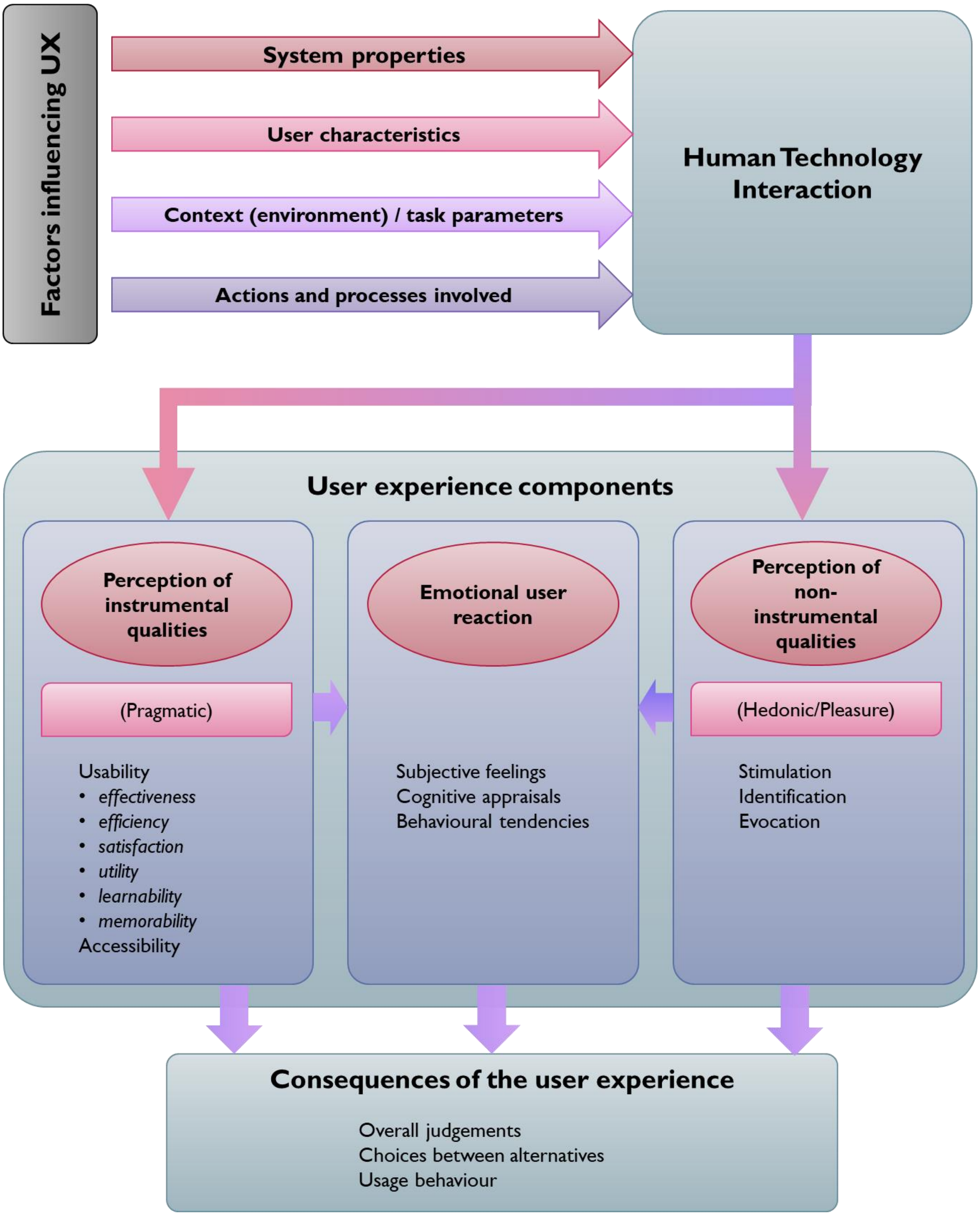


Figure 3.2: UX model for this research project.
Original diagram obtained from Mahlke (2007, p. 27), adapted by the researcher to incorporate information from Desmet and Hekkert (2007); Hassenzahl and Tractinsky (2006); Preece et al., (2002) and Roto (2007)

3.4.1 Factors influencing the user's experience

Various researchers (Desmet & Hekkert, 2007; Hassenzahl & Tractinsky, 2006; Väänänen-Vainio-Mattila et al., 2008) confirm that a user's experience can vary from person to person. As depicted in Figure 3.2, there are four main factors that have an influence on a person's UX:

Table 3.1: Main factors influencing the UX of a person

Factor	Description
System properties	The complexity, purpose, usability, functionality and behaviour of the product.
User characteristics	Predispositions, expectations, needs, motivation, mood, personality, skills, background, cultural values, and motives.
Context	Physical setting, organisational/social setting, meaningfulness of the activity, voluntariness of use.
Actions and processes involved	Physical actions as well as perceptual and cognitive processes, for example perceiving, exploring, using, remembering, comparing, and understanding.

In the following three sections, the three components of UX as indicated in Figure 3.2 are discussed.

3.4.2 Instrumental qualities as a UX component

Mahlke (2007) suggests that different quality aspects are important to different users, and would therefore have an influence on the UX. In her model, the following qualities are deemed to be important: usefulness (utility - does the product serve its purpose), and usability (efficiency; controllability; helpfulness, learnability) (Mahlke, 2007). Some researchers regard utility as a goal of usability (Preece et al., 2002), and it us regarded as such in the context of this research project.

The 7 factors that influence UX (Figure 3.1) serve as motivation for including usability and accessibility as instrumental qualities of UX (with utility as a goal of usability as mentioned before). The other factors – Valuable, Desirable, Credible and Findable, relate more to commercial products, and were not considered.

An aspect that is emphasised in this research project is the concept of accessibility, and the research of Petri and Bevan (2009) is used to substantiate this. According to them, there is a lack of consensus about the interpretation of what accessibility means. Accessibility can be seen as a sub-set of usability, or usability can be regarded as a sub-set of accessibility, depending on the type of users involved (non-disabled, younger users, or disabled and older users). Since the users in this research project can be regarded as disabled, accessibility should make a significant contribution to the UX of the learners, and therefore accessibility is regarded as a sub-category (a separate aspect) of the instrumental qualities (pragmatic dimension) of the UX. The importance of including accessibility in educational software is confirmed by Ardito et al. (2007).

Some researchers also refer to these instrumental aspects as *pragmatic attributes*. These aspects/attributes emphasise the fulfilment of an individual's behavioural goals (Hassenzahl, 2003).

In table 3.2, more detail is provided on the two pragmatic attributes - usability and accessibility.

Table 3.2: Detail of usability as a UX element

<table>
<tr><th colspan="2">Usability</th></tr>
<tr><td colspan="2">According to the ISO 9241-210:2010 standard on Ergonomics of human-system interaction – Part 210: Human-centred design for interactive systems, usability can be defined as: "The extent to which a system, product or service can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use" (International Organization for Standardization, 2015, "Terms and definitions", par. 13).

According to Petri and Bevan (2009), usability does not have an absolute definition. Their view towards usability is similar to the views of other researchers towards UX as they claim that usability is "relative to the users, goals and contexts of use that are appropriate to the particular set of circumstances" (Petrie & Bevan, 2009, p. 3). They are also of the opinion that usability emphasises the appropriate achievement of particular tasks in particular contexts of use.

Below are a number of dimensions of usability that are taken into consideration in order to establish what type of questions should be asked in order to determine the usability of the vocabulary and programming lessons.</td></tr>
<tr><td>Effectiveness</td><td>Accuracy and completeness with which users achieve specified goals (International Organization for Standardization, 2015); this to "how good a system is at doing what it is supposed to do" (Preece et al., 2002, p. 14).</td></tr>
<tr><td>Efficiency</td><td>"Refers to the way a system supports users in carrying out their tasks" (Preece et al., 2002, p. 14).</td></tr>
<tr><td>Satisfaction</td><td>"Freedom from discomfort and positive attitudes towards the use of the product" (International Organization for Standardization, 2015, "Terms and definitions", par. 10).</td></tr>
</table>

<table>
<tr><td>Utility</td><td>“Refers to the extent to which the system provides the right kind of functionality so that users can do what they need or want to do” (Preece et al., 2002, p. 16) – it can also be refer to as a “relevant” functionality (Hassenzahl, 2003, p. 4).</td></tr>
<tr><td>Learnability</td><td>“Refers to how easy a system is to use” (Preece et al., 2002, p. 16), or “the ease of learning” (Petrie & Bevan, 2009, p. 2).</td></tr>
<tr><td>Memorability</td><td>“Refers to how easy a system is to remember how to use, once learned” (Preece et al., 2002, p. 17).</td></tr>
<tr><td colspan="2">With specific reference to educational, e-learning applications, the following are also considered important:
• Usability features should allow people to manipulate the interactive software efficiently, and must be appropriate for the intended learning task (Ardito et al., 2007).
• Good usability includes a “clear and coherent interface, which involves the user in the learning process without overwhelming her/him” (Ardito et al., 2006, p. 272).</td></tr>
</table>

Practical guidelines such as usability heuristics and principles of good interface design that influence usability are discussed in section 3.5.4.

Table 3.3: Detail of accessibility as a UX element

Accessibility
Accessibility can be described as: “Usability of a product, service, environment or facility by people with the widest range of capabilities” (International Organization for Standardization, 2015, “Terms and definitions”, par. 1). In the context of this research project, accessibility refers to aspects that accommodate the needs of DHH learners specifically. These needs include those emanating from the fact that the learners cannot hear, as well as their accompanying learning and cognitive disabilities (Soegaard, 2015).

In this research project, *usability* and *accessibility* are two of the four UX elements against which the UX of the participants will be evaluated.

3.4.3 Emotional user reaction as UX component

Different researchers mention different emotions that can be evaluated as part of UX.

Dillon, as referenced in Petrie and Bevan (2009), describes *affect* (having an emotional impact) as a key issue of UX, and refers to the following emotional reactions of users: "empowered, annoyed, enriched, or confident" (in Petrie & Bevan, 2009, p.4).

Preece, Rogers and Sharp (2002) refer, amongst others, to the a number of emotions that may be a result of a positive UX: having fun, finding it enjoyable to use the system, finding it emotionally fulfilling, supportive of creativity, motivating and helpful (Preece et al., 2002).

Mahlke (2007) adds the following emotional user-reactions and the way these feelings were assessed:

- Subjective feelings (questionnaire methods)
- Motor expressions (electromyography)
- Physiological reactions (measured heart rate and dermal activity)
- Cognitive judgements (questionnaire methods)
- Behavioural tendencies (analysed performance data)

In this research project, qualitative data regarding the UX of the learners was collected using questionnaires that contains questions relating to the subjective feelings and cognitive appraisals of the learners. Observations of the learners' behaviour was also be done during the lessons, and these behaviours were discussed during the interviews with the educators who were involved in presenting the programming lesson. Therefore, *emotional user reaction* is the third of the four UX elements against which the UX of the participants are evaluated.

3.4.4 Non-instrumental qualities as UX component

Non-instrumental qualities can be described as "quality aspects that address user needs that go beyond tasks, goals and their efficient achievement" (Mahlke, 2007, p. 24). There are various approaches towards these non-instrumental qualities described in different studies. According to the approach of Mahlke (2007), the non-instrumental qualities can be divided into aesthetic aspects (the visual, haptic and acoustic aspect of a product), symbolic aspects (the product's meaning in communication with others), as well as motivational aspects. However, these qualities were applied by her in a study of mobile phones and audio players, and they do not seem to resonate with the educational aspects of this research project. Therefore, for purposes of the present research, the approach of Hassenzahl (2003) is used, where the non-instrumental qualities are referred to as the *hedonic attributes* of a product. These qualities/attributes/aspects emphasise the individual's psychological well-being, and specifically the extent to which the user is satisfied with the perceived achievement of the hedonic goals of providing stimulation, communicating identity, and provoking valued memories (Hassenzahl, 2003). These can be summarised as experiencing pleasure (Petrie & Bevan, 2009). Table 3.4 provides more detail on each of the hedonic aspects.

Table 3.4: Detail of hedonic aspects as a UX element

Hedonic aspects	
Stimulation	One of the basic needs of a person is to develop personally by increasing knowledge and developing new skills. To achieve this, a product must provide stimulation, for example by providing: • new content, • a new presentation or interaction style or • exciting functionality (Hassenzahl, 2003)
Identification	This is a social function where individuals want to be seen in specific ways by relevant others. They want to be socially recognised and exert power over others. Therefore a product has to "communicate identity" (Hassenzahl, 2003, p. 5).
Evocation	When products are used, they can provoke memories. The type of memories can influence the user's experience (Hassenzahl, 2003).

Hedonic aspects make up the fourth UX element against which the UX of the participants are evaluated.

3.5 User experience design

3.5.1 Definitions of user experience design

Various researchers and UX designers present different definitions of, and statements regarding user experience design (UXD).

- Brent Summers was quoted in an interview (in Lanoue, 2015, "The definition of UX design", par. 13) as saying: "User experience design is the process of understanding someone's needs, mental or emotional state, and technical prowess, then designing a solution that considers that information."
- In the same article, Tomer Sharon propounds that "UX design is the art and science of generating positive emotions among people who interact with products or services" (in Lanoue, 2015, "The definition of UX design", par. 4).
- Lanoue (2015) also quotes Justin Mifsud's definition: "User experience design (UXD or UED) is a design process whose sole objective is to design a system that offers a great

experience to its users. Thus, UXD embraces the theories of a number of disciplines such as user interface design, usability, accessibility, information architecture and Human Computer Interaction. User experience design is practiced by User Experience Designers—who are particularly concerned with the interaction that occurs between users and the system they are using. For example, a UX designer would take the principles that describe ways of making a product accessible, and actually embody those principles in the design process of a system so that a user that is interacting with it would find it as being accessible." (in Lanoue, 2015, "The definition of UX design", par. 5).

- UXD is about "designing the ideal experience of using a service or product" (Interaction Design Foundation, n.d., p. 5) .
- It is about the way to deliberately design the creation and shaping of an experience (Hassenzahl, 2013).
- User Experience Design [refers to] the judicious application of certain user-centred design practices, a highly contextual design mentality, and use of certain methods and techniques that are applied through process management to produce cohesive, predictable, and desirable effects in a specific person, or persona (archetype comprised of target audience habits and characteristics). All so that the affects produced meet the user's own goals and measures of success and enjoyment, as well as the objectives of the providing organization. (UX Design, 2007, "UX Design Defined", par. 1).

Having reviewed a number of definitions of UXD, the next section discusses various elements of UXD.

3.5.2 Elements of user experience design

The User Experience White Paper considers the roots of user experience design (UXD) to be founded upon the principles of Human Centred Design (HCD). These are:

- Positioning the user as a central concern in the design process.
- Identifying the aspects of the design that are important to the target user group.
- Developing the design iteratively in inviting users' participation.

- Collecting evidence of user-specific factors to assess a design. (Roto et al., 2010, p. 11)

Usability testing also forms part of UXD, and with HCD it focuses on the enhancement of user performance (UX Design, 2007). UXD also builds on principles of graphic design by using design elements such as the right typography and colours to shape the emotions of the user. Furthermore, UX designers tend to include, amongst others:

- "Motion design, the tone of the content, and information architecture" (Siang, 2017, "Emotional Design", par. 1).
- The "inclusion of emotional aspects of human experience, for example, happiness as a worthy pursuit in itself" (UX Design, 2007, "UX Design is Contextual Design", par. 4).
- Additional dimensions such as UX factors relating to, for example, affect, interpretation and meaning, as well as methods, tools and criteria used in UX work (Roto et al., 2010).

The next section illustrates and motivates how UXD is an iterative process.

3.5.3 User experience design as an iterative process

Petrie and Bevan (2009) emphasise the function of designers of highly interactive eSystems. According to them, designers should take into consideration that the "design and development process must be explicitly iterative and user-centred" (Petrie & Bevan, 2009, p. 5). The user should also be positioned as the central concern during the design process (Roto et al., 2010). Fig 3.3 illustrates UXD as an iterative process. Each phase of the process is discussed in sections 3.5.3.1 – 3.5.3.4.

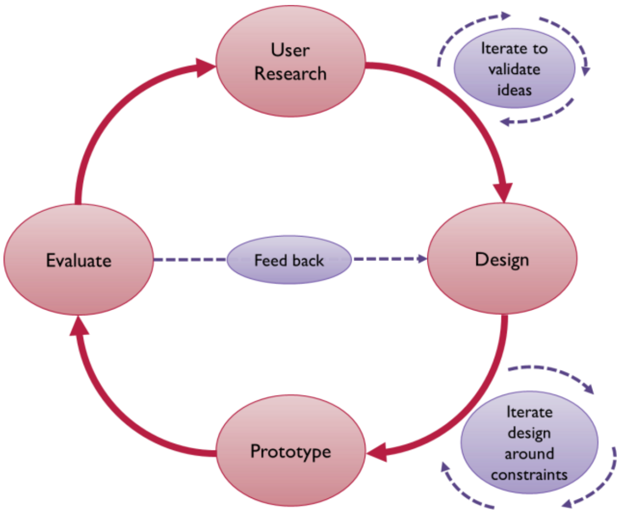


Figure 3.3: The iterative process of UX design.
Compiled by the researcher from Petrie and Bevan (2009) and Siang (2017).

3.5.3.1 User research

The iterative process begins with the identification of a problem, after which user research needs to be conducted to determine how best to solve the problem, applying creative thinking (Siang, 2017). User research includes:

- Understanding the users, tasks and context (Petrie & Bevan, 2009).
- "Identifying the aspects of the design that are important to the target user group" (Roto et al., 2010, p. 11).
- "Scoping out the factors that are known, because evidence exists, or are thought likely to be the drivers of UX in their particular instance" (Roto et al., 2010, p. 11).

3.5.3.2 Design

The design should be developed iteratively and should invite the users' participation (Roto et al., 2010). According to Petrie and Bevan (2009), alternative designs should be considered, with a view to determine how they can meet users' needs. The authors also emphasise that it is especially important to include users as evaluators of the design when people with disabilities are involved, and that target levels for accessibility should play an important role in the overall design process (Petrie & Bevan, 2009).

3.5.3.3 Build a prototype

Once a design has been developed, a prototype ranging from low fidelity to high fidelity can be built. While developing the prototype, it is possible that the designer may realise that certain design ideas will not be feasible. This process is part of the iteration, where building the prototype feeds back into the design process (Petrie & Bevan, 2009; Siang, 2017).

3.5.3.4 Evaluate

The heart of the user experience design process is evaluation (Siang, 2017). During evaluation, evidence should be collected of the users' experience of the UX factors that have been identified during the research phase of the design (Roto et al., 2010). The results obtained during the evaluation can be used to feed back to the design as well as the understanding of the users, their tasks and context (Petrie & Bevan, 2009).

In the next section, practical design guidelines that may influence the instrumental qualities (accessibility and usability) of UX are presented.

3.5.4 User experience design guidelines

As indicated in Fig. 3.3, user research is the first stage of UXD. Various sources emphasise the importance of understanding the users (Petrie & Bevan, 2009), identifying the aspect of design that are important to the group, and identifying the factors that are likely to be the drivers of UX (Roto et al., 2010). The user research conducted for this research project is described in Chapter 2. In section 3.4, the drivers of UX are identified and motivated and are illustrated in Fig. 3.2. The drivers of UX (the UX elements) are usability, accessibility, emotional user reaction and hedonic aspects. Roto et al. (2010) concur that UX designers are at times only able to deal with a few critical UX factors that influence the design for a specific scenario. Based on the user research presented in Chapter 2, the decision was made that media designed for DHH learners should have a high level of usability and accessibility.

In sections 3.5.4.1 and 3.5.4.2 that follow, UX guidelines from various sources that are applicable to DHH learners within the context of accessibility and usability are discussed. These guidelines have been incorporated into the design guidelines presented in Chapter 6.

3.5.4.1 Accessibility guidelines

The accessibility UX principles are based on three main sources:

- The W3C Web Content Accessibility Guidelines (WCAG) 2.0, which present four principles and 12 guidelines that provide the foundation for Web accessibility for persons with different disabilities (Zheng, 2016).
- The Principles of Universal Design; these seven principles work for the widest range of human abilities (Centre for Excellence in Universal Design, 2014).
- Design thinking, which is an approach that emphasises grounding the process in human needs (Quesenbery, 2014).

Table 3.5 presents principles and corresponding guidelines based on these three main sources, and which are applicable to the design of technology-supported lessons, as described by Zheng (2016); Quesenbery 2014) and Petrie and Bevan (2009). (Note: not all guidelines offered by these authors are mentioned here; rather, the table offers a selection of guidelines that seem applicable to the design of lessons for DHH learners, taking their needs into account.)

Table 3.5: Accessibility guidelines

Principles	Guidelines
Perceivable **-** information and user interface components must be presentable to users in ways they can perceive (*recognize / identify*) (Zheng, 2016; Petrie & Bevan, 2009).	Distinguishable: make it easier for users to see content, including separating the foreground clearly from the background.

Operable – user interface components and navigation must be operable (*fit, possible or desirable to use – practicable*) (Zheng, 2016; Petrie & Bevan, 2009).	Enough time: provide users with sufficient time to read and use content. Navigable: provide ways to help users navigate, find content, and determine where they are.
Understandable – information and the operation of user interface must be understandable (Zheng, 2016; Petrie & Bevan, 2009)	Make text content readable and understandable. Make pages appear and operate in predictable ways.
Easy interaction: everything works (Quesenbery, 2014).	Provide accessible instructions and feedback. Make controls large enough to operate easily.
Helpful wayfinding: guide users (Quesenbery, 2014).	Create consistent cues for orientation and navigation. Present things that are the same in the same way. Differentiate things that are different.
Clean presentation: supports meaning (Quesenbery, 2014).	Minimise distracting clutter Design content for easy comprehension. Use colour contrast to separate foreground from background. Use visual and semantic white space. Provide enough space between lines of text. Use clean typography.
Plain language: creates a conversation (Quesenbery, 2014).	Follow plain language guidelines for writing content. Use language that one's audience is familiar with, or provide definitions.

3.5.4.2 Usability heuristics and guidelines

Various checklists, heuristics and guidelines are available for interface design and usability. For the purpose of this research report, the relevant usability heuristics of Neilsen (Nielsen, 1995), and some of the principles of good interface design stated by Shneiderman (in Shneiderman & Plaisant, 2005) are provided in tables 3.6 and 3.7:

Table 3.6: Usability heuristics of Nielsen (Nielsen, 1995)

Usability principle or heuristic	Explanation
Match between system and the real world.	The system should speak the users' language, with words, phrases and concepts familiar to the user, rather than system-

	oriented terms. Follow real-world conventions that help to present information in a natural and logical order.
Consistency and standards	Users should not have to wonder whether different words, situations, or actions mean the same thing. Follow platform conventions.
Recognition rather than recall	Minimise the user's memory load by making objects, actions, and options visible. The user should not have to remember information from one part of the dialogue to another. Instructions for use of the system should be visible or easily retrievable whenever appropriate.
Aesthetic and minimalist design	Dialogues should not contain information which is irrelevant or rarely needed. Every extra unit of information in a dialogue competes with the relevant units of information and diminishes their relative visibility.

Table 3.7: A selection from Shneiderman's 8 golden principles of good interface design (Shneiderman & Plaisant, 2005)

A selection from Shneiderman's 8 golden principles of good interface design	
Strive for consistency	Consistent sequences of actions should be required in similar situations; identical terminology should be used in prompts, menus, and help screens; and consistent commands should be employed throughout.
Design dialogue to yield closure	Sequences of actions should be organised into groups with a beginning, middle, and end. The informative feedback at the completion of a group of actions gives the operators the satisfaction of accomplishment, a sense of relief, the signal to drop contingency plans and options from their minds, and an indication that the way is clear to prepare for the next group of actions.
Offer simple error handling	As far as possible, design the system so the user cannot make a serious error. If an error is made, the system should be able to detect the error and offer simple, comprehensible mechanisms for handling the error.
Reduce short-term memory load	The limitation of human information processing in short-term memory requires that displays must be kept simple. Multiple page displays should be consolidated, window-motion frequency be reduced, and

	sufficient training time should be allocated for codes, mnemonics, and sequences of actions.

Neither the vocabulary nor the programming lesson developed in this research project offers a truly interactive application. However, many of the principles that apply to interactive products can also be applied to the design of the lessons. Table 3.8 contains relevant principles in this regard as discussed by Tognazzini (2014).

Table 3.8: Principles of Interaction Design.
Researcher's selection from Tognazzini (2014)

Interaction design principle	Discussion
Consistency	The appearance of small visible structures such as icons, symbols, buttons and scroll bars needs to be strictly controlled so that users do not have to waste time figuring out how to navigate an application. It is advised that the location of such structures should be standardised.
Discoverability	Controls and other objects necessary for the successful use of software should be visibly accessible at all times.
Visible navigation	Make navigation visible: most users cannot and will not build elaborate mental maps and will become lost or tired if expected to do so.
Learnability	Ideally, products should require no learning curve: users would be presented with them for the very first time and achieve instant mastery. In practice, however, all applications and services, no matter how simple, will require a learning curve.
Readability	Text that must be read should have high contrast: favour black text on white or pale yellow backgrounds.

Colour can be used in eLearning to affect mood, encourage learning, resonate with different cultures and make information accessible to those with colour sight deficiencies. There are commonly accepted psychological effects of colours, and the right colour can put a learner in the right mood for optimal participation (George, 2010).

Table 3.9 presents a summary of the psychological effects and uses of different colours when learning material is designed.

Table 3.9: Summary of the use of colour in learning material.

Summarised by the researcher from George (2010) and Lerner (n.d.)

Colour	Psychological effect	Can be used to:
Red	A stimulant that can trigger anger or anxiety.	• Draw attention to key points. • Pointing out things not to do.
Yellow	Since yellow is the most visible colour, it is also the most attention-grabbing colour.	• Use in small amounts to draw attention, such as key words, or highlights but not in backgrounds.
Blue	It lowers the pulse, encourages serenity and reduces appetites. It is calm and conservative. Blue is often used in offices and gyms to stimulate productivity. Lighter blue help promote interaction.	• To calm learners when presenting information that may initially seem complicated or overwhelming. • Accent blue with other colours so that learners do not become too relaxed.
Green	Brings tranquillity and peacefulness. It is seen as refreshing and is the easiest colour on the eyes. Green is seen as a friendly colour that helps to relax muscles and deepen breathing. It also stimulates interaction.	• Wherever one wants – it can be a very good e-learning colour.
Yellow	It is a brain stimulant and promotes memory, clear thinking and decision-making. Yellow should be used sparingly as it is the harshest colour on the eyes.	• To highlight points that should be memorised or that are often forgotten in the content. • Use in small amounts to draw notice, such as key words, or highlights. • Yellow is also a good colour to incorporate into the quiz sections of e-learning.
Purple	A mind-balancer that promotes good judgment and spirituality. Can be used with other colours to express a mood (used with blue it is calming, with red it becomes stimulating).	• To express light-heartedness and fun in learning.
Black	Connotes finality and also works well as a transitional colour.	• Use for fonts.

White	Technically, it is the perfect balance of all colours and is seen as pure and clean, calm and neutral.	• Use it for well-thought-out white space. • Use as a font when text is on a darker background.
Grey	Grey (or silver) can be a softer background than the harsh default colour of white, and works well on almost all presentations. A darker grey can be used with light text, and a light grey background with dark text.	• Can be used as a background colour if white is not preferred.

The use of colour in the lessons for this research project is explained in Chapter 6.

3.6 User Experience evaluation

The following sub-sections describes aspects of UX evaluation.

3.6.1 A UX evaluation procedure

A number of researchers report that there is a lack of agreement on what UX means, and that this lack of shared understanding causes a problem in evaluating UX (Hassenzahl, 2008; Väänänen-Vainio-Mattila et al., 2008). In the analysis of the argument of Väänänen-Vainio-Mattila, Roto and Hassenzahl (2008) regarding the consequences of this lack of shared understanding, the following procedure with regards to UX evaluation can be derived:

A researcher should

- Agree on what we are looking for [in the user's experience];
- Pose the right questions; and
- Select a method.

The authors further suggest that once these steps are in place, a wealth of evaluation methods are available from fields such as HCI or other disciplines, and these methods can be adapted to fit the particular aspects of evaluation.

In sections 3.4.2; 3.4.3 and 3.4.4, four UX aspects that are evaluated in this research project are identified. They are usability, accessibility, emotional use reaction, as well as hedonic aspects (pleasure). In section 3.6.2, the type of behaviour, responses and feedback - (evidence) expected for each of these four UX aspects is described – this refers to *what is looked for* in the users' experience, as well as *posing the right questions* as parts of the UX evaluation procedure.

3.6.2 Identifying evidence for UX evaluation elements

Table 3.10 presents descriptions of the evidence expected for each UX element. These descriptions were used to formulate questions in the learners' questionnaire and the semi-structured interview used to interview the educators involved in the research project.

In Chapter 5, the data collection instruments are discussed, and in Chapter 7, the results of the research project are reported on, referencing the four UX elements.

Table 3.10: Possible evidence for each UX element

Usability
What evidence can be provided to ascertain that: • Learners were able to access information easily (evaluating efficiency and utility/relevant functionality)? • Learners were able to carry out tasks on their own without having to consult an educator regularly (evaluating learnability and memorability)? • Learners demonstrated behaviour which confirmed that the goals of the lessons were achieved (evaluating effectiveness)? • The learners found it easy to use the lessons and they have positive feelings regarding the lessons (evaluating satisfaction)?
Accessibility
Which evidence can be provided to determine that: • Adequate measures were implemented in the design of the lessons to address the unique learning needs of DHH learners?
Emotional user reaction
• What type of subjective feelings and emotions did the learners report on – describing how they experienced the lessons and how it made them feel? • Did the learners make any cognitive appraisals (intellectual judgements)? • Were there any specific behaviours that the researcher or educators who were involved noticed, and which gave an indication of the emotions experienced by learners; for example, having fun, finding it enjoyable to do the lessons, feeling creative, or feeling motivated?
Hedonic aspects (pleasure)
Which evidence can be provided to determine that: • The learners felt that they developed personally by learning new vocabulary, and new skills, which is not expected by the curriculum (evaluating stimulation)? • The learners felt that the lessons made provision for their needs or recognised them socially (evaluating communication of identity)? • The lessons managed to remind learners of previous experiences and/or knowledge (evaluating evocation)?

3.6.3 UX evaluation methods

According to Petrie and Bevan (2009), methods for usability, accessibility and UX evaluation can be grouped into the following categories:

- Automated checking of conformance to guidelines and standards
- Evaluations conducted by experts
- Evaluations using models and simulations
- Evaluation with users or potential users
- Evaluation of data collected during the use of eSystems (interactive electronic products, services and environments).

In this section, only the UX evaluation methods implemented in this research project are listed and motivated. Three of the evaluation methods suggested by Petrie and Bevan (2009) are:

- When prototypes are available, evaluations should be conducted by experts. "It is done to identify as many accessibility and usability issues as possible in order to eliminate them before conducting user-based evaluations" (Petrie & Bevan, 2009, p. 18).
- Evaluations using models and simulations. "Model-based evaluation methods can predict measures such as the time to complete a task or the difficulty of learning to use an interface" (Petrie & Bevan, 2009, p. 21).
- Evaluation with users or potential users. "Evaluation with users can take place during all stages of development, but should at least take place at the final stage of development. It is done to provide evidence of the accessibility and usability (or lack thereof) for developers" (Petrie & Bevan, 2009, p. 22).

Section 5.6.6 contains a description of the data collection methods for this research project.

3.6.4 UX evaluation instruments

According to Roto et al. (2010), there are various factors that guide the choice of an evaluation instrument.

> The choice of an evaluation instrument or method depends on the experiential qualities at which the system is targeted, as well as on the purpose of the evaluation (e.g. summative or formative) and other (often pragmatic) factors such as time and financial constraints. (Roto et al., 2010, p. 12).

According to Petrie and Bevan (2009), UX moves beyond the performance-based measures that have traditionally been the focus of user-based evaluations, and a variety of ways are available to assess UX. They concur that the simplest way to achieve this is by using rating scales and questionnaires.

In this research project, learners completed two questionnaires (one on the vocabulary lesson, and another on the programming lesson). A semi-structured interview was conducted with both the SASL educator, as well as the CAT educator, and the researcher observed the participants' behaviour during the programming lesson. The semi-structured interview guidelines and questionnaires are available in the electronic appendix for this dissertation (see documents 8 and 12).

3.7 Conclusion

UX is a complex field that contains aspects of human computer interaction (HCI), interaction design, human-centred design (HCD), usability testing as well as principles of graphic design. These can be referred to as the *instrumental* or *pragmatic qualities* of UX. However, UX also includes the *emotional reactions* that a user experiences, as well as *non-instrumental quality perceptions* (hedonic aspects / pleasure).

A reductive approach to UX can be used to simplify the complexity thereof, to describe it, and to identify individual elements that play a role in UX.

UX components include:

- Perception of instrumental qualities (pragmatic). Usability and accessibility are the main elements which form part of this component.
- Emotional user reaction.
- Perception of non-instrumental qualities (hedonic / pleasure).

The four elements against which UX are evaluated in this research project are usability, accessibility, emotional user reaction and hedonic aspects.

The process for UX evaluation includes:

- Agreeing on what is looked for in the user's experience.
- Posing the right questions.
- Selecting a method, and subsequently evaluation instruments.

User experience design (UXD) is an iterative process consisting of four phases: user research, designing, building a prototype, evaluating. As part of the user research phase, accessibility and usability guidelines have been developed. Usability guidelines include the usability heuristics of Nielsen, a selection from Schneiderman's 8 golden principles of good interface design, principles of Interaction Design and the use of colour to create certain psychological effects.

3.8 Summary

The chapter commenced by discussing the diversity of the field of UX by providing information on various fields studying UX and some definitions. Through a reductive approach to UX, a UX model was derived (Fig. 3.2), which contains three main components of UX.

From these three main components, the following were identified for this research project:

- UX design guidelines (section 3.5.4)
- UX evaluation elements (the elements which play a role in UX that will be measured in this research project) (sections 3.4.2; 3.4.3 and 3.4.4)
- UX evaluation questions (section 3.6.2)
- UX evaluation methods (section 3.6.3)
- UX evaluation instruments (section 3.6.4)

These components were used as follows:

The UX design guidelines were used with the mitigation strategies identified in Chapter 2, and practical guidelines for developing DHH media which are presented in Chapter 4, to develop the guidelines for the programming lesson.

The UX evaluation elements (usability, accessibility, emotional user reaction and hedonic aspects) were used to both motivate the UXD guidelines (section 3.5.4), as well as the UX evaluation questions (section 3.6.2), and assisted in choosing the relevant evaluation methods. This finally led to the design of the UX evaluation instruments.

In Chapter 4 that follows, practical guidelines to create media for DHH learners are identified. These practical guidelines, with mitigation strategies identified in Chapter 2, and the UXD guidelines identified in this chapter, are synthesised into the guidelines used to build the programming lesson. The complete guidelines are presented in Chapter 6.

Chapter 4

Technology-supported teaching and learning

Introduction

- Chapter 1: Introduction

Literature study

- Chapter 2: Unique learning challenges, strengths and needs of Deaf or Hard of Hearing individuals
- Chapter 3: User experience design and evaluation
- Chapter 4: Technology-supported teaching and learning

Research Design

- Chapter 5: Research process

Guidelines

- Chapter 6: Guidelines and technology-supported lessons

Results and analysis

- Chapter 7: Results and analysis

Conclusion

- Chapter 8: Conclusion and recommendations for future research

Chapter 4

4.1 Introduction

This is the third literature review chapter of the present research project. The purpose of this chapter is to present practical guidelines for designing learning and teaching media for Deaf and Hard of hearing (DHH) learners. These practical guidelines were used with the mitigation strategies presented in Chapter 2, and the user experience design (UXD) guidelines presented in Chapter 3, to create the guidelines for programming lessons. The guidelines can be viewed in Chapter 6.

The practical guidelines presented in this chapter form the last part of the guidelines that were synthesised to address sub-research question 2:

> *How can technology be implemented to support lessons to teach basic programming principles to Deaf and Hard of Hearing learners?*

The aim of the review of various technologies, and the way they have been applied, is to provide an overview of the scope of technology used in teaching and learning DHH learners, with a view to peruse practical guidelines that have already been applied successfully in research projects.

The chapter sets out by providing an overview of various technological devices that educators of DHH learners, or DHH individuals, themselves use. Examples of the benefits of using technology when teaching DHH learners are provided. Several advanced technologies are also mentioned. Even though these technologies are expensive to install and not likely to be used in the average DHH environment, they do provide useful practical guidelines to designing media.

Next, a number of applications which have been developed to teach DHH learners in a specific field are discussed. These include applications for teaching curriculum-specific subjects, for improving reading and comprehension, as well as applications for teaching a specific sign language. The practical guidelines obtained from each application are listed.

Since many institutions adapt their existing learning material to provide access to DHH individuals, this review includes overviews of software techniques as well as various devices that are used to provide access to these techniques. The review of such projects provide further motivation for the role that technology can play in DHH education.

This review also provides relevant examples of prototypes and products that have been developed by researchers in South Africa. Guidelines from some of these projects are described in this chapter and have been incorporated in the final guidelines.

Finally, this chapter refers to three projects where a programming language was taught to DHH learners. The review provides examples of the advantages, hidden benefits, and challenges in teaching DHH leaners to learn a programming language.

4.2 Technology devices

The use of technology in instruction and education has become an essential requirement in facilitating the success and quality of teaching and learning. Technology can especially support creativity in developing learning material. Research indicates that students are more motivated when they use technology when learning (Beal-Alvarez & Cannon, 2014; Sagirani, Nugroho, Santosa, & Kumara, 2015). In this section, different types of devices that are used in DHH education are perused.

4.2.1 Interactive devices

For the sake of this review, interactive devices refer to Personal computers (PC), laptops, smartphones and tablets – any device on which an application (or app in the case of tablets and smartphones) can be installed and used by a DHH person.

Advances in the availability of interactive devices and the capabilities of software tools provide opportunities to designers and educators to create learning material that has the potential to improve learning. This can be achieved, for example, by supplementing learning material that contains text with 'adjunct aids' such as content movies, sign language movies, pictures and finger spelling, advanced organisers and procedural drawings (Dowaliby & Lang, 1999). Especially in the field of learning sign languages, technological resources can display signs through videos and animations that support learning in a way that is far superior to static images and written descriptions in books and posters (Korte et al., 2015). Students also seem to be more attentive, motivated and learn more effectively because of the impressive visual effects as well as the immediate feedback that can be provided with digital data (Chen, 2013).

Some of the different types of applications that have been created and can be used on these interactive devices are discussed in section 4.3

The use of tablets specifically are recommended by Hart & Ahmed (2013) – they argue that learners with hearing loss are at a disadvantage when having to use technology devices for learning, since they need to become computer literate before being able to use the learning material. Computer literacy involves acquiring additional terminology and skills, whereas tablets, such as an iPad, are more intuitive tools that do not require learning as many new skills as when using a computer. A learner can use their fingertips to guide them through a lesson.

The use of handheld interactive devices (smartphones or tablets) by DHH people is increasing. It is typically used for communication purposes – sending and receiving text messages and also using video applications to communicate in sign language (Stinson, 2010).

Due to the increasing capabilities of, and applications available for handheld devices such as smartphones, these can be used to read electronic texts, to use reference materials, produce documents and collaborate by sharing files with one another (Vath et al., 2005). These devices are also suitable for use with apps using images and videos; for example, to teach sign languages. A search on iTunes can display numerous apps for iPad and Android technologies such as games and e-books, as well as other apps that can, for example, translate speech into text, teach sign languages, show titles of movies that have captions, and display the Bible in sign language.

Stinson suggests that handheld devices also have the potential to be used for educational purposes, but limitations such as cost and challenges in integrating technology with teaching and learning prevent handheld devices from being used in classroom with DHH learners (Stinson, 2010).

Feedback on apps that were developed specifically for people with hearing loss indicate that:

- Users found learning with a mobile device easy and it helped them to remember what they learned (El-Seoud, Nosseir, Taj-Eddin, El-Sofany, & Rumman, 2013).
- Participants liked the fact that they could gather information immediately and in non-educational spaces such as buses, restaurants, and shopping areas (Kim et al., 2011).
- Learners who completed mathematics games on tablets liked the mix of paper-and-pencil with "manipulative-based items", and experienced the assessment as enjoyable (Blair, Hallinen, Pfaffman, Schwartz, & Cutumisu, 2015, p. 733).

4.2.2 Peripheral devices

In South Africa, the Department of Basic Education (DBE) recommends the following classroom resources for the South African Sign Language (SASL) classes (DBE, 2014):

- Digital cameras / video recorders / tripods
- Memory cards / flash drives
- TV monitors and DVD players
- Computers / software for editing, and
- A range of DVD's to accommodate different reading levels.

The following devices are mentioned as optional:

- Webcam facilities / broadband internet access / smart-board/ tablets / smartphone with video recordings and viewing capabilities.

From this list, it is clear that educators are expected to use technology to display existing and/or create multimedia learning material. Various projects and guidelines confirm that technology such as big screens, projectors and visual aids are essential to assist communication and learning in DHH education. Many educators of DHH learners make use of data projectors and display PowerPoint presentations or learning material from CD's or DVD's onto a big screen in the front of the class, so that they can face students while they communicate, and do not have to turn their backs to write on a board (California Department of Education, 2000; Giannakos & Jaccheri, 2014; Mackall, 2004; Meadow, 1980).

Liles (2005) and Mackall (2004) report on the benefits of using interactive whiteboards in the instruction of DHH students. Interactive whiteboards can display any application from a computer or laptop, but they are touch-sensitive, and a person can write over any application in electronic ink using either a stylus or a finger. Images can be moved around on the screen, which can, for example, be used in activities such as placing pictures of various animals in specific categories. The interactive aspect seems to appeal to the DHH learners; they are eager to come to the front of the class, share their knowledge with peers and work in groups. One suggestion for the appeal of using an interactive board is that the graphic and interactive representation of information provides students with a break from the extremely demanding activity of having to concentrate on the educator's signing hands (Liles, 2005; Mackall, 2004).

4.2.3 Advanced technologies

As technology advances, there seems to be an increasing interest in applying technology to improve the quality of access to knowledge as well as the quality of life of DHH individuals. Examples of projects implementing advanced technology are:

- The development of a low-cost stand-alone device for DHH people to notify them when a doorbell is ringing. The system is based on the Raspberry pi that includes a camera, vibrator, wireless access to a network and Bluetooth communication between devices. When a visitor presses the doorbell, a captured image is transferred to the wearable device, it vibrates and a message is displayed. The visitor's image along with the date and time are sent to a server and information can be retrieved. This system greatly enhances the safety of DHH people (Kumari, Goel, & Reddy, 2015).
- A car-detecting system (*LaneMate*) where a DHH person wears a device on their wrist. The device has sensors which can detect the presence of a car behind the person. The

device vibrates to alert the DHH person – even if the a car behind them is stationary (Lee, Lee, & Kang, 2016).

- A monitoring and navigation system using a handheld smart phone and a system of wireless sensor networks. This system broadcasts pictures to DHH people so that they can avoid crowded and noisy regions (Aly, 2014).
- Several projects are developing systems where text can be translated into a visual realisation of sign language by means of a computer-generated virtual human (avatar). Examples of such systems are:
  - *VisiCAST* and *eSign* (Elliott, Glauert, Kennaway, Marshall, & Safar, 2008).
  - A system used to teach Greek sign language (Efthimiou, Fotinea, & Sapountzaki, 2006; Kouremenos, Fotinea, Efthimiou, & Ntalianis, 2010)
  - The *SMILE* project, where children interact with fantasy 3D avatars and objects to learn basic math and science concepts. The avatars communicate with the participants in written and spoken English and American Sign Language (ASL). A stereoscopic head-mounted display unit can be used (Adamo-Villani & Wright, 2007).
  - Signing math and science dictionaries that incorporate illustrations, English text and signing avatars to convey the meaning of each term in ASL and signed English (Solomon et al., 2012).

Researchers are confident that progress is being made in creating systems that use virtual human signing, and that it may be used to provide access to websites and other applications at a relatively low cost.

4.3 Applications and media designed for DHH people

Many researchers confirm that electronic lessons and the use of technology can help DHH people to learn new vocabulary, subject content and literacy skills. Deaf education is embracing the practice of teaching materials through the use of interactive multimedia, especially since many user-friendly authoring tools have become available in recent years, which enable educators to create interactive multimedia (Parton, 2006). Through technology these lessons can be made available for use to DHH people at any time. The use of electronic lessons can improve independence, confidence and motivation of DHH people; however, researchers agree that lessons or DHH learners need to be appropriately designed (Al-Osaimi, AlFedaghi, & Alsumait, 2009; Dowaliby & Lang, 1999; Lang & Steely, 2003).

4.3.1 Applications to teach curriculum-specific subjects

The following section provides an overview of relevant applications for teaching curriculum-specific subjects. Even though these applications were developed to teach specific subjects, and therefore included curriculum-specific knowledge, some of the design elements included in their applications can be transferred to the design of any technology-supported learning material.

- Mathematics and science (Adamo-Villani & Wilbur, 2007; Adamo-Villani & Wright, 2007).
  The applications developed by these researchers make use of advanced technology such as 3D animation technology and virtual reality. However, a number of their suggestions were taken into consideration in this research project, such as:
  - The importance of using colour, and the possible emotional impact of specific colours.
  - Learners should be actively involved during a lesson.
- Science (Dowaliby & Lang, 1999; Lang & Steely, 2003).
  The following design guidelines gleaned from these two science lessons were included in the design of the lessons for this research project:
  - Include pictorial aids such as static illustrations or animation with text (Dowaliby & Lang, 1999).
  - Include graphic organisers that provide schematics of key concepts (Lang & Steely, 2003).
  - Ensure that the language of the material matches the reading proficiency of students in an appropriate way (Lang & Steely, 2003).
  - Combine text with sign language, animation and graphic organisers (Lang & Steely, 2003).
  - Use short sentences and teach new vocabulary before the lesson starts (Lang & Steely, 2003).
  - Present material in such a way that learner interaction is encouraged, for example, ask questions during the presentation of the lesson (Dowaliby & Lang, 1999; Lang & Steely, 2003).
  - Include frequent questions throughout the text and at the end of study units (Dowaliby & Lang, 1999; Lang & Steely, 2003) .
- Mathematics (Techaraungrong, Suksakulchai, Kaewprapan, & Murphy, 2015)

The following are some of the principles that these researchers applied in the lessons that they developed for 7-year olds, and that could also be applied in the lessons developed for this research project:

  - Minimise the use of text.
  - Design learning in scenarios that are familiar to the learners.

- Fractions through games (Markey, Power, & Booker, 2003)

  One of the main recommendations made by these researchers is the importance of using the correct language (subject-specific terminology) when teaching mathematics. This supports the decision to teach relevant terminology related to programming before the programming lesson starts to ensure understanding and to establish meaning.

4.3.2 Applications to improve reading and comprehension

A number of projects have been developed with the aim of improving reading and comprehension. Some of these are:

- *Logic-based e-tool for Deaf children* (LODE) – an application with interactive stories and exercises with dynamic feedback (Mich et al., 2013).
- *See-and-See* – an application developed to inform educators of deaf children on the role of visual resources and multimedia educational software in reading comprehension (Nikolaraizi & Vekiri, 2012; Petrantonakis, Kosmidou, Nikolaraizi, Koutsogiorgou, & Hadjileontiadis, 2008)
- *The Boabab* – a storybook app for the iPad developed by an all-Deaf team for emerging readers (Malzkuhn & Herzig, 2013).
- A series of interactive book apps in South African Sign Language developed by Karen Hart (Hart & Ahmed, 2013) using *Picsterbooks* that can be viewed on an iPad (Picsterbooks, 2017). The books are regarded as 'remedial learning' apps.

These researchers and developers as well as several other researchers stress the importance of supplementing electronic text with visual resources such as sign language or silent motion videos, pictures, animations, graphic sign representations as well as finger-spelling of certain words. This transforms text to a format which is more accessible to DHH persons (Dowaliby & Lang, 1999; Pollack, 1997; Al-Osaimi et al., 2009; Bueno, Alonso, & del Castillo, 2007; Gentry, Chinn, & Moulton, 2005; Malzkuhn & Herzig, 2013).

4.3.3 Applications for teaching a specific sign language

It is very important that learners should become fluent in sign language, since a lack of vocabulary has a negative impact on literacy and interpersonal interaction for Deaf children (Barker, 2003). In South Africa, the *Curriculum and Assessment Policy Statements* (CAPS) for

South African Sign Language (SASL) were completed by the Department of Basic Education (DBE), and approved as policy in July 2014 (DBE, 2014). This policy enables learners to take SASL as Home Language or First Additional Language from Grade R until Grade 12. A non-profit organisation called Sign Language Education and Development (SLED) has been active in South Africa since 2001 to promote SASL. SLED delivers training to educators in Deaf schools, and also provides learning material to assist educators in creating meaningful SASL lessons. These materials include, amongst others, illustrated signed stories, games, puzzles, and literature DVD's with accompanying reading books. However, on their official website they mention that there is a "dearth of material and trained educators in SASL" (SLED, 2015b, "WHY SIGN LANGUAGE", par. 1). Some researchers in the international scene also feel that Deaf children constitute "an underrepresented group in technology development", despite the fact that technology can potentially assist them in acquiring language (Korte et al., 2015, p. 195).

A literature search on multimedia and technology that focuses on teaching a sign language only yielded very few publications. Even a review article by Beal-Alvarez and Cannon (2014) only refers to projects such as stories that were supplemented with embedded vocabulary in print/sign/fingerspelling, viewings of ASL stories, and shared reading with e-books with American Sign Language (ASL) narration with parents. Stinson (2010) reports that a variety of electronic learning materials is available to support the acquisition of sign languages, especially to develop vocabulary (dictionaries); he also mentions that literature provides limited data on the educational use and impact of these media.

In South Africa two projects are in progress to develop SASL dictionaries – more detail on these is provided in section 4.5

However, even though there seems to be a lack of academic publications on the design of applications to teach or support the learning of a sign language, a large number of applications and educational web sites is available commercially and on the World Wide Web – especially dictionaries. A few examples are:

- *American Sign Language Video Dictionaries and Quizzes* (ASLPro.com, 2014).
- *American Sign Language University* (ASLU) – a resource site for ASL students and educators (American Sign Language University, 2015)
- *DeafPlanet.com* is an interactive website for children who are deaf. It offers forums, chat rooms, educational games and activities, literature, and more. The portal is available in ASL and in French LSQ (DeafPlanet, n.d.).
- *Auslan Signbank* is a language resource site for Australian Sign Language (Auslan), containing a dictionary, offering ability to search for signs related to certain topics,

videos of deaf people using Auslan signs, information on the deaf community in Australia and links to Auslan classes (American Sign Language University, 2015).

- *Signing Savvy* - a sign language dictionary containing several thousand high resolution videos of American Sign Language (ASL) signs, finger spelled words, and other common signs used within the United States and Canada (Signing SavvyTeam, 2017).

One project worth mentioning is the *Seek and Sign* project by Korte, Potter and Nielsen (2015). They developed an interactive game-based application that aims to support young learners to learn Australian Sign Language (Auslan). In this project young Deaf learners were involved in the design of the application, and even though the reports on the project focuses on the process of "requirements elicitations prototyping" (Korte et al., 2015, p.196) with Deaf learners, they provide valuable guidelines for the design of such an application, which have been incorporated in the guidelines presented in Chapter 6.

Product and prototypes that are available in South Africa to teach or support the teaching of SASL are discussed in section 4.5

4.4 Providing access to existing learning material

In South Africa, an official policy document namely *White Paper 6: Special Needs Education; Building an Inclusive Education and Training System* has been accepted in July 2001. According to this document, *The National Disability Strategy* is not in favour of segregating persons with disabilities from any areas of society. This notion is supported by the Ministry which sees "the establishment of an inclusive education and training system as a cornerstone of an integrated and caring society and an education and training system for the 21st century" (DoE, 2001, p. 10). Based on the multitude of reports on projects and research from other countries, it is clear that many countries encourage learning with hearing loss to be included in so-called 'mainstream education' – also referred to as 'general classes'. Antia, Kreimeyer and Reed (2010) mention that more children with severe to profound hearing loss are diagnosed early these days, and receive improved care such as early language acquisition and access to technology such as cochlear implants. Therefore, in future the primary role of educators who used to teach DHH children may be to provide support to these children at local public schools (Antia, Kreimeyer, & Reed, 2010).

However, including learners with hearing loss in classes with learners and an educator who can hear, is not without challenges; these are highlighted by Chen (2013). Learners with hearing loss may experience the following problems:

- They are not able to follow the educator's explanations in class clearly, and miss some of the content of a lecture.

- They may feel uncomfortable to ask questions or to participate in discussions.

The result of these is that they underperform, may be frustrated, become anxious and have levels of low motivation (Chen, 2013).

Many research projects therefore focus on *providing access* to existing sources (such as the Internet) and learning material developed for hearing learners. In the following section some of the different types of material developed or adapted to provide access to individuals with hearing loss are discussed.

4.4.1 Integrated learning systems

A number of researchers, for example, Khwaldeh, Matar and Hunaiti (2007); Straetz, Kaibel and Raithel (2004) and Bueno, Fernández del Castillo, Garcia and Borrego (2007) implemented strategies to adapt integrated e-learning courses for DHH individuals. Some of these strategies are:

- Present learning material online that have been supplemented in various ways to take care of the needs of DHH people –including presenting audio information in a visual way (either by means sign language videos or graphics), subtitles for videos, additional pictures as well as a dictionary and glossary of terms.
- Include video conferencing facilities between DHH students and their lecturers and peers as well as chat rooms to facilitate learning in groups.
- Include interactivity and regular assessment.
- Enable learners to control the pace of learning, since each DHH person learns at a different pace.

Such e-learning systems have advantages for DHH students. Peers in these environments may not even realise that their fellow students have hearing loss. Therefore, students feel they can contribute to class discussion equally. They feel connected and are more engaged with the course material (Brokop, 2008). Other advantages of online learning courses are that the use of text provides DHH student with direct communication with the course material, instead of communication mediated by an interpreter. There are also no time constraints that require a DHH person to respond immediately, to ask a question or make a comment. DHH students using such systems report an increase in quality of communication and interaction with peers (Long, Vignare, Rappold, & Mallory, 2007; Stinson, 2010).

4.4.2 The World Wide Web

Using the World Wide Web (WWW) is necessary for any person in the 21st century, regardless of whether a person is disabled or not. One perception is that it should be easy for people who have hearing loss to use the Internet, since communication is primarily visual (text and pictures) (Barak & Sadovsky, 2008). According to the study by Barak and Sadovsky (2008), the hearing-impaired participants:

- Are more motivated to use the Internet than their hearing counterparts.
- Used the Internet more intensively, spend more time on the Internet and engage in more solitary activities.
- Used the Internet in ways similar to their hearing counterparts, but more intensively for personal and group communication.

However, the fact that online audio and video content are seldom captioned limits the possibility of DHH people to access educational material (Maiorana-Basas & Pagliaro, 2014). Another complication in accessing material on the internet is that students with hearing loss have difficulty reading and writing (Blair, 2013; Drigas et al., 2005; Fajardo, Cañas, Salmerón, & Abascal, 2006; Potter, Korte, & Nielsen, 2015). Therefore, a number of researchers are working on ways to improve access to pages on the Internet that will allow users to be less dependent on interpreting text. Debevc, Kosec, and Holzinger (2011), for example, refer to a project called *Signing Web* (a system that allows sign language-only webpages to be created and linked through a video-based technique called *signlinking*). Their own project implements transparent sign language videos that are linked to any element of the website, such as a word, a sentence, a paragraph or an entire block of text, a picture, an animation or even another video clip. Since the sign language video only appears when the user clicks on the indicator for a sign language video, the original webpage is preserved, and therefore users who do not need the videos are not affected, and no adjustment needs to be made to an existing website (Debevc et al., 2011). Results of an evaluation of this project show that deaf users appreciated the Sign Language Interpreter Module and had a great desire to use this form of sign language presentation to visit other websites.

In South Africa, an experiment was conducted where animated South African Sign Language was embedded in the South African National Accessibility Portal. Through experiments, user evaluations and web-metrics it was also found that such techniques can improve the accessibility for Deaf users in experimental conditions. However, to implement this in the real world may not be feasible, because of practical concerns such as the difficulty to create and maintain animated Sign Language, and bandwidth constraints that may not be adequate to let a user browse without becoming frustrated (Coetzee, Olivrin, & Viviers, 2009).

4.4.3 Assistive classroom technology

In this section, technology that can be used to provide DHH learners with access to learning, specifically technology to convert speech-to-text is explored. These technologies can be used to assist DHH learners while attending to general mainstream classes, or to enhance their learning experiences in a school for the Deaf.

Captioning refers to the presentation of information that is in audio format in a text format. When the viewer has a choice whether to watch the captions or not, this is called *closed captioning* (CC), and when the captions are visible all the time it is called *open captioning* (OC). Subtitling is a verbatim translation of audio, but captioning includes additional information such as an indication of which person is speaking, background noise, sound effects and music. Captions are used on television as well as in educational settings, Internet webcasts, meetings, conventions, courtrooms, and corporate training events (HLA-NC, 2003). Different types of technologies are available to provide captioning where text is displayed on a computer screen as a person (the educator or a classmate) speaks.

CART (*Communication Access Realtime Translation*): this service is provided by a trained court reporter using a stenographic machine, a computer, and computer-aided transcription software. The person is in the class with the leaners, and produces special code using combinations of keystrokes on the stenographic machine to capture all words spoken during the lecture or class. Special software converts the code into words (Bell, 2013; Solomon et al., 2012).

Standard keyboards and a computer with special software (such as *C-Print* and *Typewell*) can also be used. With these systems, the person types abbreviated versions of words, and the software converts it to full words. In this approach, the meaning of a lecture is captured, not every word spoken (Solomon et al., 2012).

Speech recognition systems are also available, but are not as accurate as the other real-time speech to text services (Brokop, 2008; Stinson, 2010). These real-time speech-to-text services are especially useful in a classroom where learners who have hearing loss have to attend class in a general educational setting. These systems also allow the text of captions to be saved and printed for use by students after a lesson. Stinson (2010) reports that literature with reliable findings that were reviewed claims the following:

- Students use the text of captions more often than handwritten notes from persons who took notes of a lecture.
- There is no difference between students’ performance with word-abbreviation-based or CART-based captioning services.
- Captioning services do not consistently increase performance compared to interpreting services. (Stinson, 2010, p. 96).

4.5 South African prototypes and products

The next sub-sections list and briefly describe prototypes and products developed in South Africa.

4.5.1 Prototypes

At the University of Stellenbosch, a number of projects that focus on communication assistance are currently underway. They explore the use of mobile phones providing for phones that are not smartphones. For non-mobile devices, they aim to use computers and network resources with minimal requirements (Van Zijl, 2012).

Some of the projects they are working on involve the following:

- A prototype English text to SASL rule-based machine translation system (Olivrin & van Zijl, 2008).
- An educational game to help siblings of Deaf children to learn basic signs (described in e-mail received 5 September 2016 (Sandra Maritz)).
- An eTutor for SASL that can assist with feedback on sign formation for a sign language learner (De Villiers, van Zijl, & Niesler, 2012).
- A hand that can fingerspell automatically if given a text input is provided - described by Sandra Maritz (personal communication, September 5, 2016).
- Dr Hanelle Fourie Blair from Stellenbosch University (SU) developed a theoretical model of an electronic sign language dictionary for foundation phase learners for her doctoral thesis in lexicography in 2013. In 2015, a student in his final year honours in Computer Science developed the software for a multimedia electronic dictionary, based on her theoretical model. The dictionary is unique because it is fully bilingual and bidirectional - users can search the dictionary by means of a picture, a sign or a word – each search method will lead to exactly the same result. Therefore, a user does not have to be literate in sign or a written language to be able to use the dictionary. For example, a user can search for the concept, word or sign 'apple'. The following will then become available: a picture of an apple, the written word 'apple', a video of 'apple' in sign language, a finger spelling of the word, a definition and a sample sentence in written as well as sign language. (Fourie Blair, 2013; Stellenbosch University, 2016). At the time of writing this dissertation, this dictionary was only a prototype with a few entries to demonstrate that and how it works. Funding is needed to create artwork, pictures, definitions and example sentences in both English and SASL. The idea is to make it available to the Deaf community either at no or at minimal cost (personal communication, September 26, 2016).

The University of Western Cape reports on a number of projects:

- The Centre of Excellence reports on a project to develop a SASL Translation System. This system strives to develop technology (hardware and software) that will translate SASL to English text, and then to apply a speech synthesiser to produce spoken English. The technology will also translate spoken English into SASL, which will be signed through an avatar (UWC, n.d.).
- The South African Sign Language research group at the University of the Western Cape is in the process of creating a fully-edged [sic] machine translation system to automatically translate between South African Sign Language and English. A major component of the system is the ability to accurately recognise facial expressions, which are used to convey emphasis, tone and mood within South African Sign Language sentences. (De la Cruz, 2016, "Autonomous facial expression recognition using the facial action coding system", par. 1).
- The South African Sign Language research group has also developed a new methodology for recognising SASL signs. The system combines hand location and hand shape recognition into one combined recognition system. It is able to recognise a very large vocabulary of 50 signs at a high average accuracy of 74.1%. This vocabulary size is much larger than existing SASL recognition systems, and achieves better accuracy than these systems in spite of the large vocabulary (Nel, 2014).

4.5.2 Products

Several DVD's, apps and services available via the Internet have been created by different institutions to assist users to either learn SASL or to communicate more efficiently, for example:

- A company called *SignGenius* created software products to teach both SASL and ASL. The application contains tips, tutorials and tests (Segno Communication cc, n.d.).
- The first electronic South African Sign Language (SASL) thesaurus has been launched by The National Institute for the Deaf (NID) in April 2016 (NID, 2016).
- *Finger Talk* is an app which can be downloaded on Android 4.0 and higher phones to helps users learn the basics of SASL. It provides a comprehensive dictionary and also tests their knowledge by means of a fun and challenging quiz. Users can also compare their quiz performance with other app users (Wigital Education, 2016) .

- An app called *Sign Short Message Service* is available from GooglePlay. This app is based on research conducted for a Master's thesis at a South African university. It provides the ability to communicate through messages in both fingerspelling and plain text, while at the same time it is also an educational tool that can be used to learn a sign language alphabet (Yeratziotis, 2012).
- A series of interactive book apps in South African Sign Language has been developed by Karen Hart using *Picsterbooks* – the iDeaf project. These books can be viewed on an iPad (Picsterbooks, 2017). The books are viewed as *remedial learning* apps.
- As mentioned previously, SLED provides materials such as illustrated signed stories, games, puzzles, literature DVD's with accompanying reading books to educators to assist in presenting SASL lessons as well as a dictionary to assist families of children who use sign language (*A South African Sign Language Dictionary for Families with Young Deaf Children.*)
- The NID is developing a digital dictionary for SASL with the support of the FW de Klerk Foundation. The dictionary will include all variations of SASL used by DHH people in South Africa, with the corresponding English word. It will enable a user to search for various signs, see how the word is used in a SASL sentence with SASL grammar, and will also display the corresponding English word in an English grammar structure (FW de Klerk Stigting, 2016).

4.6 Implementing computer programming as a tool for learning

According to Mitch Resnick (Professor of Learning Research at the MIT Media Lab where the programming language Scratch was developed), people also obtain other skills through learning to code (code to learn vs learn to code). He is of the opinion that learners who code learn strategies for solving problems, designing projects, and communicating ideas (Mitchel Resnick, 2013). Unfortunately, in South Africa the only way a DHH learner can learn to program is if the subject Information Technology (IT) is offered at their school from Grades 10 to 12, or they need to attend IT classes at a school for learners who can hear. As explained in Chapter 1, very few schools for DHH learners offer IT. However, in the new curriculum for learners with special needs (implemented January 2017), IT has been introduced. In Year 4 of the subject, provision is made for 8 hours of programming, and the programming language Scratch is recommended (DBE, 2015).

Literature relating to projects that focus on teaching a programming language to DHH learners is limited. A brief overview of a few of these projects is presented below with a view to provide examples of the hidden benefits and the challenges in teaching DHH leaners to learn a programming language.

Project 1: Miller (2009) reports on the progress of a 13-year-old boy who was exposed to a programming language called Logo – the language has a drawing tool called a Turtle that can be used to create drawings. The boy had prelingual deafness, and an almost complete lack of spoken and sign language. During the three months that he worked with Logo, his language skills in reading and writing developed remarkably. Miller suggests that in a regular language-learning context, the spontaneous development of language needs an individual to be exposed to:

- An interactive field of experience where vocabulary and rule-based knowledge is acquired according to their unique needs.
- An environment where the new knowledge can be practised and extended within relevant contexts.

The "interactivity and generativity as well as the immediate visual feedback" of the programming language provided a similar, suitable environment where the DHH learner could learn a new language (Miller, 2009, p. 90).

Project 2: Millner, Huang, and Corbett (2013) also report on the unexpected outcome of creating a bridge to language learning through programming. The case study on which they report involved a student assistant who had limited exposure to English, and an educator introduced him to the programming *StarLogo TNG* to help him to prepare for a course in video game design he wanted to attend. The programming language uses coloured blocks with text that have to be snapped together to create a program, similar to the language Scratch. It was found that the student gained a deeper understanding of English grammar differences – for example when he programmed the game 'Rock, Paper, Scissors', he realised the difference between the noun 'scissors' and the verb 'cut'. Initially, he named the program 'Rock, Paper, Cut'. He was therefore able to transfer his knowledge of the language *StarLogo TNG* to another language *ActionScript*. Subsequently, the educator expanded the teaching of programming at the school and implemented Scratch lessons for learners in Grades 3 and 7, and found more connections between English and programming. She also reports on the fact that programming in Scratch improved the writing skills of a learner. A girl who is hearing-impaired, and has Asperger's syndrome, regularly communicates with Scratch programmers through the online Scratch community. She is determined to talk to people about projects, and this improved her writing (Millner et al., 2013).

Project 3: Giannakos and Jaccheri (2014) presented a workshop to twelve 12-year old children where the children worked in groups of two, and they designed six interactive projects. During the workshop, the enjoyment, control and ease of execution with respect to the workshop were evaluated. It was found that learners enjoyed the workshop, but their control of the workshop was low, and they found many of the concepts hard to follow and unclear. Therefore, the guidelines for the design of a workshop were improved and published. From their guidelines, it is clear that lessons to DHH learners should be planned carefully. They emphasise the following (Giannakos & Jaccheri, 2014):

- Paying attention to the way to approach the learners.
- Planning the structure of the sessions, and ensuring that the interpreters are well-prepared.
- Making use of visual aids and exploit the visual interaction of the programming language used.

The review of these three projects provided valuable practical guidelines for teaching programming principles to DHH learners, as well as a motivation as to why it is beneficial to teach DHH learners a programming language – a field that has been neglected in South Africa.

4.7 Conclusion

Technology is used in multiple ways in teaching and learning for DHH learners – ranging from the very basic technologies such as using word processors to create summaries, to implementing state-of-the-art equipment such as creating virtual reality games to teach a sign language. The use of technology in teaching DHH learners has many advantages, such as:

- Mobile devices provide ubiquitous access to applications.
- Through technology, DHH learners can be taught directly, have their access and learning in mainstream classes supported, and be facilitated in collaboration with other DHH and hearing students.
- Technology provides greater flexibility to include and combine different display formats such as text, images and videos.
- Technology supports creativity in developing learning material.
- DHH learners are more motivated to learn when they use technology.
- Functional and accessible technology may help to allow DHH individuals access to education, business, and social media, and improve their quality of life and safety.

Existing applications and prototypes of applications that have been developed for DHH individuals provide valuable guidelines for developing media. A significant number of products that have been developed locally are available in South Africa for use in DHH teaching. However, the cost of developing learning material, and the challenges of integrating technology with teaching and learning prevent the widespread use of technology in DHH teaching environments.

Researchers agree that enough evidence exists to propose that technology can be used effectively in various areas of a DHH individual's life. However, more research is needed to find best practices in teaching specific subjects. In South Africa, very few schools offer computer-related subjects to DHH learners – especially computer programming is neglected, even though definite advantages and hidden benefits of teaching a programming language to DHH learners can be proved.

4.8 Summary

The chapter provided an overview of various technological devices that educators of DHH learners, or DHH individuals themselves use. These included interactive devices, peripheral devices and advanced technologies. Advantages of using technology and media to teach DHH learners were mentioned, and a few practical design guidelines were listed.

Specific applications that are used to teach curriculum-specific subjects, to improve reading and comprehension and to teach specific sign languages were discussed, and a number of practical guidelines obtained from these applications were highlighted.

Various techniques and devices that provide DHH individuals access to existing learning material and media were mentioned. These include access to learning material through integrated learning systems, access to the World Wide Web through browsers, and technology that can be used in classrooms to assist learners in, for example, note-taking and following a lecture.

A number of products developed locally in South Africa were perused. Practical guidelines from some of these products have been included in the final guidelines that can be reviewed in Chapter 6.

Some advantages, hidden benefits and the challenges an educator may experience when teaching a computer programming language to DHH learners have been highlighted. This serves as motivation as to why it is necessary to conduct research on ways to develop teaching media for DHH learners.

The next chapter presents the following:

- The design of the research project.
- The research process followed in this research project.
- The case study.

Chapter 5

Research process

Introduction

- Chapter 1: Introduction

Literature study

- Chapter 2: Unique learning challenges, strengths and needs of Deaf or Hard of Hearing individuals
- Chapter 3: User experience design and evaluation
- Chapter 4: Technology-supported teaching and learning

Research Design

- Chapter 5: Research process

Guidelines

- Chapter 6: Guidelines and technology-supported lessons

Results and analysis

- Chapter 7: Results and analysis

Conclusion

- Chapter 8: Conclusion and recommendations for future research

Chapter 5

5.1 Introduction

This chapter describes the process that was followed to turn the research questions into a research project.

The purpose of the research project was to:

- Develop a set of guidelines for the development of technology-supported lessons for the teaching of basic programming principles to Deaf and Hard of Hearing (DHH) learners at a school for the Deaf.
- Apply these guidelines to develop a high-fidelity, fully functional prototype – a set of technology-supported lessons.
- Present the lessons, and evaluate the user experience (UX) of the participants during and after completion of the lessons.

The chapter starts by providing an overview of the project design that was implemented to realise the purpose of the project. An explanation is given as to how the two research strategies (prototype construction as secondary research strategy and case study as primary research strategy) were implemented in the project design, and how the prototype construction supports the case study. The contribution of each literature review chapter to the research strategies is highlighted.

The different stages of the research process are described with detail on the application of each stage in this research project. The phases include the philosophies, approaches, strategies, research choices, time horizons as well as techniques and procedures for data collection and analysis.

A more detailed discussion of the prototype development is then provided, and the case is presented.

Finally, the way in which triangulation was applied in this research project is discussed.

5.2 Project design

Every research project has a primary goal, and a number of secondary goals that help to achieve the primary goal. The secondary goal should support the primary goal, and different methods may be used to achieve each goal (Olivier, 2009).

The primary goal of this research project was to determine the user experience (UX) of the participants during and after using and attending technology-supported lessons to learn basic programming principles. The participants included eleven Deaf and Hard of Hearing (DHH) learners at a school for the Deaf, as well as two educators who were involved in creating and presenting the lessons. According to Olivier (2009), this is a *social goal* since it deals with the people side of computing. As will be described later, a case study research strategy was used to achieve this goal.

The secondary goal of this research project was to develop guidelines for the design of technology-supported lessons to teach programming to DHH learners, and to apply these guidelines to develop a high-fidelity, fully functional prototype – a set of technology-supported lessons. According to Olivier (2009), this is a *technical goal* since it requires the implementation of a system (the lessons). Prototype construction was the research strategy used to achieve this goal.

Both the prototype construction and the evaluation of the UX of DHH learners were informed by a thorough literature review as presented in the previous three chapters.

Figure 5.1 provides an overview of the ways in which the primary and secondary research strategies relate to one another. This diagram indicates that:

- Three of the four phases of a user experience design (UXD) process were applied in the secondary strategy (the prototype construction):
    - **User research phase:** Literature reviews were conducted on the learning challenges, strengths and needs of DHH learners, UX design, and the use of technology in DHH teaching.
        - The needs and strengths of DHH learners were used to identify mitigation strategies to apply when developing teaching media (Chapter 2).
        - User experience (UX) guidelines were identified that can be applied to improve usability and accessibility (section 3.5.4).
        - Existing technology solutions for DHH people were used to determine practical guidelines to apply when developing teaching media (Chapter 4).
    - **Design phase:** The information gleaned from the literature reviews was synthesised to create practical guidelines for the teaching of basic programming principles to DHH learners (Chapter 6).
    - **Build prototype phase:** The guidelines were applied to create a high-fidelity, fully functional prototype of lessons. The lessons consisted of two vocabulary lessons – which learners mainly used on their own before the programming lesson was presented, and one programming lesson – presented by an educator. The purpose of the vocabulary lessons was to provide the learners with the specific vocabulary required for the programming lesson.
- In the primary strategy (the case study), a UX evaluation procedure was applied, as well as the *evaluation* phase of the UXD process.
    - As part of the UX evaluation procedure, literature reviews were used to identify:

        - The elements that play a role in the UX of the users of the lessons, and that were measured in this research project (sections 3.4.2; 3.4.3 and 3.4.4).
        - Relevant questions to ask when evaluating the UX of the users of the lessons (section 3.6.2).
        - Relevant evaluation methods to apply (section 3.6.3).
        - Which evaluation instruments would be suitable (section 3.6.4).
    - **Evaluate phase:** The data collection instruments were created, after which they were used to collect data, and then the data was analysed.
- Finally, this dissertation was created.

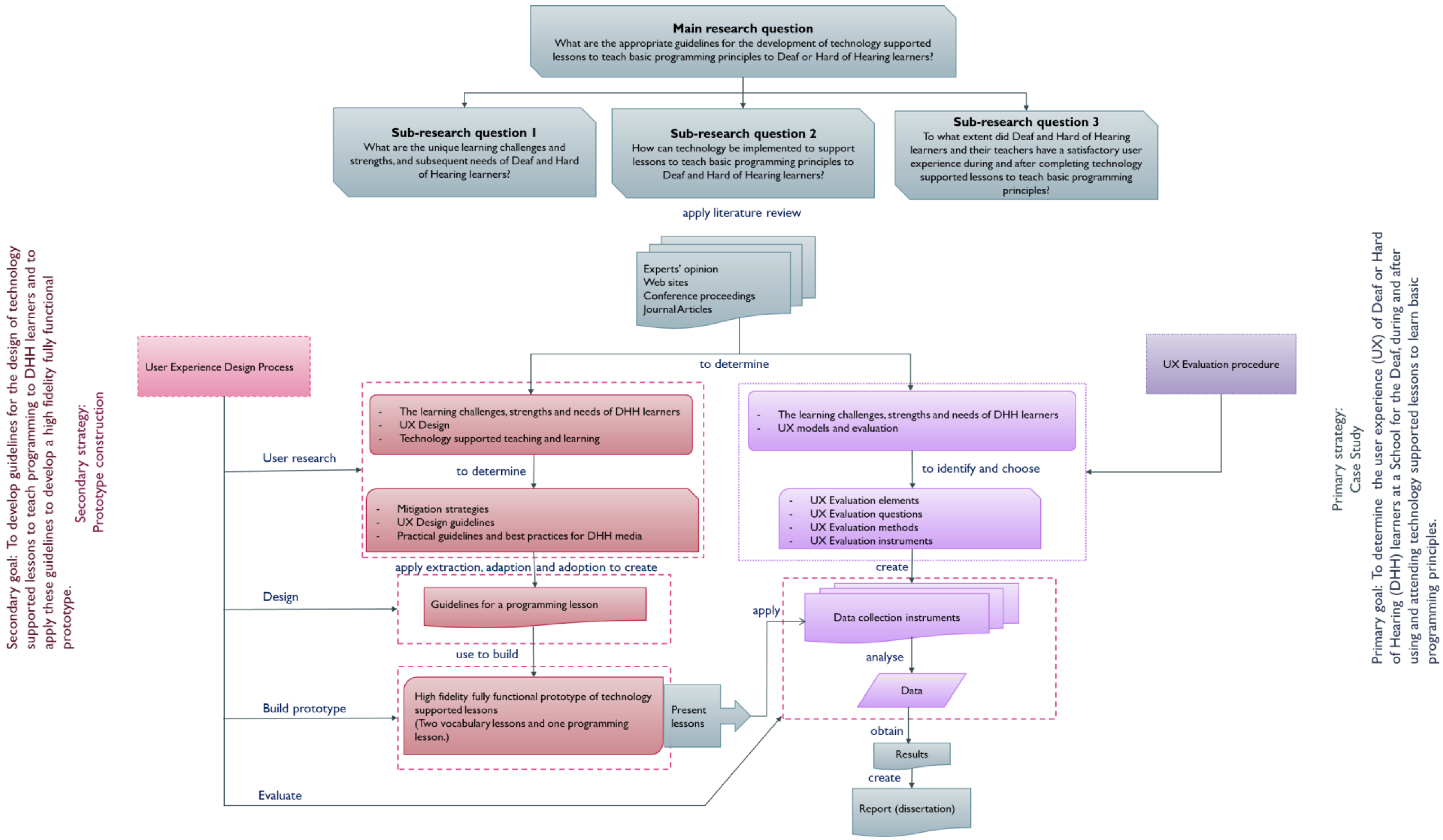


Figure 5.1: Overview of the project design

5.3 Research process

The research process is usually regarded as a number of stages that need to be followed in order to conduct and complete a research project. Saunders et al. (2003) suggest that the research process can be represented in the metaphor of an onion that consists of a number of layers – each layer represents a stage in the research process, and the layers have to be 'peeled away'; in other words, one stage needs to be completed before continuing to the next layer. As indicated in Chapter 1, section 1.5, Figure 5.2 illustrates the research process in the metaphor of an onion. This diagram has been adapted from the original sources (Saunders et al., 2003) and (Saunders et al., 2009) to include the strategies used in this research project.

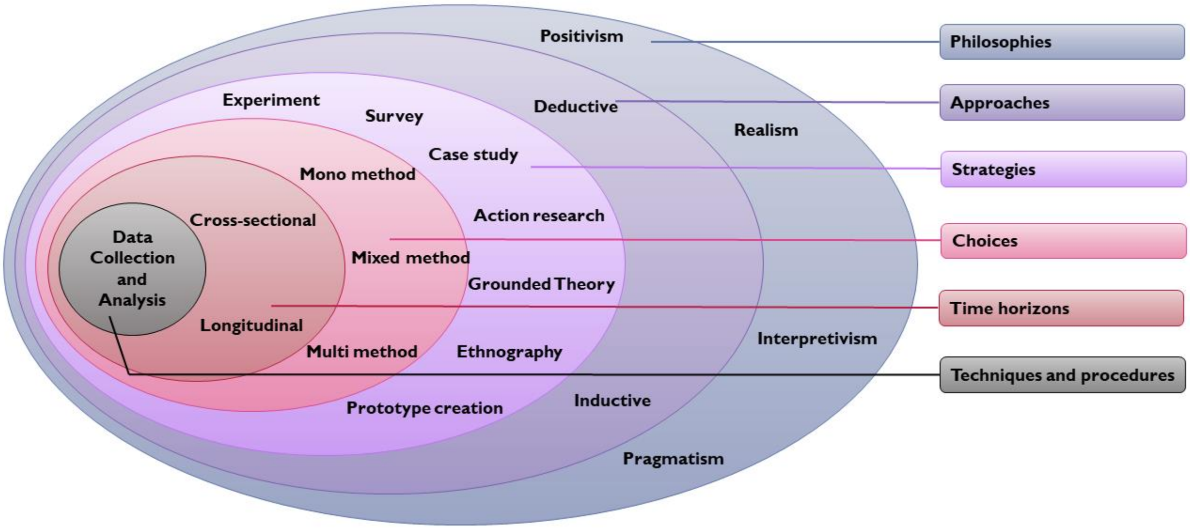


Figure 5.2: The research onion model
(Adapted from Saunders et al. 2003) and (Saunders et al. 2009)

The research philosophy and approaches used in this research project are discussed first. The next three layers – the research strategies, research choices and time horizons – can be regarded as focussing on the research design. The research design is the general plan to be followed in order to answer the research questions. It presents clear objectives, specifies data collection sources, indicates constraints of the project, and discusses ethical issues (McMillan & Schumacher, 2006; Saunders et al., 2009). The research design can also be viewed as "a plan that logically links the research questions with the evidence to be collected and analysed in a case study, ultimately circumscribing the types of findings that can emerge" (Yin, 2014, p. 240).

5.3.1 Research philosophy

The worldview of the researcher is reflected by important assumptions that are included in the adoption of the research philosophy. The research strategy and the choices made, and methods used, are underpinned by these assumptions (Saunders et al., 2009).

The research philosophy that a researcher chooses is influenced by:

- "Practical considerations, as well as
- The researcher's particular view of the relationship between knowledge and the process by which it is developed" (Saunders et al., 2009, p.108).

The research philosophy adopted for this research project is Interpretivism.

> Interpretivist positions are founded on the theoretical belief that reality is socially constructed and fluid. Thus, what we know is always negotiated within cultures, social settings, and relationship with other people. From this perspective, validity or truth cannot be grounded in an objective reality. What is taken to be valid or true is negotiated and there can be multiple, valid claims to knowledge. (Cohen & Crabtree, 2006, "View of Criteria for 'Good' Research", par. 4).

Interpretivism can further be described by exploring its ontological assumptions, aim, epistemology, the data collection techniques most often used, and the role of the researcher. A summary of the interpretivist research philosophy is provided in Table 5.1.

Table 5.1: Description of interpretivism.

Researcher's adaption from Saunders et al. (2009, p. 119); White (2005)

Aspect	Description
Ontological assumptions (the researcher's view of the nature of reality and human behaviour)	'The only reality is one constructed by the individuals involved in the research situation. Multiple realities exist in any situation, namely that of: • The researcher; • Those individuals being investigated; and • The reader or audience interpreting the study. Behaviour is intentional and creative, and it can be explained but not predicted' (White, 2005, p. 81).
Aim	• Seeks to understand reality by discovering the meaning that people in a specific setting attach to it.

	• Seeks to understand phenomena. • 'Starts with individuals and set out to understand their interpretation of the world around them' (Cohen et al., 2011; Manion, & Morrison, 2011, p. 18).
Epistemology (The researcher's view regarding what constitutes acceptable knowledge – the nature and grounds of knowledge, especially with reference to its limits and validity).	• Subjective meanings and social phenomena are acceptable. • The researcher interacts and collaborates with those he or she is studying. • Focus is on the details of the situation.
Data collection techniques most often used.	• Small samples. • In-depth investigations. • Qualitative.
Researcher's role.	'Report the realities of different individuals faithfully, and rely on voices and interpretations as obtained from participants' (White, 2005, p. 81).

According to Cohen et al. (2011), a crucial aspect of the interpretivist philosophy is that the researcher has to be empathetic towards the research subjects, has to have a concern for the individual, and understand their world from their points of view. The main undertaking of the interpretive philosophy is "to understand the subjective world of human experience" (Cohen et al., 2011, p. 17).

This research project, with the key focus on DHH learners, especially since their learning needs and challenges are taken into account, fits into the interpretivist philosophy.

5.3.2 Research approaches

Saunders et al. (2009) differentiate between two different research approaches – deductive and inductive. They define these as follows:

"Deductive approach: Research approach involving the testing of a theoretical proposition by the employment of a research strategy specifically designed for the purpose of its testing" (Saunders et al., 2009, p. 590).

"Inductive approach: Research approach involving the development of a theory as a result of the observation of empirical data" (Saunders et al., 2009, p. 593).

Easterby-Smith et al. (2008), as quoted in Saunders et al. (2009) argue that there are three reasons why it is important to make a choice about the research approach (Easterby-Smith, Thorpe):

1. It enables one to make a more informed decision about your research design.
2. It helps one to think about one's research strategies and choices – which ones will work, and which ones will not work.
3. It enables one to adapt one's research design to cater for constraints such as limited access to data, or a lack of prior knowledge of the subject – for example, one may not be able to formulate a hypothesis because one lacks sufficient understanding of the topic.

The following aspects of an inductive approach apply to the present research project:

- The researcher wanted to gain an understanding of the meanings humans (the DHH learners) attach to events (the vocabulary and programming lessons).
- The researcher had to develop a close understanding of the research context (the unique learning challenges and strengths, and subsequent needs of DHH learners).
- Qualitative data was collected.
- The researcher was part of the research process.
- The research project was not predicated on the need to generalise.

5.3.3 Research strategies

As indicated in the overview of the project design (Figure 5.1), two research strategies are used in this research project. The secondary strategy is the construction of a prototype (two vocabulary, and one programming lesson). The primary strategy is a case study where the UX of the DHH learners and educators were measured with regard to the vocabulary and programming lessons. A description of each of these two strategies follows below.

5.3.3.1 Prototype construction

"In Information Technology the term *prototype* refers to a simplified program or system that serves as a guide or example for the complete program or system" (Olivier, 2009, p. 51). Different levels of detail and functionality can be built into a prototype – this is referred to as the *design fidelity* of the prototype. According to (Pacheco, 2014; usability.gov, n.d.), design fidelity can range from:

- Low fidelity consists of paper drawings, sticky notes and sketches – these are mostly used for brainstorming and collaboration.

- Mid fidelity – also called wireframes which are digitally structured, semi-functional excluding design aesthetics or graphics, allowing click-through of a few pieces of content.
- High-fidelity prototypes which almost or fully represent the final product.

In this research, one programming lesson was developed, as well as two vocabulary lessons that contained the vocabulary required for the programming lesson. The lessons were developed based on the guidelines constructed after the literature reviews have been completed. All the lessons are entirely functional, and can therefore be regarded as a fully functional, high-fidelity prototype.

Even though three PowerPoint presentations were developed, these are considered as part of one lesson because all three slide shows (lessons) needed to be completed as part of the research project. Based on the success of this prototype, other lessons can be developed according to the guidelines to complete a syllabus to teach basic programming principles. In a real-life system (the school), lessons to teach programming will include summative assessment, but this prototype only includes the content (new knowledge and skills), and formative assessment.

One of the roles of a prototype suggested by Olivier (2009) is to act as a proof of concept – to demonstrate that the concept 'works', and is a concrete way to conclude a project. To determine the success of the guidelines used to construct the prototype, the following steps were followed:

- Learners from the school for the Deaf received the vocabulary lessons well in advance of presenting the programming lesson. They had the opportunity to review the lessons in their South African Sign Language (SASL) classes. They also received the lessons on a flash disk, and were able to review these at home if they had access to their own computers.
- They completed a questionnaire to determine their User Experience (UX) of the vocabulary lessons.
- The programming lesson was presented by an educator, in SASL, to a group of eleven learners. During the lesson, the researcher made informal observations regarding the behaviour of the learners while they interacted with the programming lesson. After completion of the lesson, the learners completed another questionnaire to determine their UX of the programming lesson. A semi-structured interview was also conducted with both the educators who were involved in creating and presenting the lesson.

5.3.3.2 *Case study*

One of the goals of a case study is to learn from the current situation in real life – studying some phenomenon in the situation where it occurs (Olivier, 2009). It requires a systematic, in-depth investigation of a case such as a programme, an event, an activity, or a set of individuals in a certain context. The purpose is to provide rich insights into particular situations, events, organisations, classrooms or even a person, and to generate knowledge (McMillan & Schumacher, 2006; Rule & John, 2011).

Conducting case study research would be the preferred method when (Yin, 2014, p. 2):

1. The main research questions are 'how' or 'why' questions.
2. A researcher has no or little control over behavioural events; and
3. The focus of the study is a contemporary (as opposed to entirely historical) phenomenon.

According to Rule and John (2011), the term 'case study' can be used in different senses in qualitative research, and for each sense a different question is answered. The different senses and relevant questions are:

- As the *unit* of the study – What is studied by the case study?
- As a *process* of conducting an investigation – How is the case study conducted?
- As a *product* – What does the case study produce?
- As an example of a *genre* (type of text) – What are the features of case study as text?

With reference to these different senses, this research project can be contextualised as summarized in Table 5.2:

Table 5.2: Contextualisation of a case study.
Researcher's interpretation

Sense in which the term 'case study' is used in qualitative research	Context in this research
The unit of study	The case to be studied in this research project is a case of an environment – a school for the Deaf, within the context of teaching basic programming principles to DHH learners using technology-supported lessons.
The process	This research is designed and conducted as a *descriptive case study*. According to Rule and John (2011), descriptive case studies 'present a complete description of a phenomenon within its context' (Rule & John, 2011, p. 8).

	For this project, the extent of the User Experience (UX) of the DHH learners and educators involved in the project is described (Chapter 7).
The product	A master's dissertation containing guidelines to develop technology-supported lessons to teach basic programming principles to DHH learners. A set of lessons created using PowerPoint to teach DHH learners the required vocabulary needed in the programming lesson. A programming lesson created using PowerPoint that can be used by an educator to teach basic programming principles to DHH learners. A conference paper or journal article.
The genre	The thesis genre.

In section 5.6, more detail is provided on the steps that were followed to design the case study.

5.3.4 Choices

The research choice refers to the way in which quantitative and qualitative techniques and procedures are combined. There are two main categories (Saunders et al., 2009):

Mono method: Using a single data collection technique and corresponding analysis procedure, for example a single quantitative data collection technique such as questionnaires, and then using a quantitative data analysis procedure.

Multiple methods (these include multi-methods and mixed-methods): Using more than one data collection technique and analysis procedure to answer the research questions.

Saunders et al. (2009) further specify a category for combining data collection techniques and analysis procedures called a *mixed-model research*, which is a sub-category of the *mixed-methods approach.* Here, quantitative and qualitative data collection techniques and analysis procedures are combined.

In the present research project, qualitative data is reported using descriptive statistics (quantitative analysis), as well as a number of narratives (qualitative analysis).

5.3.5 Time horizons

The research onion process indicates two time horizons:

Cross-sectional: This refers to the study of a "particular phenomena at a particular time" (Saunders et al., 2009, p. 155).

Longitudinal: People or events are observed over a time, with the purpose of detecting if any change has occurred over time (Saunders et al., 2009).

According to Saunders et al. (2009), cross-sectional studies may use qualitative methods, for example a case study where interviews are conducted over a short period of time. In this research project, there was a time lapse between presenting and evaluating the vocabulary lessons, and presenting and evaluating the programming lesson. However, the purpose was to study the UX of the learners for each phenomenon (lesson), therefore it qualifies as a cross-sectional study.

5.3.6 Data collection methods

Collecting data involves:

- Sources of data: People, actions, documents or artefacts are sources of data.
- Methods of data collection: The way data is collected from the source, for example, interviews, observation, questionnaires, focus groups, or storytelling.
- Instruments of data collection: The instruments used to gather data, for example interview schedules, tape recorders, and observation checklists.
- Organising data: The way the collected data is arranged, for example electronic and paper filing, card systems, or a case archive.

The research questions of the research project serves as a primary guide as to what data is needed and how to go about selecting such data (Rule & John, 2011).

The specific data collection methods used in this research project are discussed in greater detail in section 5.6.6. The various methods used are discussed here in general terms.

5.3.6.1 Literature reviews

"Literature review is the discovery and retrieval of relevant literature from available sources, whenter published conventionally, or available in the electronic media, and using the contents for your required purpose" (White, 2005, p. 63).

A review of the literature related to the research problem has a number of functions, namely to (McMillan & Schumacher, 2006):

- Define and limit the problem and shape the researcher's frame of reference;
- Avoid unintentional and unnecessary replication;
- Select promising methods and measures;
- Relate the findings to previous knowledge; and
- Suggest further research.

5.3.6.2 Questionnaires

A questionnaire is a data collection technique where each participant is required to answer the same set of questions in a specific order, and is a valid technique for a case study. This method work best with standardised questions (the same questions for all the participants), which must be interpreted in the same way by all respondents, and it follows that there are not many open-ended questions. A questionnaire can contain statements or questions. The exact questions or statements need to be defined before data collection starts, and issues cannot be explored while the questionnaire is completed (McMillan & Schumacher, 2006; Saunders et al., 2003).

There are many ways in which questions and statements can be worded, and in which responses can be captured. A number of formats that were implemented in the questionnaire for this research project are discussed in Table 5.3:

Table 5.3: Questionnaire formats

Summarised from (McMillan & Schumacher, 2006) and (Saunders et al., 2003).

Type of question	Description
Open	Participants write any response they want. These are useful in questionnaires when: • The researcher is unsure of the possible responses. • Where a detailed answer is needed. • The researcher wants to find out what the respondents' attitude and thoughts are.
Closed Form or List questions or Checklist items	Participants choose options from a list of predetermined responses, and any of the responses can be selected. These items are best for obtaining demographic information and data which easily fits into a category. In some cases, a category 'other' may be added to ensure that the researcher obtains a more comprehensive list of responses.
Category	Only one response can be chosen from a given set of categories. This is particularly useful when the researcher wants to collect data about attributes or behaviour.
Ranking	The respondent is asked to place items in order, for example write the number 1 to 5 next to each of five possible options. In this way, the researcher can determine what the relative importance of each option is to the respondent. It is suggested that there should not be more than eight items to rank.

5.3.6.3 Interviews

One way to differentiate between different types of interviews is by referring to the level of formality and structure. In this way, interviews can be regarded as structured, semi-structured or unstructured. These are compared in Table 5.4 that follows.

Table 5.4: Interview formats.

Summarised by the researcher from Rule & John (2011) and Saunders et al. (2003)

Format	Level of formality	Structure
Structured	• Formal – little social interaction; however, researcher may provide more detail if required. • Questions should be read in the same tone of voice to prevent any bias.	• Use questionnaires based on a predetermined and standardised (identical) set of questions. • The researcher reads out each question, then records the response, and usually selects the answer from a set of pre-coded answers on a standardised schedule.
Semi-structured	• Less formal since a dialogue or a discussion between the researcher and the interviewee can arise.	• The researcher may have a list of themes and questions to be covered and to initiate the discussion. • Order of questions may vary with different interviewees, and some questions may even be left out. • Additional questions may be required. • Data is recorded by note-taking or recording the conversation.
Unstructured	• Informal. • Used to explore a general area in depth. Also called an in-depth interview.	• No pre-determined list of questions to work through. • The researcher should have a clear idea about the aspects to be explored. • The interviewee talks freely about events, behaviour and beliefs in relation to the topic area.

"Semi-structured and unstructured interviews are used in qualitative research in order to conduct discussions not only to reveal and understand the 'what' and the 'how', but also to place more emphasis on exploring the 'why'" (Saunders et al., 2003, p. 248).

Different types of questions can be used in a semi-structured or unstructured interview as summarised in Table 5.5:

Table 5.5: Types of questions.

Summarised by the researcher from (Saunders et al., 2003)

Type	Description
Open questions	The design of the open question should encourage the interviewee to "provide an extensive and developmental answer" (Saunders et al., 2003, p. 262). The interviewee will have the opportunity to define and describe a situation or event, thereby revealing their attitude or delivering facts.
Probing questions	These questions are used to explore significant responses. Even though they may be worded like an open question, they request a particular focus. They may be used to seek an explanation where the researcher does not understand the meaning of the interviewee's answer, or where there is a lack of reasoning in the answer provided. Probing questions can be identified when: • The questions is introduced with a phrase such as "That's interesting . . .", or "Tell me more about . . . "(Saunders et al., 2003, p. 262). • A statement is reflected by paraphrasing the interviewee's words to encourage exploration.
Specific and closed questions	A closed question is similar to those used in questionnaires. It can be designed to obtain a specific piece of data, or to confirm a fact or opinion, for example, when a yes or no answer is expected.

5.3.6.4 Observations

In qualitative observations, the researcher can take notes of the behaviour and activities of the participants. The role of the researcher can be known to the participants, the researcher can act as a participant-observer, and the researcher can gather information through making field notes as it occurs. The researcher can either make notes in an unstructured way, or prepare a semi-structured schedule with questions or possible behaviour that the researcher hopes to observe. The notes can be organised in any classificatory system, as long as it can be used by an outside party (Creswell, 2009; Yin, 2014).

In this research project, the researcher acted as a participant-observer in an ethnographic setting. The learners doing the programming lesson were aware of the researcher, and the researcher even provided support when learners experienced difficulties with the Scratch interface that the educators who were present could not assist with.

5.4 Research process for this study

The research process for this research project is based on the notion described by Saunders et al. (2003) and Saunders et al. (2009), namely that data collection methods have a number of underlying issues which should be addressed first – similar to the layers of an onion which must be removed to get to the core. The 'research onion' was illustrated in Figure 5.2.

The research questions and objectives inform the choice of strategy, data collection techniques and analysis procedures, as well as the time horizon. Therefore, the problem statement, research questions and objectives are presented in sections 5.4.1 – 5.4.3.

5.4.1 Problem statement

There is a lack of understanding of the unique learning challenges and strengths, and subsequent needs of Deaf or Hard of Hearing learners. This leads to a lack of guidelines for the development of technology-supported lessons to teach basic programming principles to Deaf or Hard of Hearing learners.

5.4.2 Research questions

Main research question

What are the appropriate guidelines for the development of technology-supported lessons to teach basic programming principles to Deaf and Hard of Hearing learners?

Sub-research questions

1. What are the unique learning challenges and strengths, and subsequent needs of Deaf and Hard of Hearing learners?
2. How can technology be implemented to support lessons to teach basic programming principles to Deaf and Hard of Hearing learners?
3. To what extent did Deaf and Hard of Hearing learners and their educators have a satisfactory user experience during and after completing technology-supported lessons to teach basic programming principles?

5.4.3 Research objectives

Main research objective

The primary aim of this research project is to determine whether guidelines which have been designed to develop technology-supported lessons to teach basic programming principles to Deaf and Hard of Hearing learners are appropriate.

Sub-research objectives

1. To identify the unique learning challenges and strengths, and subsequent needs of Deaf and Hard of Hearing learners.
2. To create guidelines for the design of technology-supported programming lessons for Deaf and Hard of Hearing learners.
3. To evaluate the user experience of the learners and educators after completing the lessons.

5.4.4 Overview of research process for this research project

The following diagram illustrates the various layers of the 'onion' for this research project.

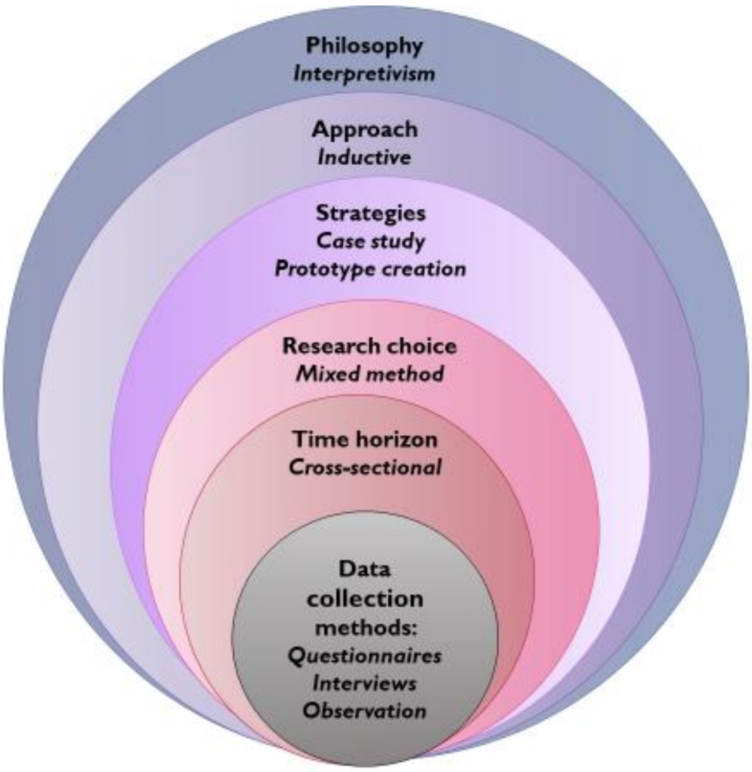


Figure 5.3: Research onion for this research project.
Adapted from Saunders et al. (2003) and Saunders et al. (2009)

The research philosophy adopted for this research project is interpretivism. The main undertaking of the interpretivist philosophy is "to understand the subjective world of human experience" (Cohen et al., 2011). This research project, with a key focus on DHH learners, taking their learning needs and challenges into account, fits into the interpretivist philosophy.

The research approach is inductive, since the project meets the following requirements as stated in Saunders et al. (2009):

Characteristic of the project are to:

- Gain an understanding of the meanings that humans attach to events (the UX of DHH learners);
- Develop a close understanding of the research context (the learning needs and challenges of DHH learners);
- Make use of qualitative data;
- Realise that the researcher is part of the research process; and
- Be less concerned with the need to generalise.

Two research strategies were implemented:

- A secondary strategy – prototype construction – which resulted in the creation of a high-fidelity, fully functional prototype – the vocabulary lessons and one programming lesson which are all supported by technology.
- A primary study – a descriptive case study – during which the UX of DHH learners were evaluated during and after they completed technology-supported lessons. Descriptive case studies "seek to develop a rich, thick description if a phenomenon" (Rule & John, 2011, p. 29). The purpose is to describe the case in its real-world context (Yin, 2014). The case studied in this research project was a case of an environment – a school for the deaf, within the context of teaching basic programming principles to DHH learners using technology-supported lessons.

A mixed model approach was chosen for data collection and data analysis procedures. Qualitative data is reported using descriptive statistics (quantitative analysis), as well as a number of narratives (qualitative analysis).

The time horizon was cross-sectional – since it "produces a 'snapshot' of a population at a particular point in time" (Cohen et al., 2011, p. 267).

The data collection methods that were used were questionnaires (for the learners), semi-structured interviews with the educators who were involved in the research project, and participant-observation (done by the researcher during the programming lesson).

In this section, the process that was followed to turn the research questions into a research project was described. In the next two sections, the two strategies (prototype construction, and case study) used in the project design are discussed.

5.5 Development of a prototype

As illustrated in Figure 5.1, user research was conducted by means of literature reviews on the unique learning needs of DHH learners, current technology-supported learning material for DHH learners, as well as UX requirements relating to DHH learners. These resulted in:

- Mitigation strategies to apply when developing teaching media for DHH learners (Chapter 2).
- User experience (UX) guidelines that can be applied to improve usability and accessibility of teaching media (section 3.5.4), and
- Practical guidelines to apply when developing teaching media (Chapter 4).

As part of the *design* phases of the UXD process, through a synthesis of the literature (extraction, adaption and adoption), the contextually relevant guidelines were developed. These guidelines are presented in Chapter 6. The guidelines were then applied to develop a high fidelity, fully functional prototype of a lesson.

The prototype consists of two vocabulary lessons – that learners mainly used on their own before the programming lesson was presented, and one programming lesson – presented by an educator using SASL. The purpose of presenting the vocabulary lessons was to provide the learners with the specific vocabulary required for the programming lesson. Both the vocabulary as well as the programming lessons were co-created with the Computer Applications Technology (CAT) and South African Sign Language (SASL) educators. The structure and layout of all the lessons are discussed in detail in Chapter 6.

5.5.1 The vocabulary lessons

Each vocabulary lesson was designed to 'tell a story'. Each story is based on a scenario the learners were already familiar with. One story contains sentences regarding a camping trip, and the other regarding a concert story. Each sentence in the story contained one new word of which the learners had to learn the word (as text), the meaning as well as the South African Sign Language (SASL) sign. These new words were either needed as background in explaining programming concepts, or were words which appear in the interface of the Scratch developing environment. Each word was presented in a number of formats:

- In an English sentence.
- In an Afrikaans sentence (the language in which the learners read and write).
- As a picture or animation.
- As a single SASL sign.
- In a SASL sentence (which was a translation of the Afrikaans sentence).

The SASL educator reviewed drafts of the vocabulary lesson, and provided input on the best practices applied at the school for the Deaf, for example:

- How to identify redundant words in sentences.
- How to structure sentences using bullets.
- How to use colour to emphasize verbs and nouns.
- Which pictures or animations are familiar to learners and could be incorporated in the lessons.

5.5.2 The programming lesson

The programming lesson guided the learners to create programs in the programming language Scratch 2.0. There were multiple reasons for choosing Scratch:

- Scratch is a user-friendly application that has specifically been designed to introduce programming to those with no previous experience (Maloney, Resnick, Rusk, Silverman, & Eastmond, 2010).
- The user interface of Scratch uses colourful blocks which are snapped together. The literature review regarding the learning needs of DHH learners (Chapter 2) indicated that they have to rely more on visual images in their learning – therefore the way colour is used in Scratch should support their learning.
- The Scratch programming language emphasises simplicity (Maloney et al., 2010).

Before the programming lesson was presented to the learners, three educators received training from the researcher using the same programming lesson which were to be presented to the DHH learners. Therefore, the educators were able to provide support to the learners when they experienced difficulties during the programming lesson. A few weeks later, one of the educators who is highly skilled in South African Sign Language (SASL), presented the programming lesson to the researcher and two other educators. This ensured that the educator was familiar with the content of the lesson, and used correct SASL signs.

The programming lesson was presented to the relevant learners during the second term of the year.

5.6 The case study description

The primary aim of this research project is to determine whether guidelines which have been designed to develop technology-supported lessons to teach basic programming principles to Deaf and Hard of Hearing learners are appropriate. This was done by evaluating the UX of the learners and educators who were involved in the research project.

5.6.1 Purpose of the case study

The primary goal of this research project was to determine the user experience (UX) of Deaf or Hard of Hearing (DHH) learners as well as certain educators at a school for the Deaf, during and after using and attending technology-supported lessons to learn basic programming principles. A case study was used as research strategy to achieve this goal. The UX evaluation elements that were evaluated were identified in sections 3.4.2; 3.4.3 and 3.4.4, and will be highlighted again in section 5.6.3.

5.6.2 Selection of case

Yin (2014) states that *case study research* would be a preferred method when: "(1) the main research questions are 'how' or 'why' questions; (2) a researcher has little or no control over behavioural events; and (3) the focus of study is a contemporary (as opposed to entirely historical) phenomenon" (Yin, 2014, p. 2). The focus of this research was a programming lesson which was presented (contemporary), and the user experience of participants which were evaluated (no control over behavioural events).

This research is a *single case* study. According to Yin (2014), a rationale for using a single case study is because it is a *common* case. "Here, the objective is to capture the circumstances and conditions of an everyday situation – again because of the lessons it might provide about the social processes related to some theoretical interest" (Yin, 2014, p. 52). The case of the school for the Deaf is studied in the context of the user experience of a technology-supported programming lesson.

The research is also a *holistic case study*. It only sets out to provide outcomes (the user experience) about one unit of analysis (the programming lessons at the school for the Deaf).

5.6.3 UX Evaluation

Figure 5.1 illustrates how a UX evaluation procedure formed the first part of the case study strategy for this research project. Through literature reviews on the unique learning needs of DHH learners, as well as user evaluation, the following were determined:

- The elements that play a role in the UX of the users of the lessons, and that were measured in this research project (sections 3.4.2; 3.4.3 and 3.4.4).
- Relevant questions to ask when evaluating the UX of the users of the lessons (section 3.6.2).
- Relevant evaluation methods to apply (section 3.6.3).
- Which evaluation instruments would be suitable (section 3.6.4).

As discussed and motivated in sections 3.4, the following four UX elements were identified against which the UX of participants were evaluated:

Usability, accessibility, emotional user reaction, and hedonic aspects (pleasure).

Table 3.10 in section 3.6.2 contains the type of questions which can be asked to provide evidence for each UX element.

Data collection instruments were developed including questions to address the various UX elements (where relevant). These include:

- A questionnaire for each lesson (vocabulary and programming) that evaluated the UX of the learners.
- A set of semi-structured interview guidelines that gleaned information from the educators who were involved in the design and presentation of the lessons were used.

The learners' questionnaires were completed with the support of the three amanuenses[4], and were presented to them in Afrikaans, which is the language which all learners who participated in the project use to read and write. However, the questionnaires presented in this dissertation are in English.

During the programming lesson, the researcher made informal observations regarding the behaviour of the learners while they interacted with the programming lesson.

The data from the questionnaires, semi-structured interviews and notes form the informal observations were then combined and analysed. The results are presented in Chapter 7.

5.6.4 Sampling

The following sub-sections provide information regarding sampling techniques and sampling size.

5.6.4.1 Sampling techniques

Sampling is the action of selecting a number of participants to take part in the research project. The participants are selected from the sampling frame or survey population (a concrete list of the elements in the population), and collectively this group is referred to as the *sample* (McMillan & Schumacher, 2006; White, 2005).

[4] An amanuensis is 'a person who writes down your words when you cannot write, for example if you are injured and have an exam' (Oxford University Press, n.d.).

Sampling techniques can be divided into two types:

- Probability or representative sampling; and
- Non-probability or judgemental sampling.

Probability sampling techniques ensure that every element in the sampling frame has an equal chance of being included in the sample. This ensures a random sample, and includes techniques such as simple random, systematic, stratified random, cluster and multi-stage sampling (Saunders et al., 2003).

When using non-probability sampling techniques, participants do not have an equal chance to be included in the sample, and these techniques are mostly used when conducting qualitative research, and when it is unfeasible to select participants from a larger group Participants are chosen based on their accessibility or the types of characteristics they may represent. Examples of these techniques are convenience (available), purposeful (purposive, judgement or judgemental), quota, snowball and self-selection (Saunders et al., 2003; White, 2005).

The sampling technique that was used in this research project is *convenience sampling*. In this technique, participants are selected because they are accessible or expedient (suitable in a given circumstance).

> A case study researcher is not interested in representiveness of the sample but in its ability to generate data which allows for a full, in-depth and trustworthy account of the case. People are therefore selected because of their relevant knowledge, interest and experience in relation to the case (Rule & John, 2011, p. 64).

For this research project, it was decided to include only learners who are computer literate as subjects so that the programming lesson could be designed to focus on programming principles and did not need to include information on computer literacy (such as how to click with the mouse and actions such as drag-and-drop or scrolling). The educator who presented the programming lesson has background knowledge of programming and is highly skilled in the use of SASL.

5.6.4.2 Sampling size

According to Six and Macefield (2016), it is acceptable to have between five and ten participants interviewed to obtain trustworthy results on the learners' UX.

> In summary, research suggests that from three to twenty participants can provide valid results, and a good baseline is between five and ten participants. In general,

> there should be more participants for more complex, highly critical projects; while fewer participants are necessary when testing more novel designs. (Six & Macefield, 2016).

The sample for this research project included eleven learners and two educators.

5.6.5 Participants' profile

As explained in section 5.6.4, participants were identified through convenience sampling. The majority of the learners had CAT as a subject, and all of them made use of SASL to communicate with educators and peers in class. Learners ranged from Grade 10 till Grade 12. More biographical data were collected about each participant. This was done with a view to determine the level of diversity of the group. The biographical aspects that were taken into account are the following:

- Grade
- Age
- Gender
- Does the participant have a cochlear implant?
- The various communication mode(s) each participant uses at school and at home.
  - Is the participant able to speak a language? If yes – which one.
  - Does the participant have a level of hearing using devices, and if so, which language(s) are understood?
  - Does the participant use SASL, finger-spelling or any other mode of communication?

5.6.6 Data collection for the case study

For the data collection of the case study of this research project, sub-research question 3 was the primary guide:

> *To what extent did Deaf or Hard of Hearing learners and their educators have a satisfactory user experience during and after completing technology-supported lessons to teach basic programming principles?*

Case study researchers often use a variety of data collection methods and tend to use multiple methods in a single study (Rule & John, 2011). The data collection for the case study is summarised in Table 5.6.

Table 5.6: Description of data collection for the case study.
Researcher's summary.

Aspect of data collection	Description
Sources of data	The DHH learners who attended the programming lesson. The CAT and SASL educators who were involved in presenting the vocabulary as well as the programming lessons. Articles (journal and conference proceedings), official documents, official web sites.
Methods of data collection	Two *questionnaires* were completed by the DHH learners: One for the vocabulary lessons, and another for the programming lesson. *Observations* were made by the researcher while the programming lesson was conducted. *Semi-structured interviews* were conducted with the CAT and the SASL educators.
Instruments of data collection	For the learners' questionnaire, hard copies of the questionnaires were filled in by an amanuensis. For the observations, the researcher made notes using a semi-structured observation schedule while the programming lesson was conducted. For the semi-structured interview with the educators, a digital voice recorder was used, as well as notes completed by the researcher while the interview was conducted.
Organising data	The hard copies of the learners' questionnaires were filed. The answers of the questionnaires were digitally captured, printed and filed.

The following is of interest regarding the completion of the learners' questionnaires:

As explained in the literature review chapter regarding the unique learning needs and challenges of DHH learners, these learners experience difficulties in reading and writing. Therefore, the following strategy was followed to complete the two questionnaires:

- Three staff members who are able to act as an amanuensis all attended the programming lesson presented by the researcher before the lesson was presented to the learners. During this lesson, the vocabulary lessons were also demonstrated to them, and they received the questionnaires for both the vocabulary and the programming lessons.

- Each amanuensis received the name(s) of learners who they needed to assist to complete the vocabulary questionnaire. They arranged a convenient date and time with the learner(s) to complete the questionnaire. The questions on the questionnaire were presented to the learners in SASL. The learners' responses were then captured on printed questionnaires by the amanuensis.
- The programming lesson's questionnaire was completed directly after the lesson itself, and the same procedure was followed as with the vocabulary questionnaire.

This strategy ensured that each learner understood the question, and that they had the opportunity to ask for the question to be re-phrased if they were unsure of what was expected of them. The amanuenses could also ensure that a valid response was supplied by the learners, and that they could write down responses to open-ended questions.

5.6.7 Data analysis

White (2005) describes qualitative data analysis as being mainly an inductive process. It involves a systematic process of selecting, categorising, comparing, synthesising and interpreting. Cohen et al. (2011) also mention that patterns, themes, categories and regularities should be noted (Cohen et al., 2011).

Cohen et al. (2011) emphasise that qualitative data analysis should abide to the principle of *fitness for purpose*, and that the researcher should be clear what he or she wants the data analysis to do, since this will determine the kind of analysis which will be undertaken (Cohen et al., 2011). In this research project, the purpose of the data analysis was to apply a *theme analysis* to measure and to report on the participants' UX, based on the four UX aspects that were evaluated.

Each instrument's data was organised and analysed in conjunction with other approaches such as presenting the data by theme (the UX aspects), and by constructing a narrative in the form of a thematic analysis.

Table 5.7 describes the data analysis approach for each data collection instrument.

Table 5.7: Data analysis approach for each data collection instrument

Instrument	Approach
Questionnaires completed by the learners.	Biographical data was captured for each participant. Descriptive statistics was used to provide a profile of the participants.
Questionnaires completed by the learners.	The questionnaires were treated separately (one questionnaire for the vocabulary lesson, and one for the programming lesson). Each participant's response was entered. Each question was analysed, and the relevant UX elements that were addressed by the responses were indicated (theme analysis and tabulating data). A summary containing descriptive statistics was provided for each UX aspect.
Semi-structured interview with educators.	The interview was conducted with each educator separately. As indicated by Cohen et al. (2011), it is acceptable to write the analysis of the data directly from an audio recording of an interview. The important details may be selected directly from the original source, rather than spending time to capture every detail of the interview (Cohen et al., 2011). Therefore, a narrative was created from the answers the educators provided, in the form of a thematic analysis.
Researcher's field notes of participant observation.	The researcher made note while observing the programming lesson, noting activities and behaviour which related to various UX aspects. These notes were then used to create a narrative, in the form of a thematic analysis.

5.6.8 Ethical considerations

Research conducted in academic institutions have to comply with sets of ethical requirements. These requirements govern and guide the practices of researchers. If the research is conducted in an ethically sound manner, it enhances the quality of research and contributes to its trustworthiness (Rule & John, 2011).

Research studies should be designed to protect participants, and the cornerstone of this protections is informed consent – "the notion that research participants should be provided with the information needed to make a meaningful decision as to whether or not they will participate" (Lazar, Feng, & Harry, 2010, p. 376).

In this study, ethical approval had to be obtained from two institutions:

1. The Nelson Mandela University: Ethical clearance was obtained from the Research Ethics Committee (Human) (Document 1 in the electronic appendix).
2. The Gauteng Department of Education (GDE): A Research Approval Letter was obtained from the GDE (Document 4 in the electronic appendix).

Since most of the participants were minors under the age of eighteen, and also in light of the requirements from the GDE, various documents were submitted for ethical clearance, and distributed to relevant parties. Documents relating to ethical clearance are available in the electronic appendix as Documents 1 – 7.

5.7 Triangulation

The term triangulation can refer to the use of (White, 2005, p. 89):

- "More than one source of data to support a researcher's conclusions,
- More than one theory to support the researcher's argument
- More than one investigator to collect the data to make findings more reliable."

In this research study, more than one source of data was used – these multiple sources provided substantiating evidence in a process referred to as data triangulation (Lazar et al., 2010). The sources included literature reviews, a questionnaire, semi-structured interviews and observations.

5.8 Conclusion

Two research strategies (prototype construction as secondary research strategy and a case study as primary research strategy) were implemented in this project design, where the prototype construction supported the case study.

This research project had two goals. The secondary goal was to develop guidelines for the design of technology-supported lessons to teach programming to DHH learners, and to apply these guidelines to develop a high-fidelity, fully functional prototype – a set of technology-supported lessons.

The primary goal of this research project was to determine the user experience (UX) of the participants during and after using and attending technology-supported lessons to learn basic programming principles. The participants included eleven DHH learners at a school for the Deaf, as well as two educators who were involved in creating and presenting the lessons. The learners were selected through convenience sampling, where the majority of learners had CAT as a subject and were very computer literate.

An interpretivist philosophy and a deductive approach influenced the way the research questions were answered in this research project.

The research questions influenced the research strategies used, the choice of the sources from which data was collected, and the time horizon.

A user experience design (UXD) process was applied to perform user research, design guidelines to create lessons for DHH leaners, and build a high-fidelity, fully functional prototype – two vocabulary, and one programming lesson. A prototype construction research strategy was followed to create the prototype.

A UX evaluation procedure was applied to gather information to create data collection instruments. These instruments were used as part of the fourth stage of the UXD process to evaluate the UX of the participants. A case study research strategy was followed to create the data collection instruments and analyse the data. This was a single, descriptive, holistic case study.

Four UX elements were evaluated – they were: Usability, accessibility, emotional user reaction, and hedonic aspects (pleasure).

Data was collected from the learners who completed the vocabulary lessons and attended the programming lesson using two questionnaires. Semi-structured interviews were conducted with the educators who participated in the development and presentation of the lessons. The researcher made observations during the presentation of the programming lesson. Data triangulation was applied through using these multiple data sources.

Each instrument's data was organised and analysed, in conjunction with other approaches such as presenting the data by theme (the UX aspects), and constructing a narrative in the form of a thematic analysis.

Ethical requirements of both the Nelson Mandela University and the Gauteng Department of Education were adhered to. As mentioned previously, documents relating to ethical clearance are available as Documents 1 – 7 in the electronic appendix.

5.9 Summary

This chapter provided an overview of the project design that was implemented in order to realise the objective of the project. This overview was visually illustrated in Figure 5.1, and the chapter provided detail on the interaction between the two research strategies that were used, the contribution of the literature reviews, as well as the user experience design and user evaluation procedures that were applied.

The research process consists of a number of phases which need to be followed. Each of the phases were described in this chapter, and detail on the application of each stage in this research project were provided. These phases included the philosophies, approaches, strategies, research choices, time horizons as well as techniques and procedures for data collection and analysis.

A detailed discussion of the prototype development was provided, and the case was presented. Finally, it was indicated how triangulation was applied in this research project.

In the next chapter, the guidelines that were used to develop the prototype are presented, with an indication of the user experience element(s) and learning challenge(s) which may be addressed by each guideline, as well as a description of the way the guideline was implemented in creating the prototype for this research project. The structure of each lesson is also illustrated and discussed.

Chapter 6

Guidelines and technology-supported lessons

Introduction

- Chapter 1: Introduction

Literature study

- Chapter 2: Unique learning challenges, strengths and needs of Deaf or Hard of Hearing individuals
- Chapter 3: User experience design and evaluation
- Chapter 4: Technology-supported teaching and learning

Research Design

- Chapter 5: Research process

Guidelines

- Chapter 6: Guidelines and technology-supported lessons

Results and analysis

- Chapter 7: Results and analysis

Conclusion

- Chapter 8: Conclusion and recommendations for future research

Chapter 6

6.1 Introduction

In the previous chapter, the research process was explained. It was noted that, as part of the user experience design (UXD) process, a high-fidelity, fully functional prototype was created. The prototype consists of two vocabulary lessons and one programming lesson. The vocabulary lessons are two Microsoft PowerPoint presentations that were used to teach the Deaf and Hard of Hearing (DHH) learners the words they had to know before attending the programming lesson. These were either words appearing in the interface of Scratch, or words needed in the explanation of programming principles and Scratch context. The learners had to learn the spelling of each word in written text, the South African Sign Language (SASL) sign for it, and the meaning of the word. The vocabulary lessons were provided on flash disks so that they could view the lessons at home. The lessons were also used in some of the regular SASL classes, and were installed on all computers to which learners had access.

The programming lesson was a Microsoft PowerPoint presentation that was used in a classroom where each learner had access to a laptop with Scratch 2.0 installed. An interactive whiteboard was installed in the front of the classroom and was linked to the educator's PC. The programming lesson was presented by an educator who is fluent in SASL, who has a programming background, and who was trained by the researcher to present the lesson. The PowerPoint slides served two purposes:

1. To serve as a guide for the educator to present the content in a logical way without leaving out important information.
2. To use multimedia techniques (colour, pictures, animation) to:
    - Explain programming concepts; and
    - Display the tasks to be completed to learners to assist them with remembering the order of the steps.

The purpose of this chapter is to present the guidelines that were used to create the technology-supported lessons to teach DHH learners the basic programming principles, as well as those lessons. The basic structure of the vocabulary and the programming lessons will be presented first. The way in which UX elements were incorporated in the design of the lessons will also be explained. Subsequently, each guideline will be presented in one of four design categories. These design categories are:

- Interface and navigation (section 6.5.1).
- Communication and support (section 6.5.2).
- The educator's role and attitude (section 6.5.3).
- The lesson structure (section 6.5.4).

For each guideline, the following will be presented:

- The guideline itself.
- How the guideline was implemented in this project (with screen shots of the actual lesson, where relevant).
- The learning challenge(s) that might be addressed by implementing the guideline.
- Reference to the researcher(s) who support this guideline.
- The UX metric(s) that will evaluate the effect of this guideline.

The basic layout and structure of each of the two lessons will now be discussed in more detail.

6.2 Basic layout and structure of lessons

The two sets of lessons which have been developed based on the guidelines – the vocabulary lessons and the programming lesson – will now be presented in more detail.

6.2.1 Vocabulary lessons

The vocabulary lessons were two Microsoft PowerPoint presentations, and were used to teach the DHH learners all the words they had to know before attending the programming lesson. These were either words appearing in the interface of Scratch, or words used in the explanation of programming principles and Scratch context. The words to be included in the vocabulary lessons were identified with the help of both the SASL and Computer Applications Technology (CAT) educators. Subsequently two 'stories' were developed based on themes the learners at the particular school were familiar with, namely a *camping trip* and a *concert*. The stories consist of short sentences in which only one word is unfamiliar.

Best practice guidelines were obtained from various sources, as presented in Chapters 2 and 4, emphasising the importance of including a multitude of communication formats when teaching new vocabulary. The researchers who support this notion include (Al-Osaimi, AlFedaghi, & Alsumait, 2009; Bueno et al., 2007; Hart, & Ahmed, 2013; Nikolaraizi, & Vekiri, 2012), to mention just a few. Therefore, the lessons provided learners with the opportunity to review each sentence in the story in both English and Afrikaans (the Language of Literacy of the learners), a video clip of the sentence in SASL containing the sign for the new word, a video clip of the SASL sign for the new word alone, a picture or animation representing the new word, and the new word in fingerspelling. In reviewing each sentence, learners were able to choose to look at the various representations in any order, and as many times as they wanted to. They could also review the sentences in the order of the storyline, or could navigate to any other sentence.

The learners and the educators who presented and interpreted the lesson had adequate time to learn and practise the new words and signs. This fulfilled the requirement that the educator should be a skilled communicator (Easterbrooks, & Stephenson, 2006).

The vocabulary lessons consist of three files. (All three files are available as Documents 15 - 17 on the electronic appendix submitted with this dissertation.)

1. An introduction, which is a video clip (in mp4 format), explains to learners how to use the vocabulary lessons. The explanation is signed in South African Sign Language (SASL).
3. A camping story (an MS PowerPoint presentation).
4. A concert and TV story (an MS PowerPoint presentation).

The video clip contains the following message:

> *You are going to learn to write a computer program later. Before you can do this, you have to learn new words. Some of the words are English, others are Afrikaans. To help you to learn the words, you are going to watch stories. Each story consists of a few sentences, and each sentence has one new word which you should learn. You can look at different things in each sentence. There are an Afrikaans sentence, an English sentence, the new word's sign, the whole sentence in sign language, and the picture. You can look at it again if you want to. The Afrikaans words in all the written sentences are not italicised, and the English words are written in italics. You can choose which one you want to look at first; the camping story, or the concert and TV story.*

As explained to the learners, each story consists of a number of sentences, and each sentence contains the new word. The learner is expected to learn how to read the word, how to recognise the SASL sign, and how to understand the meaning of the word.

The layout of each of the two stories is illustrated in Figure 6.1.

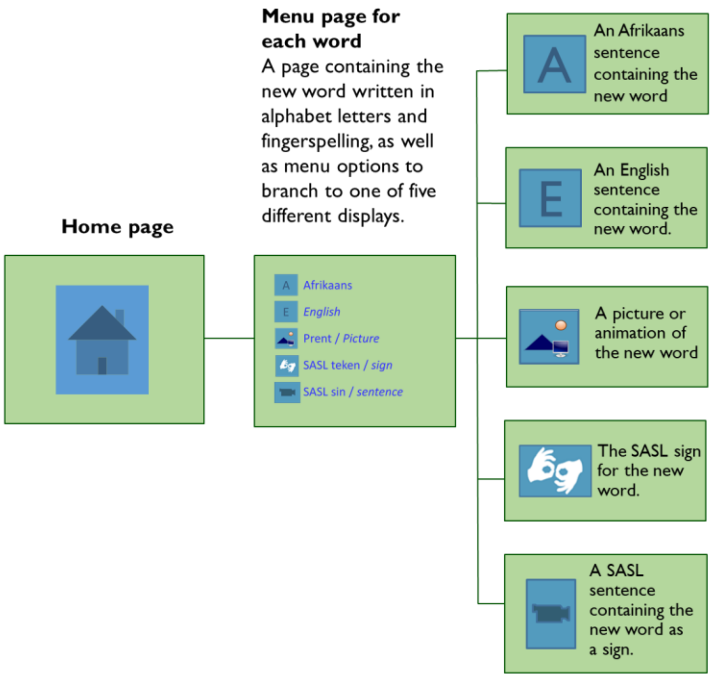


Figure 6.1: Illustration of the layout of the vocabulary lessons

The camping story will be used to present the layout of the home page, menu pages and options for each word.

The layout of the home page for the camping story is displayed in Figure 6.2.

Figure 6.2: Layout of the home page of the camping story

- The two 'Home' icons indicate that it is the home page.
- The learners can either click on the icon next to the label 'Story starts' to start reading the sentences in sequence, or they can click on an individual word to navigate to the menu page for that word. This option can be used once a learner has mastered most of the vocabulary and might just want to revisit a few words without having to work through all the preceding words.

The menu page for the word 'event' is displayed in Figure 6.3.

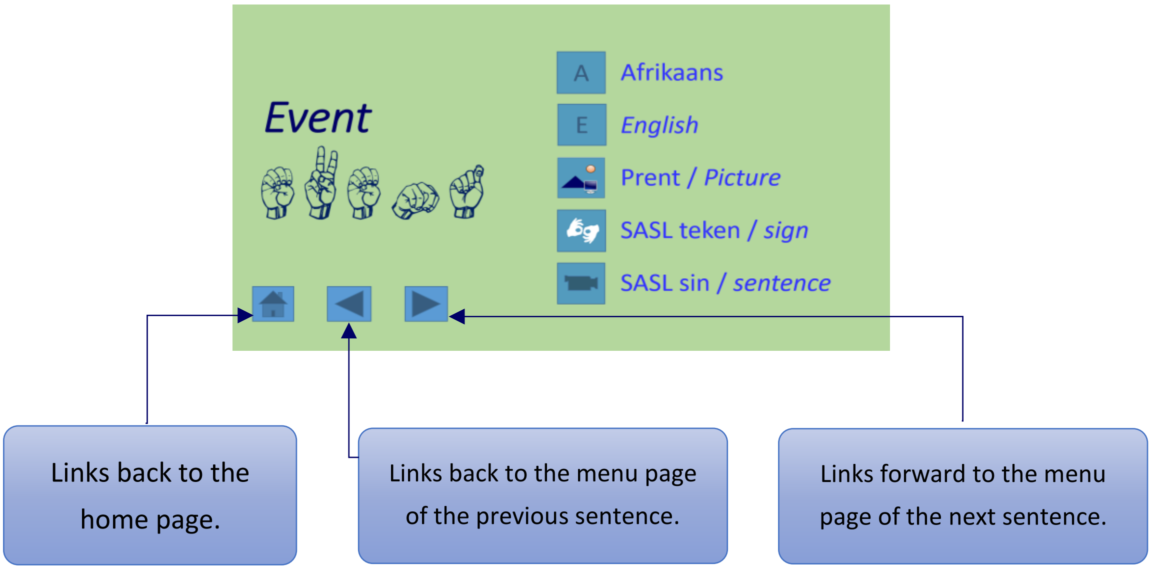


Figure 6.3: Layout of the menu page for the word 'event' in the camping story

When a learner clicks on the English button, the slide in Figure 6.4 will appear. The slide contains a sentence in English that forms part of the camping story.

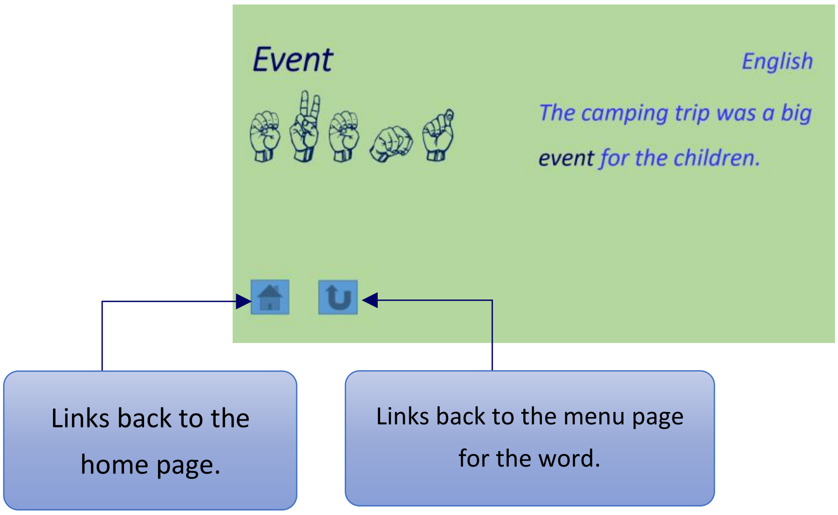


Figure 6.4: Layout of the English slide for a word

The other four slides have a similar layout, and can be viewed in Documents 15 and 16 on the electronic data source submitted with this dissertation.

The two stories were created using the following sentences (only the English sentences are provided, and the word leaners are supposed to learn is underlined – if it is an Afrikaans word they should learn, the word is not printed in italics, and it appears in brackets after the corresponding English word):

The camping story

1. *A group* (groep) of *children went camping.*
2. *The camping trip was a big event for the children.*
3. *The bus drives over a bump* (bult) *in the road.*
4. *The bus drives through a ditch* (duik) *in the road.*
5. *The motion of the bus makes some people sick.*
6. *At the camp*
    - *The children played.*
    - *The educator struggled to control us.*
7. *We saw many animals.*
8. *Some animals stay under water.*
9. *We saw a crab move.*

The concert and TV story

1. *Our school's sign choir acted in concerts with different, well-known actors* (akteurs).
2. *For the children the concert was a big event.*
3. *Everybody sang and danced on the stage.*
4. - *The stage has a backdrop.*
    - *The backdrop of this stage is blue.*
5. *Everybody in the concert wears a beautiful costume.*
6. *An actor's looks are very important.*
7. *An actor sometimes switches his clothes during the concert.*
8. *When an actor sings well,*
    - *People ask him to repeat the song.*
9. *An actor must first read a script to know what to do.*
10. *The script says:*
    - *'Move 10 steps.'*
    - *Then the actor should walk 10 steps on the stage.*
11. *The actor reads the script.*
    - *It says: 'Wait 2 seconds'.*
    - *The actor waits 2 seconds.*
    - *Then he walks again.*

6.2.2 The programming lesson

The educator who presented the lesson was not familiar with the programming language Scratch when the project started. The MS PowerPoint slide show for the programming lesson therefore served two purposes:

1. To be a guide for the educator to present the content in a logical way, and not leave out important information.
2. To use multimedia techniques (colour, pictures, animation) to
   - Explain programming concepts and to
   - Display the tasks to be completed to the learners, to assist them with remembering the sequence of the steps.

The PowerPoint slides were projected on an interactive whiteboard in front of the class. Each learner had access to his or her own laptop with Scratch 2.0 installed. The PowerPoint slides included all the relevant screen shots and animation to guide learners to write a program, so it was not necessary for the educator to switch between the slide show and the actual Scratch program. Two other educators as well as the researcher were also present to assist learners, should they not be able to perform the required actions as indicated on the slides.

The decision to let an educator present the programming lesson instead of it being a full e-learning lesson is supported by researchers such as Easterbrooks & Stephenson (2006), who encourage the use of technology as visual support to information being presented in the classroom, provided that it supports the educator's skilled explanation and discussion of the subject being taught. They do not encourage e-learning to be used as a primary source of instruction (Easterbrooks & Stephenson, 2006). Golos (2010) also supports the notion that learners engage better with learning material when an educator is involved (Golos, 2010).

The programming lesson was designed to include the same phases for each new concept or skill that was introduced:

- Words that would be important in the explanation of the next concept or skill were displayed on a blue slide.
- The new concept or skill was introduced on a grey slide, with the icon displaying 'Do what?'
- The steps to be followed were displayed on a grey slide using animation, while displaying the icon 'Do how?'
- The steps to be followed were displayed on a green slide and numbered, displaying the icon 'Do who?' Learners were then expected to follow the instructions on the slide.

Figure 6.5 contains examples of slides for each of the four phases.

Figure 6.5: Examples of slides from the programming lesson

Questions were asked frequently during the lesson to ensure that learners were still on track. Figure 6.6 displays examples of slides from the programming lesson containing questions.

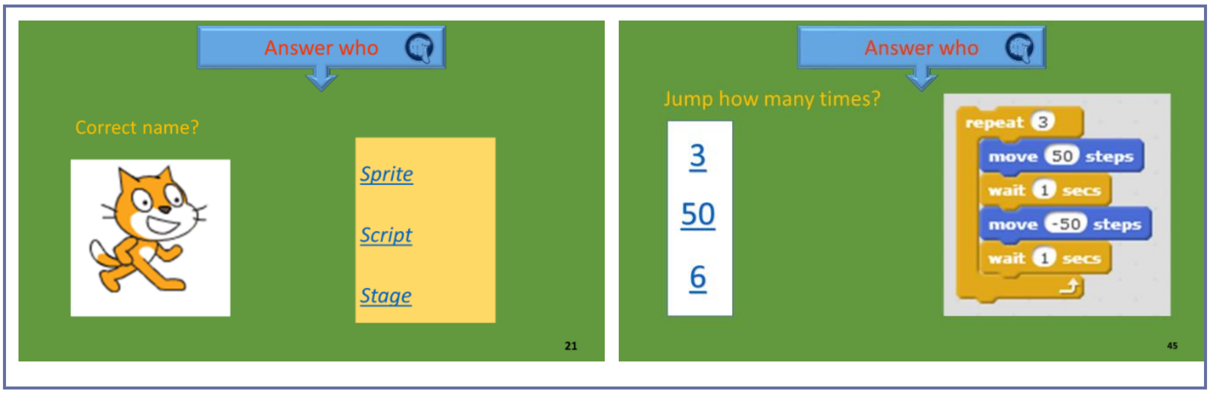


Figure 6.6: Slides from the programming lesson containing questions

An explanation of how UX elements were incorporated in the design of the vocabulary and programming lessons will be provided in the next section. Subsequently the complete set of guidelines used to design the lessons will be presented.

6.2.3 Supporting documents

The following documents were created and provided to learners during the programming lesson:

- Laminated colour-printed pages containing the scripts and indications of the backdrops and sprites that should be used for three Scratch programs. Learners could choose which of the programs to write. This can be viewed as Document 19 in the electronic appendix that forms part of this dissertation.
- A set of notes that contain visual representations of the basic skills learners need to create the programs provided. The information and layout of the notes are similar to those on the slides during the lesson. This is part of compliance to Guideline 7 which is explained in Table 6.3. The notes can be viewed as Document 20 in the electronic appendix that forms part of this dissertation.

6.3 Design recommendations made by subject experts

Even though one of the guidelines specifies that new vocabulary should be taught first, before the programming lesson, some of the words could not be used in context in any of the scenarios. Therefore, it was decided to teach these words during the programming lesson, in the context of programming, linking them to something the learners had experienced previously. Table 6.1 contains a summary of these words with explanations about the way they were contextualised in the programming scenario and linked to previous knowledge:

Table 6.1: New words taught during programming lesson

New word(s)	Explanation
Scratch	The name of the programming language Scratch originates from the technique of scratching that is used by disk jockeys to mix sounds on a turntable. This relates to the ease with which programming instructions can be 'remixed' – changed and adapted – and sound, animation and pictures can be 'mixed' in a program (Resnick, 2017,"Origin of the Word", par. 2). The Deaf community will not relate to the reference to the turntable of a disc jockey; therefore it was decided to introduce the SASL sign for the name of the programming language once learners have seen a script for the first time. The SASL sign that was developed mimics the motion of stacking blocks on top of one another.
Set fisheye effect to *A programming instruction that changes the appearance of the sprite to bulge like the eyes of a fish. For example:* 	Learners will recognise the word *effect*, since they have changed text effects in Word. They will also know the word *fisheye*, and since the effect of the instruction can be demonstrated, it was decided to teach the complete instruction in the context of writing the program. 
Clear graphic effects *A programming instruction that will let a sprite return to its normal appearance after it has been changed, for example, after its colour has been changed, or after it has been distorted by using an instruction such as [set fisheye effect to 100]*	This again relates to text effects, which the learners implemented when they learnt how to use Word in the subject CAT. They have also used graphs in Excel, and will therefore recognise the words *graphic* and *effects*. Therefore it was decided to teach this programming instruction when they are writing the program, and when the effect of the instruction can be demonstrated (in context). 
Sprite	The word *sprite* has more than one meaning. It can either be: • "a fairy or an elf, or • a graphic image, usually animated, that a user can interact with and move around (used in Web and multimedia productions)"

New word(s)	Explanation
	(TechTarget, 2005, "sprite", par. 1). Since there is no word in SASL that is relevant and suitable, it was decided to use a combination of signs, which, if directly translated, means 'an art person' – meaning a person created as a drawing. Learners will be introduced to the word *sprite* after they have seen the interface of Scratch and learned the analogy of an actor reading a script and then acting on the stage.

6.4 Incorporation of UX elements during design

The four elements against which UX were evaluated in this research project are usability, accessibility, emotional user reaction and hedonic aspects, as motivated in Chapter 3. The design guidelines presented in section 6.5 indicate which of these four elements may be influenced by each guideline. The evaluation instruments and results will be discussed in Chapter 7.

Of the four UX elements against which the UX of participants was evaluated, three elements have been included in the design of the prototype (the two vocabulary, and one programming lesson). These three elements are *usability*, *accessibility* and *hedonic aspects*.

The user experience design (UXD) process is explained in section 3.5.3, guidelines for accessibility appear in section 3.5.4.1, while guidelines for usability can be found in section 3.5.4.2.

In deciding on the structure and layout of each lesson, the hedonic aspects as a UX element were taken into account. Hedonic aspects comprise three components, as explained in section 3.4.4 and Table 3.4: S*timulation*, *identification* and *evocation*. These components of hedonic aspects were incorporated as follows in the prototype created:

Learners should find the project *stimulating*. Since they had never before programmed, the format of the vocabulary lessons was new to them. Moreover, Scratch offers an exciting interface using colour and a variety of pictures.

Various aspects that took the needs of DHH learners into account were included to promote *identification* with the lessons. These included, amongst others, providing video clips of SASL, providing fingerspelling of words, using colour to emphasise certain concepts, and using icons with text.

Familiar scenarios were used in the lessons in an attempt to provoke memories (*evocation*). These included themes that were familiar to the learners (the camping trip, as well as a concert where the Sign Language choir performed). All the learners who participated in the project had CAT as a subject. Some of the concepts they encountered in Scratch programming (for example, how to clear a graphics effect) were concepts they also encountered in their work with graphics in Word.

All the guidelines used to create the vocabulary and the programming lessons are presented in the next section.

6.5 The guidelines

User experience guidelines, as described in section 3.5.4, as well as best practices suggested in various research projects, as discussed in Chapters 2 and 4, have been combined to create guidelines to create technology-supported lessons for the DHH learners. The guidelines are presented in sections 6.5.1 – 6.5.4. The guidelines are presented in four categories, namely interface and navigation, communication and support, educator's role and attitude, and lesson structure. For each guideline, the following are indicated:

- How the guideline was implemented in this project.
- The learning challenge(s) or strength(s) that would possibly be addressed by the guideline.
- The researcher(s) who support this guideline.
- The UX element that may be addressed in implementing this guideline.

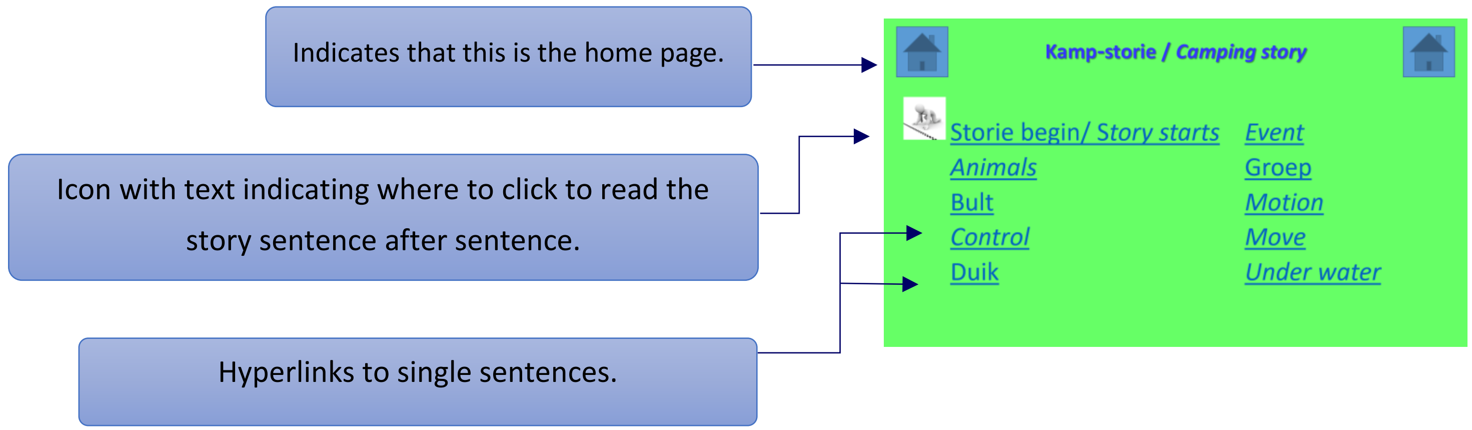
Even though the guidelines are categorised and separate challenges and UX elements are listed, it should be noted that the guidelines, challenges and UX elements are interdependent. They cannot be evaluated in isolation, and each of them contributes to a holistic approach in creating learning material for DH learners. Some of the guidelines would also be beneficial when creating learning material for hearing learners.

6.5.1 Guidelines for interface and navigation

The guidelines in Table 6.2 below focus on the creation of suitable interfaces for learning material for DHH learners, as well as navigation techniques.

Table 6.2: Guidelines for interface and navigation

Guideline 1
Present information and components in ways that enable DHH leaners to recognise them, and to find it possible and desirable to use them, for example: 1.1. Make navigation visible, and controls recognisable and large enough to operate easily. 1.2. Use text and icons. If icons alone are used, explain them to the learners beforehand. 1.3. Be consistent with the layout of the pages.
Implementation in this project
1.1. The vocabulary lesson pages contained only a few control buttons. Large action buttons, which are used in Microsoft PowerPoint and other applications, were used. The action buttons appeared in the same position on each page. 1.2. On the menu page for each word, some icons had text next to them. Other icons (such as the ones linking to the home page, previous or next sentence, and the menu page of a word), did not have descriptive text; however, their use was explained to learners when the lessons were introduced. 1.3. All the pages in the vocabulary lesson had the same layout.
The home page
The home page of each story has icons indicating that it is the home page. It has an icon on which the learner can click to start reading the story. A learner might not want to read the complete story, but might just want to have a look at aspects of certain words. All the new words which the learners should learn appear on the home page as a hyperlink. Most learners should be familiar with hyperlinks, since they often browse the internet.



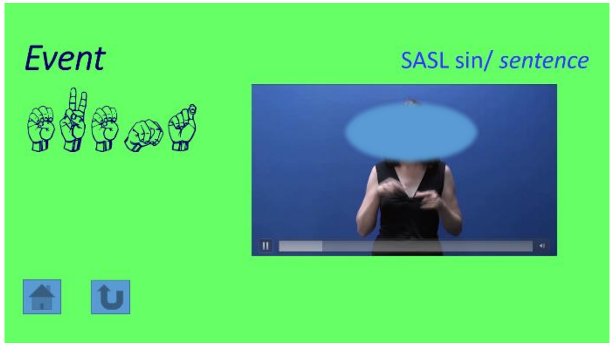
The menu page for each word

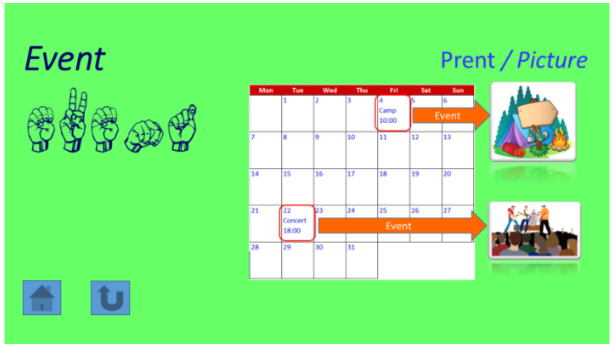
Each sentence in the story has a 'menu' that displays the following:

- The new word of which they are supposed to learn the meaning.
- The fingerspelling of the word (using the RealSASL font).
- Five icons with text on which the learners can click to see the different ways in which the new word is represented.
- A home (Home) action button that will let the learner return to the home page.
- A back (Previous) action button that will navigate to the previous sentence.
- A forward (Next) action button that will navigate to the next sentence.

Information pages

Once the learner has clicked on an icon, for example to see the picture representation of a word, or to see the SASL sign, a page is displayed containing the relevant representation.





- The layout of all pages is the same.
- Each page contains a home action button so that learners can go to the home page from any other page.
- A return action button is provided to navigate back to the menu options for the word.
- The video clip plays in a media player which learners are familiar with since they watch videos on YouTube regularly. They can pause the video or replay it.

Learning challenge(s) or strength(s)	Researcher(s)	UX element
Comprehension skills Knowledge and knowledge organisation Distractibility Use enhanced visuospatial memory	(Fajardo et al., 2006; Korte et al., 2015; Nielsen, 1995; Petrie & Bevan, 2009; Quesenbery, 2014; Tognazzini, 2014; Zheng, 2016)	Usability Accessibility

Guideline 2

The design should be aesthetically pleasing and minimalistic, for example:

2.1. Use readable and understandable text.

2.2. Use clean typography.

2.3. Minimise distracting clutter.

2.4. Use colour contrasts to separate the foreground from the background.

2.5. Use visual and semantic white space. 2.6. Provide enough space between lines of text.
Implementation in this project
The colours for the backgrounds of slides and the font colours were chosen based on the psychological effect of colours, as explained in section 3.5.4.2 and Table 3.9, as well as on conventions already applied by the school. The school has a convention to display nouns in blue, and verbs in red. The Calibri font was used, which is clear and easy to read. The lessons can be viewed on the electronic data supplied with this dissertation to observe how these guidelines were implemented.

Learning challenge(s) or strength(s)	Researcher(s)	UX element
Comprehension skills Knowledge and knowledge organisation Distractibility	(Petrie & Bevan, 2009; Quesenbery, 2014; Tognazzini, 2014; Zheng, 2016)	Usability Accessibility

6.5.2 Guidelines for communication and support

The guidelines in Table 6.3 refer to all the design elements relating to improving communication with DHH learners, and providing them with support. These guidelines focus mainly on increasing accessibility and usability.

Table 6.3: Guidelines for communication and support

Guideline 3
Use big screens, projectors and other visual aids to assist with communication.
Implementation in this project
The following technology was available in the class where the lesson was presented: • Each learner had his/her own laptop with Scratch 2.0 installed.

- The educator's laptop was connected to a data projector fitted in the ceiling of the class. The programming lesson was projected onto a white touch screen in the front of the classroom.
- The use of the Smartboard enabled the educator to click on relevant places on the board without having to walk up and down to her laptop and back to advance the slide show.

Learning challenge(s)or strength(s)	**Researcher(s)**	**UX element**
Comprehension skills Memory problems Distractibility	(Giannakos & Jaccheri, 2014; Skrebneva, 2010)	Accessibility Usability

Guideline 4

When creating video clips, visual distractions that would interfere with the interpreter should be avoided; specifically.

4.1. The background should be monochrome and subtle.

4.2. An interpreter with a dark complexion should be placed in front of a lighter background and wear light-coloured clothes. Fair-skinned interpreters should be placed against a darker background, and wear darker clothes.

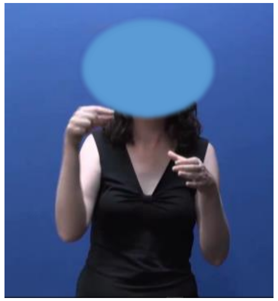
4.3. Gestures should be within a box parameter – not above the head, and not below the waist.

Implementation in this project

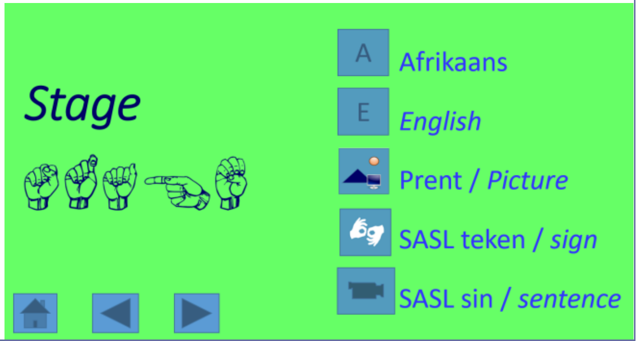
4.1. A so-called 'blue screen' was used as background to film the interpreter.

4.2. The interpreter was fair-skinned, and wore a short-sleeved black dress. Therefore, hand gestures against the body were clearly visible.

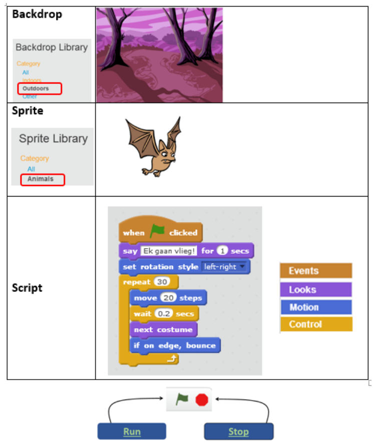
4.3. The educator who presented the programming lesson is a skilled South African Sign Language (SASL) educator who provides training in SASL to other educators, and all gestures fell within the required parameters.



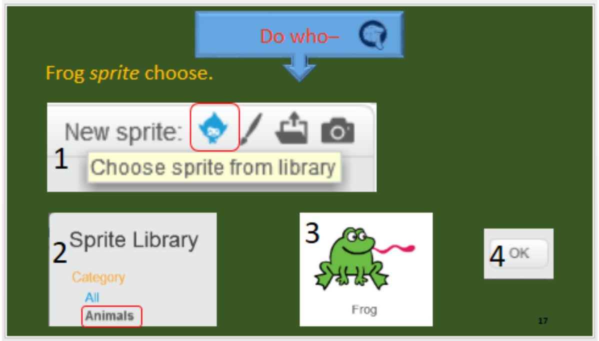
Learning challenge(s) or strength(s)	Researcher(s)	UX element
Distractibility Comprehension skills	(Hart, 2016)	Accessibility Usability
Guideline 5		
When creating video clips involving sign language, use a local person who can sign the language used by the learners who will view the videos.		
Implementation in this project		
The interpreter who appears in all the sign language videos teaches SASL and English at the school. She is a CODA (Child of Deaf Adult) and her first language is SASL. She is therefore a skilled educator and interpreter, who knows the language the learners speak very well, and the learners are also used to her teaching them new vocabulary in both the subjects SASL and English.		
Learning challenge(s) or strength(s)	**Researcher(s)**	**UX element**
Comprehension skills	(Hart & Ahmed, 2013)	Accessibility Usability
Guideline 6		
Include multiple communication elements when explaining a new concept, for example: Text, fingerspelling, picture or animation, a SASL gesture, and a SASL sentence.		

Implementation in this project		
In the vocabulary lessons, each sentence in the story contains one word that may be unfamiliar to the learners. Learners have the opportunity to review this new word in one of five ways: The sentence in Afrikaans, the sentence in English, a picture or animation relating to the new word, the SASL sign for the new word, and the sentence in SASL (which includes the sign and fingerspelling of the new word). 		
Learning challenge(s) or strength(s)	**Researcher(s)**	**UX element**
Comprehension skills Knowledge and knowledge organisation	(Al-Osaimi et al., 2009; Bueno, Fernández del Castillo, et al., 2007; Dowaliby & Lang, 1999; Gentry et al., 2005; Hart & Ahmed, 2013; Khwaldeh et al., 2007; Malzkuhn & Herzig, 2013; Marschark et al., 2011; Nikolaraizi & Vekiri, 2012; Petrantonakis et al., 2008; Straetz et al., 2004)	Accessibility Usability
Guideline 7		
Use visual organisers to review important information or display the order of steps to complete a task. Visual organisers can include animation, pictures or photographs.		

Implementation in this project
Two types of visual organisers used in the programming lesson:



- When a new task in the programming lesson was demonstrated to students, for example, how to add a new sprite to an existing program, screen shots of the relevant icons on which the learners should click were displayed using animation. After the demonstration, the same icons were displayed with numbers to indicate the order in which the tasks should be executed. Learners then had the opportunity to review the slide show and to try to perform the tasks themselves, but they were able to refer back to the displayed information until they performed all the tasks. This slide is an example of the steps to add a new sprite.

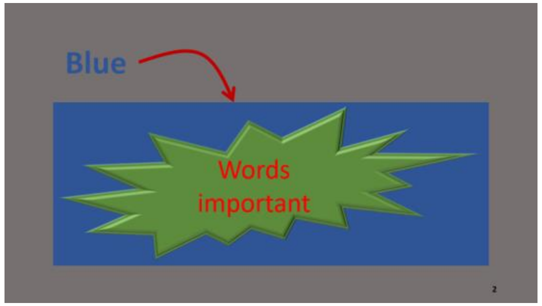
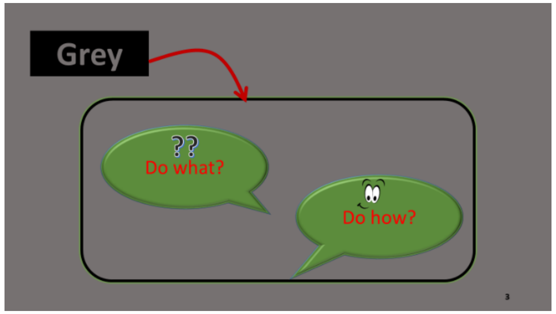
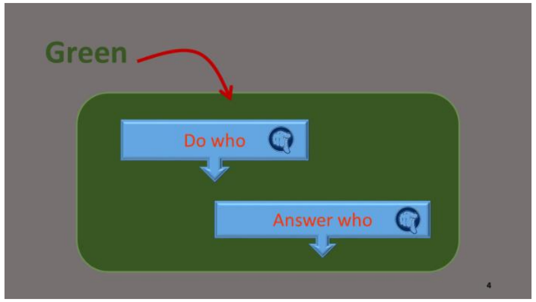


- During the programming lesson, learners were guided to create a short program. Then they were presented with a number of pre-written programs. The information to write each program was supplied on a page and indicated the stage, sprite and script they would need. Learners could choose which program they wanted to write. The instructions were displayed in a colourful way with pictures and diagrams.

Learning challenge(s) or strength(s)	Researcher(s)	UX element
• Knowledge and organising knowledge • Improve comprehension skills • Improve reading skills • Improve visual perceptual skills • Improve memory skills • Improve metacognition	(Easterbrooks & Stephenson, 2006; Lang & Steely, 2003; Luckner, Bowen, & Carter, 2001; Marschark et al., 2011; Nikolaraizi & Vekiri, 2012; Skrebneva, 2010)	Accessibility Usability Hedonic aspects (evocation)

Guideline 8		
Language should be modified and simplified, and it must be easy to read and understand the text and content: Therefore: 8.1. Formulate fairly short sentences with a relatively simple structure. 8.2. Replace high-level carrier language with lower-level alternatives. 8.3. Use language that the learners are familiar with, or provide definitions. 8.4. Replace passive verbs with active verbs. 8.5. Remove superfluous (unnecessary) language. 8.6. Remove ambiguity. 8.7. Format text using bullets, spacing, brackets, and italics.		
Implementation in this project		
See Document 14 in the electronic appendix submitted with this project that contains the sentences that were read to the interpreter, as well as the text as it appears in the vocabulary lessons when the above principles are applied.		
Learning challenge(s) or strength(s)	**Researcher(s)**	**UX element**
Comprehension skills	(Bell, 2014; Lang & Steely, 2003; Mich et al., 2013; Nielsen, 1995; Petrie & Bevan, 2009 ; Quesenbery, 2014; Techaraungrong et al., 2015; Zheng, 2016)	Accessibility Usability

Guideline 9
Use colours, shapes and icons to organise information and educational units.
Implementation in this project
Vocabulary lesson
• All nouns are displayed in blue, and verbs in red. This is according to the standards used at the school. • All English words are displayed in italics, and Afrikaans text is written with no additional formatting. This is also according to the standards used at school. • Red rectangles have been added to each of the SASL sentence video clips around each of the new words the learners should learn.
Programming lesson
Various colours were used, based on the explanation of the psychological effect of colour as explained in section 3.5.4.2 and Table 3.9. To support metacognition, the meaning of some of the colours was explained to learners when the lesson started: • Slides with a blue background were used when learners had to focus on important new words (since blue is used to calm learners when presenting information that may seem overwhelming or complicated). • A blue slide with an icon that resembles the 'default' for new information was displayed before the important words were displayed. • Slides with a light grey background were used when learners had to focus on the information on the slide and on the educator. • Grey slides could also contain one of two different 'icons' (text in a certain shape), to indicate what the purpose of the next few slides would be. The icons could either be 'Do what?' or 'Do how?' • Slides with a green background were used to indicate to learners that they were supposed to interact – either with the program on their laptop, or with the educator. Green was chosen since it is said to bring tranquillity and peacefulness, and it stimulates interaction. • The green slides contained one of two different icons (text in a certain shape) to indicate that learners should either perform an action, or answer a question. • Icons were added to the text in the shapes. These act as a quick reminder of what the learners should do – for example, the eyes indicate they should look at the board – not work at their laptops' screens.

<table>
<tr><td>
</td><td>
</td><td>
</td></tr>
<tr><th>Learning challenge(s) or strength(s)</th><th>Researcher(s)</th><th>UX element</th></tr>
<tr><td>Knowledge and knowledge organisation
Metacognition
Memory
Distractibility</td><td>(Brokop, 2008; Efthimiou et al., 2006); Giannakos & Jaccheri, 2014; Marschark et al., 2011)</td><td>Accessibility
Usability
Hedonic aspects (evocation)</td></tr>
<tr><th colspan="3">Guideline 10</th></tr>
<tr><td colspan="3">Use animated cartoons for positive or negative feedback to learners.</td></tr>
<tr><th colspan="3">Implementation in this project</th></tr>
<tr><td colspan="3">To determine whether learners have any preference regarding the way feedback is provided to them, three different types of feedback were provided during the programming lesson when they had to answer questions.
• A Clipart emoticon showing thumbs up and a happy face for a correct answer, and a clipart emoticon showing thumbs down and a sad face for an incorrect answer.
• An animated cartoon showing thumbs up and a happy face for a correct answer, and an animated cartoon showing thumbs down and a sad face for an incorrect answer.
• A green tick mark (✓) for a correct answer, and a red cross (×) for an incorrect answer.</td></tr>
</table>

Learning challenge(s) or strength(s)	Researcher(s)	UX element
Metacognition Knowledge and knowledge organisation	(Efthimiou et al., 2006)	Accessibility Usability Emotional user reaction

6.5.3 Guidelines for the educator's role and attitude

Table 6.4 contains guidelines for the educator's role and attitude while facilitating the vocabulary lesson and/or presenting the programming lesson.

Table 6.4: Guidelines for the educator's role and attitude

Guideline 11		
If learners are to use electronic learning material on their own, ensure that they are able to navigate the lesson.		
Implementation in this project		
The educators received copies of the vocabulary lessons. They demonstrated the lessons to the learners before the learners received a flash disk containing the lessons to use on their own computers at home. The SASL educator also incorporated the lessons in her own lessons; therefore learners had ample exposure to the way the navigation keys operate.		
Learning challenge(s) or strength(s)	**Researcher(s)**	**UX element**
Metacognition Relational and individual-item orientations	(Bueno, Fernández del Castillo et al., 2007; Tognazzini, 2014)	Accessibility Usability

Guideline 12		
The educator and/or the interpreter should be skilled communicators and must be well-prepared. Therefore: 12.1. Ensure that learners and the educator and/or the interpreter are able to use specialised subject-related vocabulary using either signs or fingerspelling the words. 12.2. Interpreters need to have some subject knowledge – for example, basic knowledge of programming.		
Implementation in this project		
The educator who presented the programming lesson is a skilled qualified SASL interpreter. She has some background knowledge of programming languages, even though she has never taught programming. She was trained by the researcher to use the programming lesson, and presented the lesson to the researcher before presenting it to the learners.		
Learning challenge(s) and strength(s)	**Researcher(s)**	**UX element**
Knowledge and knowledge organisation Metacognition Comprehension skills	(Easterbrooks & Stephenson, 2006; Giannakos & Jaccheri, 2014)	Accessibility Usability

Guideline 13
Ensure that the learners follow the instructions and are able to carry them out in the correct sequence – provide explicit guidance: 13.1. If an interpreter is used, the educator should wait for the interpreter to finish before continuing, and allow sufficient time for learners to read the information (if applicable). 13.2. Maintain eye contact with learners to ensure that they follow the instructions. 13.3. Give instructions slowly, step by step. 13.4. Repeat instructions if some learners did not understand or follow. 13.5. Consider each learner's difficulties and deal with them individually.

Implementation in this project		
• The educator who presented the lesson did so using SASL. No interpreter was needed. • The PowerPoint presentation that was developed for the programming lesson provided support to the educator to give instructions step by step. New instructions were first displayed using animation. Then a slide was displayed containing all the steps, with each step numbered.		
Learning challenge(s) or strength(s)	**Researcher(s)**	**UX element**
Metacognition Improving memory skills Improving comprehension skills	(Giannakos & Jaccheri, 2014; Marschark et al., 2011; Skrebneva, 2010)	Usability Accessibility Hedonic aspects (evocation)

6.5.4 Guidelines for the lesson structure

The guidelines in Table 6.5 focus on the structure and progression of the programming lesson.

Table 6.5: Guidelines for the lesson structure

Guideline 14		
Teach new vocabulary first, before presenting the programming lesson.		
Implementation in this project		
Learners had ample time to review the vocabulary lessons in classes where access to computers was available. Learners also received a copy of the lessons to use on their own computers at home. They were exposed to these lessons for a number of weeks before the programming lesson was presented in the second term.		
Learning challenge(s) or strength(s)	**Researcher(s)**	**UX element**
Improving comprehension skills Relational and individual-item orientations	(Lang & Steely, 2003; Markey et al., 2003; Skrebneva, 2010)	Usability Accessibility Hedonic aspects (evocation)
Guideline 15		

Teach vocabulary related to programming by referring to concepts learners already know, and teach the words in context.		
Implementation in this project		
• The two 'stories' that were used (as explained in section 6.2.1) were based on scenarios with which the learners were familiar. • The words they had to learn were each used in sentences that formed part of one of the scenarios. • Examples of crucial words in Scratch which the learners had to learn are *stage*, *actor* and *script*. One of the first concepts they learn when using Scratch is that the little cartoon (sprite) will follow the commands the programmer chose and perform actions on the white space, similar to an actor who reads a script and then performs on stage.		
Learning challenge(s) or strength(s)	**Researcher(s)**	**UX element**
Knowledge and knowledge organisation.	(Golos, 2010; Kuntze et al., 2014; Techaraungrong et al., 2015)	Accessibility Usability Hedonic aspects (evocation)
Guideline 16		
The material presented to the learners should be linked to what they have experienced and seen before.		
Implementation in this project		
• As mentioned before, the vocabulary lessons that were presented referred to the scenarios of a camping trip, and a concert or TV story with which learners were familiar. • Some of the pictures in the vocabulary lessons were sourced from Scratch, for example, for the word *animals*, the three animals (a crab, fish and frog) were used. Learners saw these animals on their camping trip, and the same three animals were the sprites used in the program the learners wrote during the programming lesson. The picture used for the concept *under water* were also taken from one of the backdrops in Scratch.		

Learning challenge(s) or strength(s)	Researcher(s)	UX element
Knowledge and knowledge organisation Relational and individual-item orientation Metacognition	(Marschark et al., 2011; Skrebneva, 2010; Techaraungrong et al., 2015)	Accessibility Usability Hedonic aspects: evocation

Guideline 17

Engage students cognitively. Therefore:

17.1. Use minds-on activities and apply active learning principles.

17.2. Add questions often during the lesson to ensure that learners are on track.

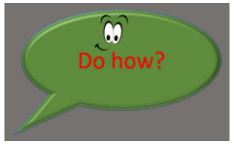
Implementation in this project

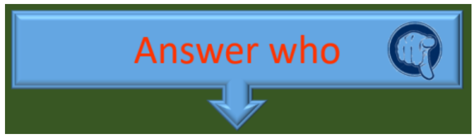
Minds-on activities and active learning

New concepts were always taught using the same approach:

- The new concept was introduced on a grey slide, with the icon displaying 'Do what?'
- The steps to be followed were displayed on a grey slide using animation, while displaying the icon 'Do how?'
- The steps to be followed were displayed on a green slide, numbered, displaying the icon 'Do who?'

Learners had to apply their new knowledge immediately, so they were constantly engaged and active.

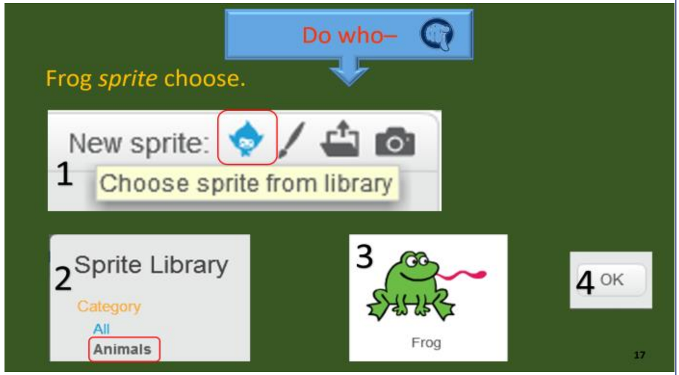


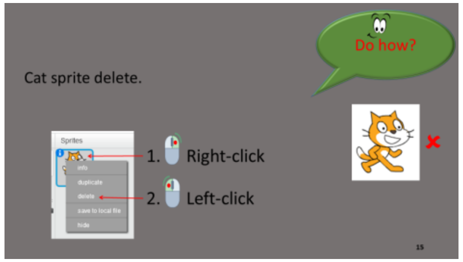


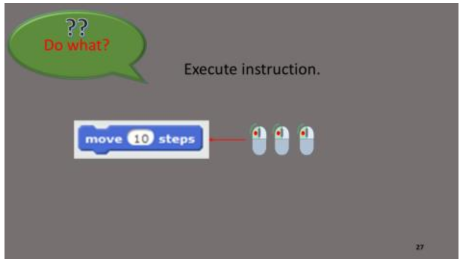
		Questions
Learners frequently had to answer questions. The questions were indicated by displaying an icon, 'Answer who?'. A number of options were provided as answers, and learners had to indicate which answer they chose. When the educator clicked on the answer, an icon was displayed to indicate whether or not the answer was correct. 		
Learning challenge(s) or strength(s)	**Researcher(s)**	**UX element**
Knowledge and knowledge organisation Improving comprehension skills Metacognition	(Dowaliby & Lang, 1999; Drigas et al., 2005; Easterbrooks & Stephenson, 2006; Lang & Steely, 2003; Petrantonakis et al., 2008)	Usability Accessibility Hedonic aspects (evocation)
Guideline 18		
Focus on providing practical information.		

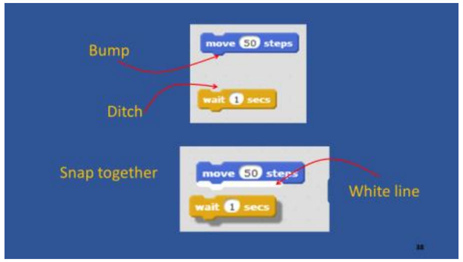
Implementation in this project

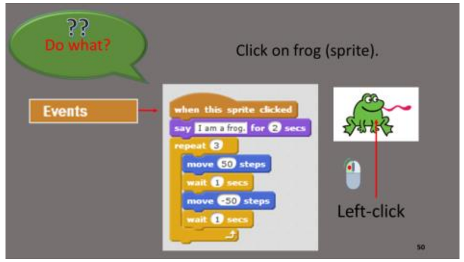
- The steps to be followed for every new activity were displayed using animation.
- The icons to be clicked on were framed in red and/or highlighted using arrows.
- Once the order of the steps was displayed on grey slides, the steps were displayed on a green slide, and numbered, so learners could follow the steps.
- Details were provided about practical matters such as the relevant mouse button to click.











Learning challenge(s)/strength(s)	Researcher(s)	UX element
Metacognition. Relational and individual-item orientations. Knowledge and knowledge organisation	(Giannakos & Jaccheri, 2014)	Accessibility Usability Hedonic aspects (evocation)

In developing the guidelines, the secondary goal of this research project was achieved, which was to develop guidelines for the design of technology-supported lessons to teach programming to DHH learners, and to apply these guidelines to develop a high-fidelity, fully functional prototype – a set of technology-supported lessons. It also concludes the secondary research strategy, which was prototype construction (see sections 5.2; 5.3.3.1 and Figure 5.1).

6.6 Summary

In this chapter, the two vocabulary lessons and one programming lesson were presented, as well as the guidelines used to create them. The chapter started by discussing and illustrating the layout and structure of the vocabulary, and then the programming lessons. Diagrams and screenshots of individual slides were provided to illustrate what the interfaces and certain components such as navigation buttons look like. The sentences that had been used to create the stories for the vocabulary lessons were provided.

It was also explained how usability, accessibility and hedonic aspects were included in the design of the lessons as UX elements.

Each guideline was then presented in one of four design categories: Interface and navigation, Communication and support, The educator's role and attitude, and The lesson structure.

For each guideline, the following were indicated:

- The guideline itself.
- How the guideline was implemented in this project (with screen shots of the actual lesson, where relevant).
- The learning challenge(s) that could possibly be addressed by implementing the guidelines.
- Reference to the researcher(s) who support this guideline.
- The UX metric(s) that will evaluate the effect of this guideline.

The next chapter presents the results of the evaluation of the UX of the participants in this research project.

Chapter 7

Results and analysis

Introduction

- Chapter 1: Introduction

Literature study

- Chapter 2: Unique learning challenges, strengths and needs of Deaf or Hard of Hearing individuals
- Chapter 3: User experience design and evaluation
- Chapter 4: Technology-supported teaching and learning

Research Design

- Chapter 5: Research process

Guidelines

- Chapter 6: Guidelines and technology-supported lessons

Results and analysis

- Chapter 7: Results and analysis

Conclusion

- Chapter 8: Conclusion and recommendations for future research

Chapter 7

7.1 Introduction

The previous chapter provided details on the guidelines that were used to create the high-fidelity, fully functional prototype (two vocabulary lessons and one programming lesson). These guidelines and the prototype were the products of the secondary research strategy (prototype construction), as explained in Chapter 5 and illustrated in Figure 5.1.

The results of the secondary research strategy (case study) form the focal point of this chapter. The vocabulary and programming lessons were used at a school for the Deaf. Three data sources were then utilised to evaluate the user experience (UX) of both the learners and the educators who had been involved in the research project.

The chapter starts by providing background information on the school for the Deaf, highlighting the profile of the learners and the subjects offered by the school. Technical details are then provided about the video clips used in the vocabulary lessons, and the biographical data of the learners are presented in a table.

The UX evaluation methods used in this research project will be discussed to provide motivation for the choice of data-collection instruments. The results obtained for each of the data-collection instruments will then be presented. An analysis of, and the conclusion reached from the responses will be provided for each question in the learners' questionnaires, and in the semi-structured interview with the educators. The conclusion about each response indicates whether or not evidence exists of a positive UX, and of the four EX elements it refers to. The four UX elements evaluated were usability, accessibility, emotional user reaction and hedonic aspects. Colour coding was used to indicate a satisfactory UX (green) or an unsatisfactory UX (red). This provides an instant visual overview of the results.

The researcher's observations during the presentation of the programming lesson were summarised as a narrative highlighting various aspects, such as the classroom setup and atmosphere, the progression of the lesson, and the learners' behaviour.

Themed analysis was then used to combine the results of the three data-collection instruments. The evidence for the four UX elements is provided in section 7.8. Based on the responses from the learners and educators, and the researcher's experience while analysing the data, some recommendations were made with regard to the vocabulary lessons and the questionnaires.

7.2 Background of the school for the Deaf

All information regarding the school for the Deaf where the research project was conducted has been obtained from the school's official website, the parent newsletter of 27 May 2016, the 2015-2016 Annual Report, and personal communication with the principal of the school. The school is situated in Pretoria, in the Gauteng Province of South Africa. The policy of the Gauteng Department of Education (GDE) stipulates that the name of the school may not be mentioned in this dissertation, therefore no references are included, since those would contain the name of the school.

The school provides special education to about 200 learners from three years old up to Grade 12 (usually 17 to 18 years old). Learners are from diverse personal, social and economic backgrounds, and they all have severe hearing loss. Some learners have multiple barriers to learning that include developmental, intellectual, sensory, physical, social and economic disabilities.

The school uses South African Sign Language (SASL) as the language of learning and teaching (LoLT), and English as the language of literacy. SASL is also taught as a subject (Home Language). All educators are either able to use SASL, or they have interpreters who translate lessons into SASL in classes.

The academic curriculum of the GDE is followed up to Grade 12. However, learners who pass Grade 12 receive an Endorsed National Senior Certificate – this is a Matric certificate with five subjects (the National Senior Certificate comprises seven subjects). Learners may choose to complete the last year (Grade 12) of the curriculum over two years. The first year of Grade 12 is then referred to as the 'Bridge Year'. The curriculum includes the subject Computer Applications Technology (CAT), which learners can attend from Grade 10 to Grade 12.

A pre-vocational curriculum is offered to the learners who find it difficult to master the CAPS curriculum. These learners do skills subjects such as metal work, woodwork, hospitality studies, needlework, upholstery, basic computer skills, and craft, arts and skills.

The staff also compile an individualised curriculum for a small group of learners who experience too many barriers to learning to follow the CAPS or the pre-vocational curriculums.

Classes are divided into small groups with an educator/learner ratio of 1:8. A number of educator assistants are available to support learners in class. All of the assistants are able to use SASL, and a number of them are alumni of the school.

During assessment, a number of concessions have been made for learners in Grades 7 to 12. These include:

- An additional 20 minutes per hour to write the examination paper.
- Permission to use a dictionary during examinations.
- Permission to have a SASL interpreter available to ensure the learner understands the questions.
- Exam papers that have been adapted for Deaf learners by the Department of Education (DoE).

It is a high priority at the school to develop the language, reading and writing abilities of learners. Various projects have been implemented successfully, including the *iDeaf* project mentioned in section 4.5.2.

Learners are also able to participate in various sport and cultural events, such as athletics, rugby, soccer, netball, chess and the sign language choir. The sign language choir regularly performs at churches and business functions, often with well-known artists.

Very few learners have access to computers at home – they are completely dependent on the access to computers provided by the school.

7.3 Technical information regarding video clips

This technical overview of the recording and processing of the video clips that were used in the vocabulary lessons was provided by the technical assistant who created the videos at the *Directorate: Teaching and Learning of the Tshwane University of Technology* (TUT).

1. The videos for the single SASL signs and the SASL sentences were shot in HD-1920 x 1080 and were exported in MOV format.
2. The clips were then trimmed using *Adobe Premiere Pro CC*, and were exported as (Format-H.264, Preset-YouTube Widescreen 1080p) MP4 format files. The duration of the single sign clips are between one and three seconds, and the sentence videos from 20 seconds to one minute.
3. The trimmed videos were imported in *Camtasia Studio 8.0*, where a red frame was added to each sign of the new word in the SASL sentence videos. The frame can be found under *Effects-Callouts*.
4. Captions for certain words were also added to the instruction video using *Camtasia Studio 8.0*.
5. The videos had an interlacing problem after the editing, and all of them were formatted using *Adobe After Effects CS6*. The videos were placed individually on the timeline in a new HDTV 24fps black background composition. The videos were played on the timeline and paused where an interlacing error occurs. The effect used for the videos

can be found in the options *Blur and Sharpen,* then select *Reduce Interlace Flicker*. The *Softness* for the videos was set on 4.5 and the *Sharpen* effect was used and set on 18.

6. The de-interlaced videos were then imported into *Adobe Premiere Media Encoder*, and exported as Format- H.264, Preset-YouTube Widescreen 1080p, Mp4 video clip

7.4 Guidelines for the development of technology-supported lessons

A complete description of each guideline with indications of the way it was implemented in creating the prototype for this project was presented in Chapter 6. The complete guidelines to develop technology-supported lessons to teach basic programming principles to DHH learners are displayed in Table 7.1.

Table 7.1: Guidelines for the development of technology-supported lessons

Guidelines for interface and navigation
Guideline 1
Present information and components in ways that enable DHH leaners to recognise them, and to find it possible and desirable to use them, for example: 1.1. Make navigation visible, and controls recognisable and large enough to operate easily. 1.2. Use text and icons. If icons alone are used, explain them to the learners beforehand. 1.3. Be consistent with the layout of the pages.
Guideline 2
The design should be aesthetically pleasing and minimalistic, for example: 2.1. Use readable and understandable text. 2.2. Use clean typography. 2.3. Minimise distracting clutter. 2.4. Use colour contrast to separate foreground from background. 2.5. Use visual and semantic white space. *2.6.* Provide enough space between lines of text.
Guidelines for communication and support
Guideline 3
Use big screens, projectors and other visual aids to assist with communication.

Guideline 4
When creating video clips, visual distractions that would interfere with the interpreter should be avoided; specifically: 4.1. The background should be monochrome and subtle. 4.2. An interpreter with a dark complexion should be placed in front of a lighter background and wear light-coloured clothes. Fair-skinned interpreters should be placed against a darker background and wear darker clothes. 4.3. Gestures should be within a box parameter – not above the head, and not below the waist.
Guideline 5
When creating video clips involving sign language, use a local person who can sign the language used by the learners who will view the videos.
Guideline 6
Include multiple communication elements when explaining a new concept, for example: Text, fingerspelling, picture or animation, a SASL gesture, and a SASL sentence.
Guideline 7
Use visual organisers to review important information or display the order of steps to complete a task. Visual organisers include animation, pictures and/or photographs.
Guideline 8
Language should be modified and simplified, and the text and content should be easy to read and to understand. Therefore: 8.1. Formulate fairly short sentences with a relatively simple structure. 8.2. Replace high-level carrier language with lower-level alternatives. 8.3. Use language that the learners are familiar with, or provide definitions. 8.4. Replace passive verbs with active verbs. 8.5. Remove superfluous (unnecessary) text. 8.6. Remove ambiguity. 8.7. Format text using bullets, spacing, brackets, italics.
Guideline 9
Use colours, shapes and icons to organise information and educational units.
Guideline 10
Use animated cartoons for positive or negative feedback to learners.

Guidelines for the educator's role and attitude
Guideline 11
If learners are to use electronic learning material on their own, ensure that they are able to navigate the lesson.
Guideline 12
The educator and/or the interpreter should be skilled communicators and must be well-prepared. Therefore: 12.1. Ensure that learners and the educator and/or the interpreter are able to use specialised subject content vocabulary using either signs or fingerspelling the words. 12.2. Interpreters need to have some subject knowledge – for example, basic knowledge of programming.
Guideline 13
Ensure that the learners follow the instructions and are able to carry them out in the correct sequence – provide explicit guidance: 13.1. If an interpreter is used, the educator should wait for the interpreter to finish before continuing, and allow enough time for learners to read the information (if applicable). 13.2. Maintain eye contact with learners to ensure that they follow the instructions. 13.3. Give instructions slowly, step by step. 13.4. Repeat instructions if some learners did not understand or follow. 13.5. Take into consideration each learner's difficulties and deal with them individually.
Guidelines for the lesson structure
Guideline 14
Teach new vocabulary first, before presenting the programming lesson.
Guideline 15
Teach vocabulary related to programming by referring to concepts learners already know, and teach the words in context.
Guideline 16
The material presented to the learners should be linked to what they have experienced and seen before.
Guideline 17
Engage students cognitively. Therefore: 17.1. Use minds-on activities and apply active learning principles. 17.2. Often ask questions during the lesson to ensure that learners are on track.
Guideline 18
Focus on providing practical information.

7.5 Biographical data of participants

The first part of the questionnaire on the vocabulary lesson required learners to enter some biographical data. Eleven learners completed and evaluated both the vocabulary and the programming lessons. The following demographic data were collected:

Table 7.2: Biographical data of learners

				Home			School			
Number	Grade	Age	Gender	Speak[5]	SASL	Other	Speak	SASL	Other	Cochlear implant
1	10	17	F	Pedi				X	Read and write Afrikaans	No
2	8	16	F	Zulu				X	Read and write Afrikaans	No
3	9	16	F		Gestures[6]			X	Read and write Afrikaans	No
4	9	16	F	Zulu	Gestures			X	Read and write Afrikaans	No
5	11	17	F	Sepedi				X	Read and write Afrikaans	No
6	10	18	M	Afrikaans			Afrikaans	X	Read and write Afrikaans	Yes
7	OB*	19	M	Afrikaans English		Gestures		X	Read and write Afrikaans	No
8	10	16	M			Gestures		X	Read and write Afrikaans	No
9	10	16	F	Afrikaans	X[7]			X	Read and write Afrikaans	No
10	8	16	M			Gestures		X	Read and write Afrikaans	No
11	10	20	M			Gestures		X	Read and write Afrikaans	No

* Bridge year before Grade 12

[5] 'Speaking at home' refers to the home language the family members speak.
[6] These learners indicated that they do not use pure SASL at home. They rather make gestures their parents have learned to understand.
[7] One learner uses SASL at home since both her parents are Deaf.

7.6 UX evaluation methods

As discussed and motivated in section 3.6.3, three evaluation methods were implemented in this research project. The ways in which these methods were implemented are discussed in the following three sections.

7.6.1 Evaluation conducted by experts

During the development of both lessons the prototypes were discussed with the educators who were involved in creating the vocabulary lessons (reading the text and signing the SASL sentences and words) and presenting the programming lesson. The usability and accessibility of the vocabulary and programming lessons were reviewed and inspected by demonstrating and discussing the prototype with both educators. The SASL educator also received training to present the Scratch programming lesson. Both educators provided valuable suggestions that were incorporated in the design of the lessons.

7.6.2 Evaluation using models and simulations

In this research project, the actual lessons were used as models. The educator who had to teach the programming lesson was not familiar with the programming language Scratch. Therefore, the complete lesson was 'taught' to her to familiarise her with its content and navigation (a PowerPoint slide show). The same educator also had to work through the vocabulary lesson, since a number of new signs had to be developed. Therefore, she was able to test the difficulty of learning the interface. Since both educators teach DHH leaners daily, their judgement of the quality of the usability and accessibility of both lessons could be trusted, and their suggestions were incorporated in the guidelines.

7.6.3 Evaluation with users or potential users

Cockton (2013) specifies three types of usability evaluation methods: Testing, inspection and inquiry. In this research project inquiry methods were used, namely field observation, interviews and questionnaires (Cockton, 2013).

The learners were given the vocabulary lessons well ahead of the programming lesson. Both the educator who teaches SASL and English, as well as the CAT educator used the vocabulary lessons in class. They also received the vocabulary lessons on a flash disk, and were able to view them at home if they had access to a computer. Some assistance was therefore given to learners in navigating the vocabulary lessons. Before learners attended the programming lesson, an evaluation of their experience was done in the form of a questionnaire they completed with the help of an amanuensis. "Formative methods focus on the user's behaviour, intentions and expectations in order to understand any problems they encountered" (Petrie & Bevan, 2009, p. 22).

The learners completed another questionnaire after they had attended the programming lesson, containing questions that focused on their experience with the programming lesson itself.

Interviews were conducted with both of the educators who had been involved in presenting the programming lesson. The interviews provided an opportunity to document the observations of the two educators.

7.7 Results

In this research project, four UX elements were identified to evaluate the UX of the DHH learners and the two educators who had been involved in the project, namely usability, accessibility, emotional user reaction and hedonic aspects. Table 3.10 in section 3.6.2 contains descriptions of the evidence expected for each UX element. These descriptions were used to formulate questions in the learners' questionnaire and the semi-structured interview used to interview the educators. In this section, all questions in the learners' questionnaires (for both the vocabulary and the programming lessons), the semi-structured interviews were analysed, and conclusions were reached.

In the conclusions, a colour code was used to indicate whether the analysis of the question provided evidence of dissatisfaction or areas of concern, or a satisfactory UX for a specific UX element. The colour red indicates dissatisfaction, and green indicates a satisfactory UX.

The researcher's observations during the presentation of the programming lesson are presented as a narrative.

In this research project, the various factors that can influence a person's UX were not taken into consideration when the UX of the DHH learners was evaluated.

7.7.1 Results: Learners' questionnaires

Table 7.3: Results from vocabulary questionnaire, question 1

When you learned the new words, in what order did you usually view the slides?						
Results		1	2	3	4	5
	Written sentence in Afrikaans	5	2		2	2
	Written sentence in English	3	4		1	3
	Picture	1	2	6	1	1
	Video of single SASL sign	1	2	1	6	1
	Video with SASL sentence	1	1	4	1	4
Analysis	The results indicate that most learners accessed the different components of the vocabulary lesson in the order they were presented on the menu slides for each word. The educators also reported that, at first, the learners thought they were expected to view the components in the order they were presented, from top to bottom. Once educators had made them aware of the fact that they could branch to the different slides in the order they preferred, most of them started to view the SASL sentence and picture first [reference interviews]. Therefore, it can be recommended that a few additional slides be added to each vocabulary lesson to indicate to learners that they are permitted to view the slides in any order.					
Conclusion	Evidence of dissatisfaction					
	Usability					

Table 7.4: Results from vocabulary questionnaire, question 2

Did you find it easy to go to the slide you wanted?			
Results	Response options	Participant count	Percentage
	Yes	11	100%
	No	0	0%

	All learners found it easy to navigate to the slide they wanted to view. Learners could choose more than one reason, and also provide their own reasons. The responses were as follows:

Possible options	Option count
I understood what the icons meant.	9
Someone helped me to start, and then I found it easy.	4
Another reason.	0

Analysis	These results indicate that the learners found it easy to navigate to the required slides in the vocabulary lessons, and it can be claimed that the use of recognisable icons contributed to the effectivity and usefulness of the vocabulary lessons.			
Conclusion	Evidence of satisfaction			
	Usability (effectivity, usefulness)	accessibility		

Table 7.5: Results from vocabulary questionnaire, question 3

How (much) did you like the colours in the vocabulary lessons?			
Results	Response options	Participant count	Percentage
	Not at all	0	0%
	They were not too bad	1	9%
	Loved them	10	91%
Analysis	The majority of learners had very positive feelings about the use of colours in the vocabulary lessons.		
Conclusion	Evidence of satisfaction		
	Usability (satisfaction)		

Table 7.6: Results from vocabulary questionnaire, question 4

	Was it easy to read the text?		
Results	Response options	Participant count	Percentage
	Yes	11	100%
	No	0	0%
	All learners found it easy to read the text. Learners could choose more than one reason, and also provide their own reasons. The responses were as follows:		
	Possible options		Option count
	The letters were big enough.		7
	There were only a few words on a line.		10
	The font was easy to read.		2
	No learner provided any option other than those provided on the questionnaire.		
Analysis	Most learners indicated that using a large font and having only a few words on a line contributed to the accessibility of the vocabulary lessons.		
Conclusion	Evidence of satisfaction		
	Usability (utility)	Accessibility		

Table 7.7: Results from vocabulary questionnaire, question 5

<table>
<tr><td colspan="5">What is your opinion about the fingerspelling of each word that was displayed? Choose all the options you agree with.</td></tr>
<tr><td rowspan="6">Results</td><td colspan="3">Possible options</td><td>Option count</td></tr>
<tr><td colspan="3">I remember a new word better if I see it written in two different ways.</td><td>7</td></tr>
<tr><td colspan="3">When fingerspelling is included, it makes me feel as if the lesson was specially designed for me.</td><td>7</td></tr>
<tr><td colspan="3">It is difficult to read fingerspelling that is displayed as a picture.</td><td>2</td></tr>
<tr><td colspan="3">I do not know fingerspelling signs very well.</td><td>1</td></tr>
<tr><td colspan="3">I prefer a single sign to a fingerspelling word.</td><td>6</td></tr>
<tr><td>Analysis</td><td colspan="4">Learners had to choose all the options they agreed with.
Seven of them were positive about the fingerspelling representation of the words in the vocabulary lessons, since they were of the opinion that they remembered a word better when it is written in two different ways.
Six learners indicated that they preferred a single sign to a word displayed in fingerspelling. This requirement was met in the vocabulary lessons, since the SASL educator composed signs for some of the words for which no SASL sign in context was available, such as event, backdrop and looks.
Two learners indicated that they found it difficult to read fingerspelling that is displayed as a picture, and one learner admitted to not knowing fingerspelling very well. However, this did not have a negative impact on the usability of the vocabulary lessons, since understanding the fingerspelling representation of a word was not a prerequisite for understanding the meaning of a word.
The majority of the learners (seven learners), felt as if the lessons were designed for them specifically because fingerspelling of words were included.</td></tr>
<tr><td rowspan="2">Conclusion</td><td colspan="4">Evidence of satisfaction</td></tr>
<tr><td>Utility
(memorability, effectiveness)</td><td>Accessibility</td><td></td><td>Hedonic aspects
(identity)</td></tr>
</table>

Table 7.8: Results from vocabulary questionnaire, question 6

<table>
<tr><td colspan="5">What is your opinion about the pictures that were displayed with new words in the vocabulary lessons? Choose all the options you agree with:</td></tr>
<tr><td rowspan="5">Results</td><td colspan="2">Possible options</td><td colspan="2">Option count</td></tr>
<tr><td colspan="2">The pictures were not really necessary.</td><td colspan="2">2</td></tr>
<tr><td colspan="2">Some of the pictures confused me.</td><td colspan="2">2</td></tr>
<tr><td colspan="2">It helped me to understand the meaning of the words better.</td><td colspan="2">10</td></tr>
<tr><td colspan="2">It helped me to remember the meaning of the words better.</td><td colspan="2">8</td></tr>
<tr><td>Analysis</td><td colspan="4">The majority of learners were of the opinion that the pictures helped them to understand and remember the meaning of words better.</td></tr>
<tr><td rowspan="2">Conclusion</td><td colspan="4">Evidence of satisfaction</td></tr>
<tr><td>Usability
(learnability, memorability)</td><td>Accessibility</td><td></td><td></td></tr>
</table>

Table 7.9: Results from vocabulary questionnaire, question 7

What type of pictures did you like most? *Write 1, 2, or 3 in each of the following boxes, where 1 means you liked it the most, and 3 means you liked it the least.*					
Results		Most		Least	
		1	2	3	
	A photo	5	6		
	A cartoon			11	
	Animation	6	5		
Analysis	Most learners preferred either a photo or an animation in the illustration of a word. However, it cannot be concluded that they disliked a cartoon, or that using a cartoon did not contribute to their understanding of or remembering the meaning of a word.				
Conclusion	Evidence of satisfaction				
	Usability (satisfaction)				

Table 7.10: Results from vocabulary questionnaire, question 8

<table>
<tr><td colspan="4">Did you see many words in the sentences of the vocabulary lesson that you did not understand?</td></tr>
<tr><td rowspan="16">Results</td><td>Response options</td><td>Participant count</td><td>Percentage</td></tr>
<tr><td>I never read the sentences</td><td>0</td><td>0%</td></tr>
<tr><td>No, I understood all the words.</td><td>4</td><td>36%</td></tr>
<tr><td>Yes – a lot.</td><td>2</td><td>18%</td></tr>
<tr><td>Just a few.</td><td>5</td><td>45%</td></tr>
<tr><td colspan="3">a) If you did see words in the sentences that you did not understand, what did you do? Choose all the options you agree with:</td></tr>
<tr><td>Response options</td><td>Participant count</td><td>Percentage</td></tr>
<tr><td>I wrote down the words and asked an educator to help me.</td><td>3</td><td>27%</td></tr>
<tr><td>I ignored them and then looked at the video with the SASL explanation, or at the picture.</td><td>7</td><td>64%</td></tr>
<tr><td>No response.</td><td>1</td><td>9%</td></tr>
<tr><td colspan="3">b) How did it make you feel when you did not understand a word?</td></tr>
<tr><td>Response options</td><td>Participant count</td><td>Percentage</td></tr>
<tr><td>I became anxious and was unable to continue.</td><td>1</td><td>9%</td></tr>
<tr><td>It was not a problem – I just waited for the educator or a friend to help me.</td><td>9</td><td>82%</td></tr>
<tr><td>Something else: I just read it again.</td><td>1</td><td>9%</td></tr>
<tr><td colspan="3"></td></tr>
<tr><td>Analysis</td><td colspan="3">Learners reported that they had read all the sentences in the vocabulary lessons, and that they saw very few words in the sentences that they could not understand. Only one learner reported that he/she felt anxious when he/she found words he/she did not understand. The others either asked someone for assistance, or reviewed one of the other options to understand the meaning of the new word.</td></tr>
<tr><td rowspan="2">Conclusion</td><td colspan="3">Evidence of satisfaction</td></tr>
<tr><td colspan="3">Usability (effectiveness) | | Emotional reaction (confidence) |</td></tr>
</table>

Table 7.11: Results from vocabulary questionnaire, question 9

	What colour were the verbs in the vocabulary lesson?			
Results	Response options	Participant count	Percentage	
	Blue *(incorrect)*	2	18%	
	Red *(correct)*	9	82%	
Analysis	Only two learners either forgot what colour the verbs were, or did not realise that the colours had a special meaning. Since the colours used for verbs and nouns are part of the convention used for all learning material at the school, this concept was not explained to learners when they started the vocabulary lessons. It may be beneficial to add a slide to the instructions of the vocabulary lessons to draw learners' attention to the use of colour.			
Conclusion	Evidence of satisfaction			
	Usability (memorability, effectiveness)	Accessibility		

Table 7.12: Results from vocabulary questionnaire, question 10

	What helped you most to learn the new words?	
Results	Comments	Number of participants who made this comment.
	The SASL sentence	9
	The SASL sign	2
	Pictures	3
	English	3
	Afrikaans	1
Analysis	Most learners were of the opinion that the SASL sentence helped them the most with learning new words.	

conclusion	Evidence of satisfaction			
	Usability (learnability, effectiveness)	Accessibility		

Table 7.13: Results from vocabulary questionnaire, question 11

What did you like most about the vocabulary lessons?		
Results	Comments	Number of participants who made this comment.
	The SASL sentence	4
	SASL sign	2
	Pictures	4
	English	2
	Afrikaans	3
	Costume (the word)	1
Analysis	Amanuenses reported that it was difficult to translate the words 'helped most' and 'liked most' in a way the learners could understand. Therefore, the learners were not sure how to interpret Q10 and Q11. Nevertheless, it seems as if the learners appreciated the visual aspects that were included for their benefit.	

Conclusion	Evidence of satisfaction			
	Usability (satisfaction)	Accessibility		

Table 7.14: Results from vocabulary questionnaire, question 12

	What did you like least about the vocabulary lessons?	
Results	Comments	Number of participants who made this comment.
	Liked everything	1
	SASL sentence	1
	English	2
	SASL sign	3
	Picture	3
	Afrikaans	2
Analysis	It seems as if learners viewed this statement to be similar to question 1, where they had to indicate in what order they viewed the slides. The intention of this question was to determine if learners found aspects of the lessons boring, too complicated or unclear. However, the answers provided by the learners do not provide any conclusive evidence.	
Conclusion	Inconclusive evidence.	

Table 7.15: Results from programming lesson questionnaire, question 1

How much did you like the colours in the programming lessons?			
Results	Response options	Participant count	Percentage
	Not at all	0	0%
	They were not too bad	1	9%
	Loved them	10	91%
Analysis	Learners were satisfied with the use of colours in the programming lesson.		
Conclusion	Evidence of satisfaction		
	Usability (satisfaction)	Accessibility	

Table 7.16: Results from programming lesson questionnaire, question 2

What were you supposed to do when you saw a green slide?			
Results	Learn new skills *(Incorrect)*	2	18%
	Do activities myself *(Correct)*	8	73%
	Listen to the educator *(Incorrect)*	1	9%

Analysis	Most learners could remember that they were supposed to do activities themselves when a green slide was displayed.			
Conclusion	Evidence of satisfaction			
	Usability (memorability)	Accessibility		

Table 7.17: Results from programming lesson questionnaire, question 3

What was the colour of the slide that displayed new or important words?			
Results	Grey *(Incorrect)*	0	0%
	White *(Incorrect)*	0	0%
	Blue *(Correct)*	11	100%
Analysis	All learners could remember that the new or important words were displayed on a blue slide.		

Conclusion	Evidence of satisfaction			
	Usability (memorability)	Accessibility		

Table 7.18: Results from programming lesson questionnaire, question 4

<table>
<tr><td colspan="5">Was it easy to read the text?</td></tr>
<tr><td rowspan="8">Results</td><td colspan="2">Response options</td><td colspan="1">Participant count</td><td>Percentage</td></tr>
<tr><td colspan="2">Yes</td><td>11</td><td>100%</td></tr>
<tr><td colspan="2">No</td><td>0</td><td>0%</td></tr>
<tr><td colspan="4">All learners found it easy to read the text.
Learners could choose more than one reason, and also provide their own reason. The responses were as follows:</td></tr>
<tr><td colspan="3">Possible options</td><td>Option count</td></tr>
<tr><td colspan="3">The letters were big enough.</td><td>5</td></tr>
<tr><td colspan="3">There were only a few words on a line.</td><td>6</td></tr>
<tr><td colspan="3">The font was easy to read.</td><td>3</td></tr>
<tr><td>Analysis</td><td colspan="4">All learners found it easy to read the text. Most of them were of the opinion that the big letters and few words on a line contributed most to the legibility.</td></tr>
<tr><td rowspan="2">Conclusion</td><td colspan="4">Evidence of satisfaction</td></tr>
<tr><td>Usability
(satisfaction)</td><td>Accessibility</td><td></td><td></td></tr>
</table>

Table 7.19: Results from programming lesson questionnaire, question 5

	Did you see many words in the programming lesson that you did not understand?		
Results	Response options	Participant count	Percentage
	Yes	0	0%
	No	11	100%
	a) If you did see words in the sentences that you did not understand, what did you do? Choose all the options you agree with:		
	Response options	Participant count	Percentage
	I asked the educator to explain it to me, and then carried on working.	0	0%
	I ignored the word and tried to do the work anyway.	0	0%
	Something else.	0	0%
	No response.	11	100%
	b) How did you feel when you did not understand a word?		
	Response options	Participant count	Percentage
	I became anxious and could not continue.	1	9%
	It was not a problem – I just waited for the educator or a friend to help me.	5	45%
	Something else: I just read it again.	0	0%
	No response.	5	45%
Analysis	Learners reported that there were very few words in the programming lesson's slides that they did not understand. Only one learner experienced anxiety when there were unfamiliar words. Unfortunately, no learners reported on any action they took – probably because they experienced only a few unfamiliar words.		
Conclusion	Evidence of satisfaction		
	Usability (satisfaction)	Accessibility	Emotional reaction (confidence)

Table 7.20: Results from programming lesson questionnaire, question 6

When you gave a correct or a wrong answer, a picture appeared. Write a number from 1 to 3 in each of the following boxes, where 1 is the one you liked most, and 3 is the one you liked least:				
Results		1	2	3
	The emoticons that had no animation.		3	7
	The emoticons with animation.	10	1	
	The check mark or cross.	1	6	3
	Participant 2 did not indicate 2nd and 3rd choice.			
Analysis	Most of the learners preferred the emoticon with animation to indicate whether they answered a question correctly or incorrectly.			
Conclusion	Evidence of satisfaction			
	Usability (satisfaction)			

Table 7.21: Results from programming lesson questionnaire, question 7

Did you ever use the printed notes when you wrote your program?			
Results	Response options	Participant count	Percentage
	Yes	9	82%
	No	2	18%

	If YES: What did you like the most about the notes?			
	Comments			
	1. The step-by-step explanation made it easier *(Numbered screenshots)*			
	2. The bat that flew – crazy!			
	3. The words with the pictures made them easy to understand			
	4. They were very clear and helped me to understand			
	5. [To write] the program of the cat and the mouse together on the stage			
	6. The colours on the notes (the groups) and those on the computer were the same and it was easy to do because it was the same.			
	7. Pictures were clear. Easy to understand.			
	8. [To write the program of] the bat that flew – I understood everything, knew what to do, easy.			
	9. Interesting			
	If NO: Why did you not use them?			
	Comments			
	1. I could remember (what to do) by myself.			
	2. I understood what to do.			
Analysis	The notes were useful, and learners consulted them when they had to create their own programs. The comments made by the learners indicate that the layout of the notes and the use of colours and pictures made the notes accessible.			
Conclusion	Evidence of satisfaction			
	Usability (learnability, satisfaction)	Accessibility	Emotional reaction (interest)	

Table 7.22: Results from programming lesson questionnaire, question 8

<table>
<tr><th colspan="5">What helped you most in learning to write a program?</th></tr>
<tr><td rowspan="11">Results</td><td colspan="4">1. The explanations with arrows that show where they [the program blocks] come from, and the circles that show what you should pay attention to.</td></tr>
<tr><td colspan="4">2. The grey slides that explained everything.</td></tr>
<tr><td colspan="4">3. Explanation and activities we had to do ourselves.</td></tr>
<tr><td colspan="4">4. Explanation and doing [the activities] together.</td></tr>
<tr><td colspan="4">5. The numbers with the pictures that explained step-by-step what to do.</td></tr>
<tr><td colspan="4">6. Step-by-step explanation.</td></tr>
<tr><td colspan="4">7. To first see everything and then do it myself.</td></tr>
<tr><td colspan="4">8. The group name and colour were displayed again so I knew where to find it when I had to do it myself.</td></tr>
<tr><td colspan="4">9. The step-by-step with numbers helped.</td></tr>
<tr><td colspan="4">10. The pictures.</td></tr>
<tr><td colspan="4">11. The colours.</td></tr>
<tr><td>Analysis</td><td colspan="4">From the comments made by learners, the following were highlighted:
• Progressions and step-by-step explanations are important when presenting new learning material to DHH learners.
• It helped learners to have a clear indication of when they had to focus on the screen to follow explanations, and when they could work by themselves.
• Having the same format and order of explanation on the green slides (when learners had to perform the activity) as on the grey slides (the explanation) helped the learners know exactly what to do.
• Pictures, colours and animation contributed to understanding and memorability.
• Active learning contributed to understanding.</td></tr>
<tr><td rowspan="2">Conclusion</td><td colspan="4">Evidence of satisfaction</td></tr>
<tr><td>Usability
(learnability, satisfaction)</td><td>Accessibility</td><td></td><td></td></tr>
</table>

Table 7.23: Results from programming lesson questionnaire, question 9

<table>
<tr><th colspan="5">What did you like about the way your educator explained the programming lesson?</th></tr>
<tr><td rowspan="11">Results</td><td colspan="4">1. She explained the work clearly, step by step.</td></tr>
<tr><td colspan="4">2. She explained the different groups of instructions well.</td></tr>
<tr><td colspan="4">3. That learners could choose the answers themselves.</td></tr>
<tr><td colspan="4">4. Explained clearly.</td></tr>
<tr><td colspan="4">5. She used sign language, so I could understand clearly.</td></tr>
<tr><td colspan="4">6. She used sign language to explain everything.</td></tr>
<tr><td colspan="4">7. Click on the board to show how the steps follow one another.</td></tr>
<tr><td colspan="4">8. She used sign language and that helped me to understand it clearly.</td></tr>
<tr><td colspan="4">9. She explained in sign language and was very patient.</td></tr>
<tr><td colspan="4">10. The order of the lesson, what must be done first, second, third ….</td></tr>
<tr><td colspan="4">11. Explanation together with pictures.</td></tr>
<tr><td>Analysis</td><td colspan="4">Learners liked the following:
• That all explanations were done in SASL, and they were not expected to read many instructions by themselves.
• The explanations were done step by step and were supplemented by pictures and animation.
• To be involved in the lesson by choosing the correct answers to questions on the interactive whiteboard.</td></tr>
<tr><td rowspan="2">Conclusion</td><td colspan="4">Evidence of satisfaction</td></tr>
<tr><td>Usability
(learnability, satisfaction)</td><td>Accessibility</td><td></td><td>Hedonic aspects
(communication of identity)</td></tr>
</table>

Table 7.24: Results from programming lesson questionnaire, question 10

	What did you NOT like about the way your educator explained the programming lesson?			
Results	1. There was nothing I disliked.			
	2. No problem.			
	3. Lots of explanation. It could have been shorter. I want to do more by myself.			
	4. I understood everything very well and enjoyed it.			
	5. There was nothing I did not like.			
	6. There was nothing I did not like.			
	7. No problems.			
	8. Nothing I did not like.			
	9. Nothing.			
	10. Everything was right.			
	11. No comment was entered.			
Analysis	Learners were very satisfied with the lesson. Only one learner wanted to work faster and did not want to wait for more detailed explanations.			
Conclusion	Evidence of satisfaction			
	Usability (satisfaction, utility, effectiveness)	Accessibility		

Table 7.25: Results from programming lesson questionnaire, question 11

<table>
<tr><th colspan="5">What did you like most about the programming lesson?</th></tr>
<tr><td rowspan="11">Results</td><td colspan="4">1. To write the script for the various animals.</td></tr>
<tr><td colspan="4">2. Liked the program with the mouse that created a triangle the most. Liked everything in the lesson.</td></tr>
<tr><td colspan="4">3. Own activities I could do and to see what happens.</td></tr>
<tr><td colspan="4">4. The pictures.</td></tr>
<tr><td colspan="4">5. The pictures, colours and animation.</td></tr>
<tr><td colspan="4">6. It was colourful and with the signs I understood and enjoyed it.</td></tr>
<tr><td colspan="4">7. If something was difficult the educator explained it well so I can understand.</td></tr>
<tr><td colspan="4">8. The animations of the explanations.</td></tr>
<tr><td colspan="4">9. The crab and the frog. I enjoyed the lesson a lot. It was easy.</td></tr>
<tr><td colspan="4">10. I enjoyed it to create a program by myself.</td></tr>
<tr><td colspan="4">11. After explanation to do something yourself and see how it works.</td></tr>
<tr><td>Analysis</td><td colspan="4">From the comments, it is clear that the learners liked learning how to program. They especially liked:
• Being actively involved;
• Experiencing success when their programs executed successfully;
• The visual components that were added, such as pictures, colours and animation; and
• The educator’s patience.</td></tr>
<tr><td rowspan="2">Conclusion</td><td colspan="4">Evidence of satisfaction</td></tr>
<tr><td>Usability
(efficiency, satisfaction)</td><td>Accessibility</td><td>Emotional reaction
(enjoyment)</td><td>Hedonic aspects
(stimulation)</td></tr>
</table>

Table 7.26: Results from programming lesson questionnaire, question 12

	What did you like least about the programming lesson?			
Results	1. I liked everything.			
	2. Everything was good. No problem.			
	3. The educator's repetition of words such as where to find a sprite or what is an event, etc.			
	4. No comment entered			
	5. I liked everything.			
	6. There was nothing I disliked.			
	7. Cannot say – nothing was bad.			
	8. Liked everything.			
	9. Understood everything clearly.			
	10. No problems.			
	11. Liked everything – nothing was boring.			
Analysis	Learners enjoyed the programming lesson. They were not bored and did not find anything unsatisfying.			
Conclusion	Evidence of satisfaction			
	Usability (efficiency, satisfaction)	Accessibility		

Table 7.27: Results from programming lesson questionnaire, question 13

Would you like to do a lesson in programming again someday to learn more about it?				
Results	Response options	Participant count	Percentage	
	Yes	11	100%	
	No	0	0%	
	If YES: Why?			
	1. I enjoyed it very much to build the program.			
	2. I enjoy it to create a program by myself.			
	3. Want to learn more about it, want to do programming (computer) work, work overseas.			
	4. I want to learn more new words and concepts so I can teach it to others.			
	5. It was nice to understand it and do it myself. I enjoyed it very much.			
	6. I want to learn more about it. I enjoyed it.			
	7. I like it to create programs – it is not boring. I learn new words and stuff.			
	8. It was nice to do it myself – I enjoyed it very much.			
	9. I enjoyed it very much and it was interesting to learn how to do it.			
	10. I understood well, it was easy. I enjoyed it to 'play' like this.			
	11. It is interesting – like to see how the sprite does something.			
Analysis	From the learners' comments, it is clear that they found the programming lesson stimulating, enjoyable, fun and understandable			
Conclusion	Evidence of satisfaction			
	Usability (satisfaction)		Emotional reaction (enjoyment, interest)	Hedonic aspects (stimulation)

7.7.2 Results: Educators' semi-structured interviews

Table 7.28: Results from semi-structured interview, vocabulary lesson, question 1

	Describe any difficulties learners experienced in accessing computers to work through the lesson on their own.			
Feedback and analysis	Learners who are boarders do not have access to computers after school. They are dependent on the use of computers during school hours. The SASL and CAT educators gave learners time during their scheduled lessons to work on the vocabulary lessons. When educators from other subjects were absent, learners who participated in the project went to the CAT class for invigilation, and worked on the vocabulary lessons. Therefore, learners had sufficient time to access the vocabulary lessons and learn the meanings of all the required words. (Interview with educators, May, 2017)			
Conclusion	Evidence of satisfaction			
		Accessibility		

Table 7.29: Results from semi-structured interview, vocabulary lesson, question 2

<table>
<tr><td colspan="5">What feedback have you received from the learners regarding the vocabulary lessons?</td></tr>
<tr><td>Feedback and analysis</td><td colspan="4">They understood everything very well and they perceived as being easy and clear – they did not struggle at all (CAT educator, interview, May 15, 2017).
The concept was new to them. They had never seen learning material where they had so many options for explaining the meaning of one word. Initially they looked at the different options from the top to the bottom, but when educators told them they were allowed to view the options in the order they prefer, most of them watched the SASL sentence and the pictures first, rather than to read the Afrikaans or English sentences (SASL educator, interview, May 15, 2017).</td></tr>
<tr><td rowspan="2">Conclusion</td><td colspan="4">Evidence of satisfaction</td></tr>
<tr><td>Usability
(efficiency, utility)</td><td>Accessibility</td><td></td><td></td></tr>
</table>

Table 7.30: Results from semi-structured interview, vocabulary lesson, question 3

<table>
<tr><td colspan="2">To what extent do you think learners had mastered the required new vocabulary before they attended the programming lesson?</td></tr>
<tr><td>Feedback and analysis</td><td>Some of the learners had a better vocabulary than others, so they were already familiar with some of the words in the vocabulary lessons. However, the words that were chosen for the vocabulary lessons were definitely those that most learners would not have known. When the programming lesson was presented, it was clear that learners knew the vocabulary. When a word from the vocabulary lesson appeared on the screen, learners made the relevant sign before the SASL educator started the explanation (SASL educator, interview, May 15, 2017).
The learners completed the vocabulary lessons before the school holidays. After the holidays, the CAT educator revised the vocabulary lessons again, and the learners reported that they could still remember all the signs (CAT educator, interview, May 15, 2017).</td></tr>
</table>

Conclusion	Evidence of satisfaction			
	Usability (learnability, memorability, effectiveness)			Hedonic aspects (evocation)

Table 7.31: Results from semi-structured interview, vocabulary lesson, question 4

	What is your opinion regarding the format of the vocabulary lesson?
Feedback and analysis	**Feedback** I think it is a very good idea to teach vocabulary in such a manner with stories although the preparation and hard work that go into it before the time is enormous. But it works very, very well. The only thing that was not really necessary was the fingerspelling of the word. It does not contribute to the learning of the meaning of the new word (CAT educator, interview, May 15, 2017). It was very successful to teach the words that are part of the actual lesson first in a separate scenario (SASL educator, interview, May 15, 2017). **Analysis** Some of the factors that the educators seemed to consider to be the key to the success of the lessons are: • Learners could see sign language as part of the explanation – usually they just get a list of words with a description in text. This helped them to understand the meaning of the word immediately. • The technology enabled them to be in control of their own learning. They could complete the lessons at their own pace and view the explanations in the order they preferred.

Conclusion	Evidence of satisfaction			
	Usability (effectiveness, satisfaction)	Accessibility		

Table 7.32: Results from semi-structured interview, vocabulary lesson, question 5

Do you have the resources (time and equipment) to create similar vocabulary lessons?	
Feedback and analysis	Cameras and other technology are available to create similar lessons. However, it is very time-consuming and it will be very difficult to find the time to create similar lessons (SASL educator, interview, May 15, 2017). It would not be possible to create such lessons for a complete subject. The learners would also need additional time to learn the vocabulary first, so they would need to have access to computers after school (CAT educator, interview, May 15, 2017).
Conclusion	This question was asked as part of background of the case, and does not form part of the UX evaluation of the project.

Table 7.33: Results from semi-structured interview, vocabulary lesson, question 6

Do you think it would be worth the effort for you to create similar lessons to teach learners SASL vocabulary for your subject yourself?	
Feedback and analysis	It would definitely be worth it, if it were possible for an educator to find the time to create such lessons (CAT educator, interview, May 15, 2017). It would be of great value if concepts that learners have to know, and which are difficult to remember, such as the concept 'personification' in English, could be taught in advance. If learners could be given an explanation in context and were able to go back to the explanation, it would be of great value to the educator. If vocabulary is taught before the lesson, then learners already know the sign and the spelling and have background knowledge. Deaf learners do not necessarily have the background for new vocabulary that hearing learners usually have (SASL educator, interview, May 15, 2017).

Conclusion	Evidence of satisfaction			
	Usability (effectiveness)			

Table 7.34: Results from semi-structured interview, vocabulary lesson, question 7

If similar lessons were created by someone else, would you incorporate them in your syllabus and encourage learners to use them?				
Feedback and analysis	The educators would definitely use vocabulary lessons provided in this format in their classes, and encourage the learners to use them if someone else created them. They were confident that the learners would enjoy using such lessons.			
Conclusion	Evidence of satisfaction			
	Usability (effectiveness, satisfaction)			

Table 7.35: Results from semi-structured interview, vocabulary lesson, question 8

What would you change about the vocabulary lesson?	
Analysis	**Feedback** The fingerspelling was not necessary – it just takes time to add it to the lessons and it does not contribute to understanding. However, having fingerspelling in the lesson is not distracting (CAT educator, interview, May 15, 2017).

	Analysis The lessons were well planned and designed. The educators liked the colours, the different options, and the ability to go forwards and backwards to the different words (SASL educator, interview, May 15, 2017).			
Conclusion	Evidence of satisfaction			
	Usability (efficiency, utility, effectiveness)	Accessibility		

Table 7.36: Results from semi-structured interview, vocabulary lesson, question 9

Are there any general comments you would like to make about the vocabulary lesson?				
Feedback and analysis	**Feedback** I was very impressed with the layout of the lesson and how the learners experienced it (SASL educator, interview, May 15, 2017). **Analysis** Learners enjoyed the vocabulary lessons very much. They often collaborated, sitting at the computer together. Educators could look at what they were talking about, and it was definitely about the lessons. They found the animation and pictures interesting, cute and funny. They laughed merrily when they saw photos of learners they knew (CAT educator, interview, May 15, 2017).			
Conclusion	Evidence of satisfaction			
	Usability (satisfaction)		Emotional reaction (enjoyment, fun, interested)	Hedonic aspects (evocation, stimulation)

Table 7.37: Results from semi-structured interview, programming lesson, question 1

<table>
<tr><th colspan="5">How did you feel about introducing programming to the learners?</th></tr>
<tr><td>Feedback and analysis</td><td colspan="4">The CAT educator was very excited about introducing programming, and was eager to see the effect that the vocabulary lessons that had been taught beforehand would have on the programming lesson (CAT educator, interview, May 15, 2017).
The SASL educator who presented the programming lesson felt very emotional, because there are very few people who do research on DHH teaching and who are willing to develop something specifically for DHH learners. She felt honoured to be part of the project and saw it as a very positive experience. She was of the opinion that being taught programming could have a positive outcome for DHH learners. She could see that the learners were excited and enjoyed the lesson (SASL educator, interview, May 15, 2017).</td></tr>
<tr><td rowspan="2">Conclusion</td><td colspan="4">Evidence of satisfaction</td></tr>
<tr><td></td><td></td><td>Emotional reaction
(excitement, enjoyment)</td><td>Hedonic aspects
(communication of identity)</td></tr>
</table>

Table 7.38: Results from semi-structured interview, programming lesson, question 1 - follow-up question

<table>
<tr><th colspan="2">To what extent do you think the vocabulary lesson that had been studied before the time contributed to the success of the programming lesson?</th></tr>
<tr><td>Feedback and analysis</td><td>Teaching vocabulary first affected the programming lesson in a very positive manner. Learners understood the programming concepts very quickly, because the educator did not have to spend time on explaining many new words. The progression of the lesson was much smoother, because there were no interruptions where it was necessary to explain something that was not part of the actual lesson.
The educator was also of the opinion that the time an educator spends on first teaching the necessary vocabulary for a lesson would save time during the actual lesson (CAT educator, interview, May 15, 2017).</td></tr>
</table>

Conclusion	Evidence of satisfaction			
	Usability (effectiveness, satisfaction)	Accessibility		

Table 7.39: Results from semi-structured interview, programming lesson, question 2

	To what extent did you notice the learners displaying any of the following behaviours or emotions while they attended the lesson? Enjoyment and excitement, boredom, understanding, confusion, participation, peer-learning, collaboration, embarrassment.
Analysis	There was excitement and enjoyment, because the learners did not know what was going to happen – they just knew it was going to be a lesson involving technology. During the lesson there were many smiles, and they would tap another learner to get attention, and say: 'Look what I managed to do' (SASL educator, interview, May 15, 2017). They were very excited when they were successful – the educators reported that learners signed: 'Yes – I could do it.' (CAT educator, interview, May 15, 2017). They understood that they were in control of what was happening to a sprite. They had conversations about the programming, for example, asking: 'How do you think we can make this happen?' (SASL educator, interview, May 15, 2017). They clearly understood what was going on (CAT educator, interview, May 15, 2017). The learners were actively engaged and participated willingly. When the SASL educator explained new concepts and skills on the grey slides, she could see that they were keen to try it out themselves. They watched intently and were eager to try out new skills (CAT educator, interview, May 15, 2017). Learners collaborated and helped one another if someone was uncertain of what to do (SASL educator, interview, May 15, 2017) Some worked faster than others, and then they enjoyed showing the other learners what to do (CAT educator, interview, May 15, 2017). No learners showed any signs of embarrassment when they did not know what to do (SASL educator, interview, May 15, 2017).

Conclusion	Evidence of satisfaction			
			Emotional reaction and behaviour (excitement, enjoyment, understanding, participation, collaboration, motivation)	Hedonic aspects (stimulation)
Feedback and analysis	One learner was slightly anxious when he did not manage to open Scratch the first time. Another struggled to drag an instruction to the script area, because the computer's mouse did not function properly. Initially, learners struggled to switch between the script area tab and the costumes tab. Those learners who did have difficulties were quickly assisted by their peers and the educators. However, the layout in Scratch is very user-friendly, and learners only experienced difficulties with very minor interface issues (CAT educator, interview, May 15, 2017). Two learners did not pay adequate attention during the lesson, and had some difficulty in performing tasks when they had to create a program by themselves. According to the educator, these learners have short attention spans and often do not pay attention during lessons, so their behaviour was not an indication of a problem with the lesson structure (SASL educator, interview, May 15, 2017).			
Conclusion	Evidence of dissatisfaction			
			Emotional reaction (mild anxiety, mild confusion in using the Scratch interface)	

Table 7.40: Results from semi-structured interview, programming lesson, question 3

<table>
<tr><td colspan="5">What other emotions or behaviour of the learners that you find worth mentioning did you notice during the lesson?</td></tr>
<tr><td>Feedback and analysis</td><td colspan="4">Learners were more excited than in their usual classes, because they had experienced success. The effect was that they wanted to learn more.
They were stimulated, because they usually find their work in class quite difficult, and now they were able to make cute things happen on the screen (CAT educator, interview, May 15, 2017).
They enjoyed the variety of the activities and even of the feedback provided [the thumbs up sign, thumbs-up animation or green tick mark].
Learners clapped hands and laughed, showing that they found it to be a very positive experience (SASL educator, interview, May 15, 2017).</td></tr>
<tr><td rowspan="2">Conclusion</td><td colspan="4">Evidence of satisfaction</td></tr>
<tr><td>Usability
(effectiveness, satisfaction)</td><td></td><td>Emotional reaction
(motivated, fun, joy)</td><td>Hedonic aspects
(stimulation)</td></tr>
</table>

Table 7.41: Results from semi-structured interview, programming lesson, question 4

What did you notice learners having difficulties with during the lesson?
This question was already addressed in the discussion of question 2.

Table 7.42: Results from semi-structured interview, programming lesson, question 5

<table>
<tr><th colspan="5">Did the format of the lesson give you any new ideas about the way you could present lessons in future?</th></tr>
<tr><td>Feedback and analysis</td><td colspan="4">The structured lesson format where step-by-step explanations are provided is an aspect the educators will definitely apply. The arrows and the layout of slides help to present the information logically and chronologically and one could do the explanation step-by-step by means of the slide. (SASL educator, interview, May 15, 2017).
The use of colour-coded slides (the grey, green and blues slides) could definitely help learners and educators to focus on the task at hand. If all educators were to use colour coding, the learners would get used to the format and it would have a positive effect on their ability to concentrate. Learners will know when to pay attention. The idea of doing the vocabulary lesson separately to make the actual lesson easier to present has a lot of value (CAT educator, interview, May 15, 2017).</td></tr>
<tr><td rowspan="2">Conclusion</td><td colspan="4">Evidence of satisfaction</td></tr>
<tr><td>Usability
(efficiency, effectiveness,
satisfaction)</td><td></td><td></td><td></td></tr>
</table>

Table 7.43: Results from semi-structured interview, programming lesson, question 6

<table>
<tr><td colspan="5">What new skills do you think learners obtained through this introduction to Scratch?</td></tr>
<tr><td>Feedback and analysis</td><td colspan="4">Learners understood the logic of providing instructions, and it will be executed step-by-step. They also learned that what they had thought was difficult at first, was not so difficult at all, and that they were able to apply their new knowledge. This will definitely help to give them the courage to attempt mastering new skills in future (CAT educator, interview, May 15, 2017).
The exposure to a different type of application – other than just Word or Excel – is good (SASL educator, interview, May 15, 2017).</td></tr>
<tr><td rowspan="2">Conclusion</td><td colspan="4">Evidence of satisfactory</td></tr>
<tr><td>Usability
(satisfaction)</td><td></td><td>Emotional reaction
(courage)</td><td></td></tr>
</table>

Table 7.44: Results from semi-structured interview, programming lesson, question 7

<table>
<tr><td colspan="2">Do you think Deaf or Hearing impaired (DHH) learners benefit from being taught the basic principles of programming?</td></tr>
<tr><td>Feedback and analysis</td><td>The SASL educator was of the opinion that it would be beneficial for DHH learners to learn to program, since programming is a very suitable career for them. Communication with hearing people is a constant challenge to DHH individuals. As programmers, they will not have to communicate with colleagues constantly. Once the initial specifications for a program have been provided, they can communicate via e-mail, and even work from home (SASL educator, interview, May 15, 2017).
The CAT educator stated that learning to program changes the way one thinks, and it would be interesting to see how far DHH learners would progress when the more challenging concepts of programming is presented.</td></tr>
</table>

Conclusion	This question was asked as part of the background to the case, and does not form part of the UX evaluation of the project.

Table 7.45: Results from semi-structured interview, programming lesson, question 8

<table>
<tr><th colspan="5">Are there any other general comments you would like to make about the programming lesson?</th></tr>
<tr><td>Feedback and analysis</td><td colspan="4">Learners experienced the lesson as a very positive event. They wanted to know when they will be able to do programming again, and if the researcher would be coming back again to teach them more.
DHH learners do not often experience success. During the programming lesson, they could see results immediately. That made them feel successful and happy with themselves (CAT educator, interview, May 15, 2017).
Learners were proud of their achievements and wanted to share them with their peers and with the educators (SASL educator, interview, May 15, 2017).
The contributors to success included:
• The step-by-step explanations, and the fact that the learners implemented their new skills immediately; and
• The numbered steps on the green slides were in the same order as the explanations – this technique enabled the learners to work independently and at their own pace.</td></tr>
<tr><td rowspan="2">Conclusion</td><td colspan="4">Evidence of satisfaction</td></tr>
<tr><td>Usability
(effectiveness, satisfaction)</td><td></td><td>Emotional reaction
(pride, achievement)</td><td></td></tr>
</table>

7.7.3 Results: Researcher's observations

The SASL educator presented the programming lesson one afternoon after school in the second term. The next section provides a summary of the observations and experience of the researcher during the lesson presentation.

7.7.3.1 Classroom setup

Each learner had access to a laptop with Scratch installed. The SASL educator's personal computer was linked to an interactive whiteboard. The educator displayed the programming lesson (a PowerPoint presentation) that had been created by the researcher on the interactive whiteboard.

The learners' desks were arranged in a semi-circle so that they all had a clear view of the interactive whiteboard. Two other educators who assisted learners when they had to work on the laptops were present, as well as the researcher. The educators and the researcher stood behind learners so that they had a clear view of the screens of the laptops and could see when learners experienced difficulties when performing tasks.

7.7.3.2 Communication

The lesson was presented by the SASL educator using SASL, with no verbal communication. One educator translated comments made by learners, questions they asked and feedback provided by the SASL educator, since the researcher is not able to use or understand SASL. When learners had difficulty with the Scratch interface or wanted to do something that was not part of the lesson, the educators acted as translators between the learners and the researcher, who then provided assistance.

7.7.3.3 Lesson progression

The SASL educator introduced the lesson by reminding learners of the vocabulary lessons they had attended in the previous semester, and explained that they would be using all the words from that lesson to learn to write a computer program.

She used the programming lesson presentation to explain how the learners would have to pay attention to colours during the lesson. A blue slide contained important words that would appear in the explanation that followed, a grey slide indicated that learners should watch the educator and the whiteboard, and a green slide indicated that the learners should perform the task as explained on the slide. The educator emphasised that they would only be allowed to work when the green slide was displayed.

She explained that they would learn how to write a computer program, and asked if they could provide examples of a computer program. They were hesitant to answer, but did mention PowerPoint, Word, Excel and a ‘photo program’. One of the first slides in the presentation was linked to the program that the learners would learn to write during the lesson. The program contained three sprites. When the educator clicked on any of the three sprites on the interactive whiteboard, it displayed animation. (A crab opened and closed its claws, a frog jumped from side to side, and a fish grew bigger and then smaller using the fish-eye effect program block.) The learners laughed at the animation, and when the educator asked if they wanted to learn how to create such a program, they nodded their heads and one signed ‘I would like to do this.’

The lesson was designed to follow a specific ‘pattern’. First, learners were reminded of important words on a blue slide, for example, *stage*, *actor* and *script*, then a sequence of actions was demonstrated on grey slides, and finally a single green slide displayed the actions learners should perform by themselves.

New skills displayed on the grey slides required the learners to focus for a short time before they had to perform certain tasks. Most learners quickly adapted to the lesson structure and paid careful attention when the grey slides were displayed, waiting for the green slides before they worked on the laptops themselves. The educator repeated the questions learners asked before answering them.

Through the slides containing screenshots, text and animation, learners were guided to write the program that had been demonstrated to them in the beginning. They all succeeded in creating the complete program, with very few difficulties. A few slides contained questions and multiple-choice answers. Learners were called to the interactive whiteboard and had to touch the answers they thought were correct. When the correct answers were indicated, a slide was displayed with a positive image, namely a tick mark, or a smiley face, or an animation showing a happy face and a thumbs-up sign.

After 55 minutes the lesson was over, and learners received printouts of three different Scratch programs, as well as a set of notes containing the information they saw on the slides during the lesson.

The notes contained the basic information for creating a new program – how to add a new sprite, how to add a new background, and how to delete a sprite. Learners were told that they could choose the program they would like to create. One program was very easy, containing only one sprite and a new background, the second one contained one sprite with a few program blocks they had not used during the programming lesson, and the third program contained two sprites with a number of unfamiliar program blocks (including an If-statement).

Learners were very confident in creating the programs. Some only created one or two programs, but most of them completed all three programs. The three educators then acted as amanuenses and completed the questionnaires with each learner.

7.7.3.4 Classroom atmosphere

Before the class started, educators explained that Deaf learners usually do not express their emotions. They tend to be phlegmatic and do not easily express joy and happiness. However, the learners were very friendly when they entered the classroom and did not seem to mind having a stranger with them in the class.

They were all very alert and immediately paid attention to the educator when she indicated that the lesson would start. When they saw the animation on the example program they laughed and showed interest in what would follow. When they had to perform the first task, which was just to move a move-block to the script area and click on it so that the sprite would move on the stage, they were slightly hesitant. However, all of them immediately managed to perform the task. Once they had experienced success with more tasks, they seemed to gain confidence. They collaborated with one another and answered questions without any hesitation. They seemed to be very relaxed, enjoying the application of their new skills.

7.7.3.5 Learners' behaviour and display of emotion

At first, the learners seemed to be slightly hesitant, especially when the script for one of the sprites was displayed and they were told that they would be creating that. However, as the lesson progressed, and they saw that they were only expected to carry out small tasks, they relaxed and were very excited about what they were able to accomplish.

Behaviour and emotions that were often noticed were:

- Collaboration – the learners quickly helped the learners next to them if they did not manage to complete a task, and even reminded other learners to pay attention to the presentation when a grey slide was displayed.
- Participation and interaction – some learners read words out loud when they were displayed, or signed the words. They were eager to go to the front of the class and choose an answer when the questions were displayed. They called one another, the educators and even the researcher to demonstrate their programs once they worked.

Even after they had completed their programs and the questionnaires, some of them still stayed in class and discussed the programs with one another, even demonstrating how the frog jumped.

- Joy and excitement – some learners laughed out loud when they were able to create animation. They clapped hands; one threw his arms in the air when his program worked.
- Confidence – at first the educator had to call a learner to choose an answer when the question was displayed. Soon the learners volunteered and were eager to be the one to choose the answer (learners were not familiar with the way the interactive whiteboard worked). When they made mistakes in creating a script, they were not worried, they immediately asked for help and seemed very eager to get past the mistake so that they could continue.

Contrary to the initial expectation, learners were extremely involved and focused. They participated freely, often showing emotions and clearly enjoying the whole experience.

7.7.3.6 Comments from learners

All three educators translated comments learners made during the lesson. Some of the comments were the following (the learners used SASL, the educators translated the comments to Afrikaans, and the researcher translated those comments to English for the purpose of the dissertation):

- I would like to create this.
- This is very cute.
- Now we are going to teach learners at other Deaf schools to do this.
- I want to learn more about this [programming], so I can become an educator who can teach small children how to do this.
- Will she [the researcher] come back and teach us to do more?

7.7.3.7 Difficulties experienced during the lesson

The learners experienced very few difficulties with using the Scratch interface. There were small details of using the interface that were not mentioned in the presentation, for example, how to display the script of a sprite again after a new background had been selected or a sprite deleted. These problems were handled as they occurred and did not seem to upset the learners at all.

Two learners did not seem to know what to do when they had to create the programs provided. However, they were able to succeed once the educator showed them how to use the notes. The educator who presented the lesson commented that she had noticed that these two learners did not always pay attention during the explanations, and that this was normal behaviour for them – they were usually restless and easily distracted in class.

7.7.3.8 Indicators of a successful lesson

Despite not specifically determining indicators of a successful lesson prior to the implementation thereof, certain learner behaviours could be interpreted as potential indicators of success. These include:

- They immediately recognised words that they had learned in the vocabulary lessons. They either showed the sign for the word that appeared on the screen, or read the word out aloud. They even provided the Afrikaans equivalent for words displayed in English – for example, saying 'diere' when the word 'animals' was displayed.
- They realised what the function of the [repeat] block was – they correctly calculated that the frog would jump six times if a [repeat (3)] block was used, and the frog jumped once to the left and once to the right inside the [repeat] block.
- When they created the programs provided, they were able to find program blocks in a group they had not seen during the lesson, for example the [pen up] and [pen down] blocks from the Pen group, and the [pick random] block from the Operators group. This is an indication that they realised that the colour of a block is an indication of the group it can be found in.
- One learner called the researcher and communicated in SASL, which the researcher cannot interpret – but it was clear that he explained that the code in the script area, and specifically the [say] block was responsible for the mouse sprite displaying the word 'Ouch' in a pop-up when the cat sprite touched the mouse sprite.
- They challenged one another to complete all three programs.
- They had no difficulty in recognising any of the words they had learned in the vocabulary lesson.

7.7.3.9 Comments by the researcher

Before the lesson was presented, the educators warned the researcher not to expect too much display of emotion from the learners. According to them, people are often disappointed when they speak to learners at the school, because the learners do not laugh at their jokes, and it seems as if the learners are not interested. The educators were of the opinion that Deaf learners are used to not knowing exactly what a conversation is about, and that they preferred not showing what they feel for fear of not acting appropriately (personal conversation, May 3, 2017).

However, the reaction of the learners during the lesson was completely the opposite of what had been predicted. They collaborated with one another, participated in the lesson, and often displayed feelings of joy and excitement. From the ease with which they completed tasks and created the provided programs at the end of the lesson, it was clear that they had mastered the required vocabulary and the basic skills of programming presented in the programming lesson.

The entire experience of creating and seeing the programming lesson presented was extremely satisfying.

7.8 Synthesis

In the next sub-sections, the main responses from all the data sources that provide evidence of the four UX aspects (usability, accessibility, emotional user reaction and hedonic aspects) are reported on.

7.8.1 Evidence of usability and accessibility

Design guidelines that improve the accessibility of the lessons usually also contribute to improved usability (researcher's interpretation). Therefore, the main responses that provide evidence of usability and accessibility are reported on together in this section.

In this project, usability was more relevant to learners using the vocabulary lesson, and to the educators using the programming lesson.

For the vocabulary lesson, the following suggestions with regard to usability and accessibility can be made based on the evidence from learners' and educators' responses, as well as the researcher's observations:

- It was easy to navigate to the slides learners wanted, probably because icons were used that were familiar to the learners.
- The colours that were used in the slides were pleasing.
- It was easy to read the text on the slides, mainly because the letters were big enough and there were only a few words on a line.
- The use of pictures to illustrate a word helped the learners to understand and remember the words better, and they liked a photo or an animation more than a cartoon.

- The text used in the sentences was at a suitable level, with only a few learners who reported that there were words they did not understand.
- The use of colour codes to indicate verbs and nouns was successful.
- The SASL sentences were instrumental in the learners understanding the meaning of the words, and when learners realised that could choose the order in which they viewed the slides, most of them chose to view the SASL sentence first.
- The variety of formats used to represent a word helped the learners to understand and remember the meaning of the words.
- The learners remembered the meaning of the words from the vocabulary lessons very well, even though the programming lesson was presented many weeks after they had last seen the vocabulary lessons. A possible contributor to this success might be that the words were taught in context through the 'stories' where each new word was used in a sentence, and the sentences read in sequence created a story.
- The learners were able to control the pace and order of the lesson, which is an advantage of using technology.

The only aspect of the vocabulary lessons about which the learners and educators seemed to disagree was the use of fingerspelling icons to write the words. The learners reported that having the words written in fingerspelling helped them to remember the word better – the majority indicated the option "I remember a new word better if I see it written in two different ways". However, the educators said the learners were not used to seeing complete words spelled with fingerspelling icons and it is not a skill that forms part of any curriculum. Fingerspelling is used as part of sign language to spell, for example, names of places and people, and also to spell words for which a sign does not exist. Therefore, fingerspelling is usually seen in three dimensions, and not as a two-dimensional icon. Educators also said that the time and effort involved in including fingerspelling in the lessons are not worth the (possible) improvement in understanding (interview with educators, May, 2017).

Educators noticed that the learners initially viewed the vocabulary lesson slides in the order in which the icons appeared on the slides (from top to bottom). So, they viewed the Afrikaans text first, and the SASL video last. When educators pointed out to them that they could watch the slides in any order, most of them watched the SASL video first. Therefore, the usability of the vocabulary lessons could be improved by adding a slide at the beginning that explains to learners that they could view the slides in any order.

For the vocabulary lesson, the following suggestions with regard to usability and accessibility can be made, based on the evidence from learners' and educators' responses, as well as the researcher's observations:

- Pleasing colours were used in the slides.
  The use of colour-coded slides (blue, grey and green) assisted the learners with their organisation of knowledge, and reduced distractibility. Learners knew when to focus on the new knowledge and skills presented, and when to apply their new knowledge.
- It was easy to read the text in the slides, mainly because the letters were big enough and there were only a few words on a line.
- The language used in the programming lesson's slides was satisfactorily simplified.
- The learners loved the animated emoticon that was displayed in response to a correct answer.
- The printed notes that learners could consult when they had to create programs themselves were useful. A possible reason for the usability is that the notes contained the same pictures and icons as the slides in the programming lesson. The steps to follow were numbered and the notes were printed in colour.
- Various factors contributed to the success of the programming lesson, including:
  - The information being presented in small 'chunks'.
  - Ample opportunity for learners to apply their new knowledge and skills (active learning).
  - Pictures, colours and animation that assisted in organising information.
  - The use of an interactive whiteboard where the spot the learner should click on was clearly indicated by the educator who touched the relevant spot with the electronic pen.
  - The lesson was presented in SASL by an educator whose first language is SASL.
  - Learners learned the vocabulary relevant to programming or needed as background knowledge before they attended the programming lesson.

The results obtained indicate that the learners and educators had a satisfactory user experience as far as usability and accessibility were concerned. They found the lessons to be easy to learn, memorable and effective, and in general they were satisfied while and after using and attending the lessons.

7.8.2 Evidence of emotional user reaction

For the vocabulary lesson, the following suggestions with regard to emotional user reaction can be made based on both the learners' and the educators' responses:

- Learners were confident and excited when they applied the vocabulary lessons.
- They found the lessons interesting and fun.
- They enjoyed doing the lessons.
- The lessons encouraged collaboration between the learners.

For the programming lesson, the following suggestions with regard to emotional user reaction can be made based on the learners' and educators' responses, as well as on the researcher's observations:

- Learners were confident and excited while they attended the programming lesson.
- They found the lesson interesting and fun.
- They enjoyed being active in the lesson, completing the required activities and answering questions.
- They experienced success and were proud of their accomplishments.
- They enjoyed collaborating and helping one another.
- The learners found it easy to follow the instructions and were motivated to complete the activities by themselves.
- The learners appreciated the educator's patience.
- Learners had the courage to attempt new skills thanks to having experienced success.

The results obtained indicate that the learners and educators experienced positive emotional reactions during and after the lessons, and therefore had a satisfactory user experience as far as emotional user experience is concerned.

7.8.3 Evidence of hedonic aspects

For the vocabulary and programming lessons, the following suggestions with regard to hedonic aspects can be made based on the learners' and educators' responses, as well as the researcher's observations:

- The use of fingerspelling icons in the lessons made the learners feel as if the lessons were created specifically for them (positive communication of identity).
- The use of SASL videos in the vocabulary lessons and the programming lesson encouraged learners' identification with the content.

- The familiar scenarios (camping story and TV and concert story) contributed to the learners' identification with the content of the vocabulary lessons.
- The opportunity to apply new skills, the interactivity of the lessons and the success the learners experienced provided stimulation.
- Learners could still recall all the vocabulary lessons by the time the programming lesson was presented (sufficient evocation).

7.9 Recommendations

Based on the feedback and analysis from all data sources, recommendations regarding the usability of the vocabulary lessons and the format of the learners' questionnaires can be made.

7.9.1 Improving the usability of the vocabulary lessons

The responses to question 10 (Table 7.12) in the questionnaire on the vocabulary lessons indicated that the learners believed the SASL sentences were the most helpful to them when they had to learn the meaning of new words. According to the responses to question 11 (Table 7.13), they liked the SASL sentences and pictures the most. However, the responses to question 1 (Table 7.3) seem to indicate that most learners viewed the slides in the order in which the options were displayed on the menu slides of each word. Therefore, the *learnability* - and therefore the usability - of the vocabulary lessons can be improved by providing clear instructions at the beginning of each vocabulary lesson to demonstrate to learners that they could view the options for each word in the order they preferred.

7.9.2 Improving the questionnaires

The educators found it difficult to translate the concepts 'What did you *like* the most in the lesson?', versus 'What *helped* you the most in the lesson?'. They said it was impossible to make a clear distinction between the two concepts in SASL, and the learners found it difficult to express what helped them and what they liked. Knowing what helped them refers to metacognition. Many researchers have referred to the fact that metacognition is a challenge for Deaf learners.

It could therefore be suggested that the questions in the questionnaire for learners should be unambiguous and standardised so that responses to all questions are the same. The learners should preferably be given a limited number of responses to choose from. Also, icons could be used so that learners can indicate their response to questions. Examples of such questions are:

How would you feel if there were no videos of the SASL sign in the vocabulary lessons?	☹	😐	☺
How would you feel if there were no Afrikaans sentences in the vocabulary lessons?	☹	😐	☺

The researcher would then be able to obtain statistics about specific aspects instead of leaving it up to the learners to apply metacognition and indicate which factors might have been contributors to success.

It is recommended, however, that a few open-ended questions still be included where learners can state their own ideas and feelings.

7.10 Conclusion

In this research project, four UX elements have been identified to evaluate the UX of the DHH learners and the two educators who have been involved in the project. These UX elements were usability, accessibility, emotional user reaction and hedonic aspects. The various factors that could influence a person's UX were not taken into consideration when the UX of the DHH learners was evaluated.

Three sources of data were analysed to determine to what extent the users (learners and educators) had a satisfactory UX. The data sources were processed as follows:

- Learners' questionnaires: The learners' responses to each question were summarised in table form. Some of the results were reported by means of descriptive statistics. The responses to each question were analysed and the analysis was presented as a short narrative. Based on all the analyses, a conclusion was made that indicated the UX element(s) that were implicated by the responses. Colour coding was used to indicate whether the final evidence indicated satisfaction or dissatisfaction with the relevant UX element(s) (green text and shading indicated satisfaction, and red text and shading indicated dissatisfaction). The results, analysis and conclusion for each question are provided in Tables 7.3 to 7.27.
- Interviews with educators: All educators' responses to all the questions were translated from Afrikaans into English, and summarised in table form in a Word document (this document is available as Document 10 in the electronic appendix submitted with this dissertation). In section 7.7.2, these responses were analysed and grouped per question, and feedback and analyses were presented as short narratives. Based on each

analysis, a conclusion was made that indicated the UX element(s) that were implicated by the responses. Colour coding was used to indicate whether the final evidence indicated satisfaction or dissatisfaction with the relevant UX element(s) (green text and shading indicated satisfaction, and red text and shading indicated dissatisfaction). The feedback, analysis and conclusion for each question are provided in Tables 7.28 to 7.45.

- Researcher's observation: A narrative has been created describing, inter alia, the classroom setup and atmosphere, as well as the lesson progression and learners' behaviour (section 7.7.3).

Theme analysis was done, taking all the results, analyses and conclusions into account, and a synthesis of the results was presented in section 7.8.

In reviewing the results obtained from the learners' questionnaires, interviews with educators, and the observation notes of the researcher, it can be concluded that the evaluation of the four usability elements – usability, accessibility, emotional user interaction and hedonic aspects – shows evidence of a satisfactory user experience. Therefore the guidelines that were developed and applied to create both the vocabulary and programming lessons to teach basic programming principles to Deaf and Hard of Hearing learners were appropriate.

7.11 Summary

The main focus of this chapter was to present the results of the research process. The chapter set out by providing background to the school for the Deaf where the research project was conducted. It then gave a technical overview regarding the recording and processing of the video clips that were used in the vocabulary lessons, as provided by the technical assistant who created the videos.

The results of the secondary research strategy (prototype construction) were the set of guidelines for creating technology-supported lessons to teach DHH learners programming principles, as well as the high-fidelity, fully functional prototype. The guidelines were presented in section 7.4. The prototype can be viewed in Documents 15 to 18 in the electronic appendix that was submitted with this dissertation.

The three UX evaluation methods that were used in this research project were discussed, and the biographical data of the learners who participated in the project was provided.

The result of the secondary research strategy (case study) was the data obtained from the UX evaluation done by the learners and educators who took part in the project, as well as the observation report by the researcher. The data of these three data collection instruments were presented in section 7.7. Data from the learners' questionnaires and educators' interviews were presented per question in tables. An analysis and conclusion were provided, using colour codes to indicate satisfaction, or dissatisfaction. The researcher's observations were presented as a narrative.

A thematic analysis of the results was done, and presented as evidence of the four UX elements that had been evaluated (section 7.8).

Finally, recommendations were made on the way the usability of the vocabulary lessons could be increased, and how the questionnaires could be compiled.

The next chapter is the final chapter of this dissertation. It contains answers to the research questions, the limitations of the study, the significance and contributions of the study, and finally lists the lessons learnt while conducting the research, and suggestions for future research using the knowledge emanating from this project.

Chapter 8

Conclusion and recommendations for future research

Introduction

- Chapter 1: Introduction

Literature study

- Chapter 2: Unique learning challenges, strengths and needs of Deaf or Hard of Hearing individuals
- Chapter 3: User experience design and evaluation
- Chapter 4: Technology-supported teaching and learning

Research Design

- Chapter 5: Research process

Guidelines

- Chapter 6: Guidelines and technology-supported lessons

Results and analysis

- Chapter 7: Results and analysis

Conclusion

- Chapter 8: Conclusion and recommendations for future research

Chapter 8

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8.1 Introduction

The purpose of this research project was to:

- Develop a set of guidelines for the development of technology-supported lessons to teach programming principles to Deaf and Hard of Hearing (DHH) learners at a school for the Deaf,
- Apply these guidelines to develop a high-fidelity, fully functional prototype – a set of technology-supported lessons, and then
- Present the lessons and evaluate the user experience (UX) of the DHH learners and educators who were involved, during and after the learner completed the lessons.

In this chapter, the problem statement and research questions in Chapter 1 are revisited based on the knowledge gleaned from the literature reviews, and the results of the UX evaluations by participants. This will act as evidence that the project achieved its purpose.

The chapter commences by providing an updated diagram illustrating the components of the project design. The diagram is similar to Figure 5.1, but contains references to the chapters and/or sections where each aspect of the project design was addressed. Thereafter, the main as well as the three sub-research questions are listed. For each sub-research question, the question itself and the corresponding research objective are stated. The findings of the relevant sub-research question are discussed, and evidence is provided to prove that the sub-research question has been answered through the research process followed in this project.

The limitations of the study are presented, and the significance and contributions of the study are highlighted. Finally, the chapter lists the lessons learnt while conducting the research, and suggests future research that can emanate from this project.

8.2 Research overview

An update of Figure 5.1 that provided an overview of the project design is presented in Figure 8.1. This figure supplies references to the chapters and/or sections where each aspect of the project design was addressed.

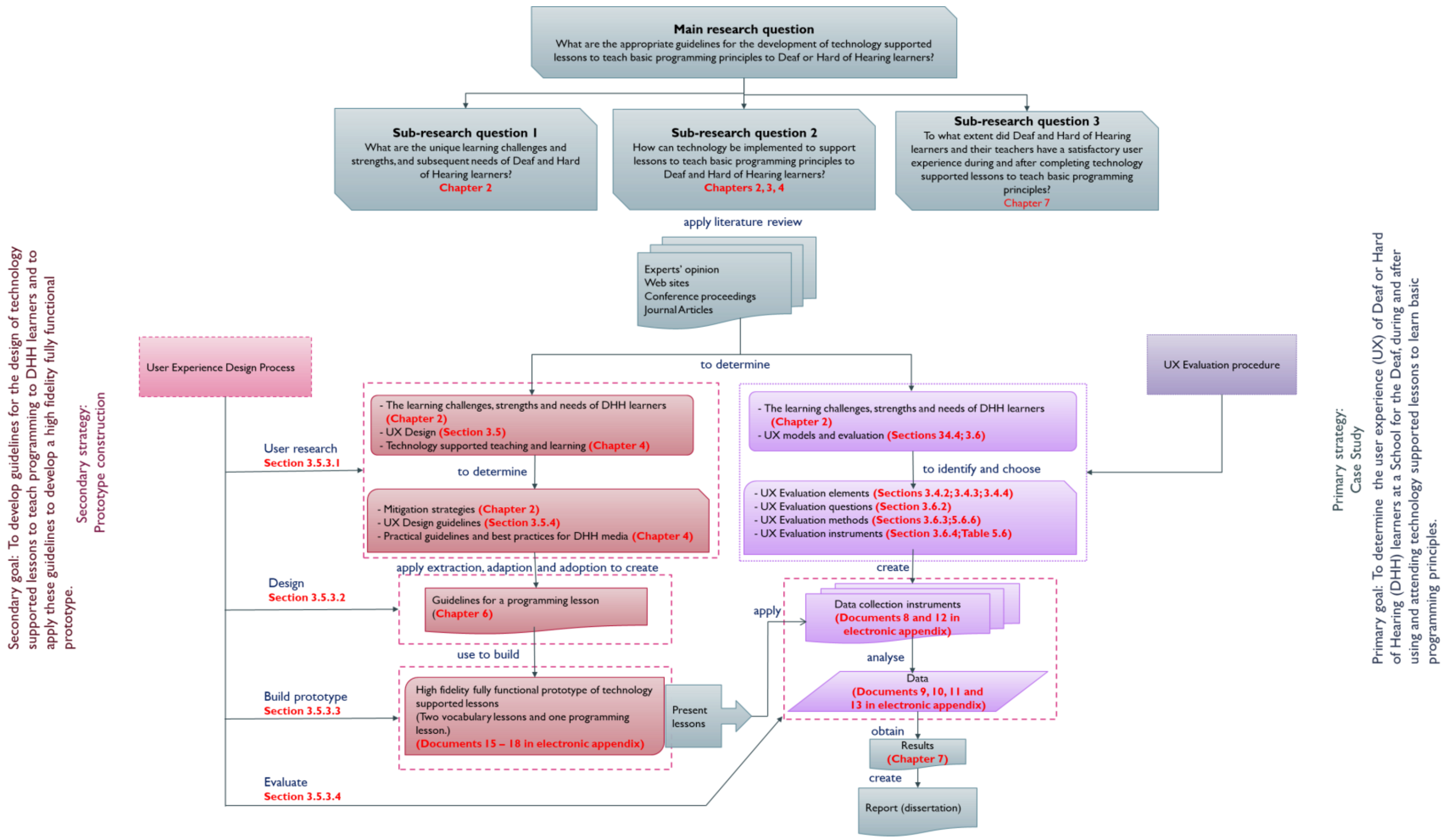

Figure 8.1: Overview of the project design with references

8.3 Research questions and objectives

In Chapter 1, the problem that this research project wanted to solve was described. The following problem statement was defined:

> *What are the appropriate guidelines for the development of technology-supported lessons to teach basic programming principles to Deaf and Hard of Hearing learners?*

Based on the problem statement, a set of research questions and related objectives were identified. In this section, findings on the research questions and related objectives stated in Chapter 1 are presented.

8.3.1 Main research question

The main research question for this research project was:

> *What are the appropriate guidelines for the development of technology-supported lessons to teach basic programming principles to Deaf and Hard of Hearing learners?*

The primary objective of this research project was to determine whether the guidelines that have been designed to develop technology-supported lessons to teach basic programming principles to Deaf and Hard of Hearing learners are appropriate.

This main research question was answered through addressing three sub-research questions and corresponding objectives. These are discussed below.

8.3.2 Sub-research question 1

8.3.2.1 The question

What are the unique learning challenges and strengths, and subsequent needs of Deaf and Hard of Hearing learners?

8.3.2.2 Corresponding research objective

To identify the unique learning challenges and strengths, and subsequent needs of Deaf and Hard of Hearing learners.

8.3.2.3 Findings on sub-research question 1

Through literature review, the following was determined:

DHH learners have the same capacities as hearing learners. However, their literacy levels (reading, writing and mathematical abilities) are far below the average of the population. There are cognitive differences between DHH and hearing learners, and even between DHH learners themselves. Some learners have multiple barriers to learning that include developmental, intellectual, sensory, physical, social and economic disabilities. DHH learners usually experience learning challenges in the following areas: Comprehension skills, application of knowledge and knowledge organisation, relational and individual-item orientations, metacognition, memory, and distractibility.

One of the strengths of DHH learners is that they have better visuospatial memory, and the ability to generate and manipulate mental images. These learning challenges, strengths and subsequent needs of DHH learners were discussed in detail in Chapter 2.

It was also determined that it is not sufficient to simply remove communication barriers when developing learning material for DHH learners. The diversity of, and learning needs of the DHH population, justify that learning material should be specially developed for DHH learners, providing for their needs and capitalising on their strengths. This issue was addressed in sub-research question 2.

8.3.3 Sub-research question 2

8.3.3.1 The question

How can technology be implemented to support lessons to teach basic programming principles to Deaf and Hard of Hearing learners?

8.3.3.2 Corresponding research objective

To create guidelines for the design of technology-supported lessons to teach basic programming principles to Deaf and Hard of Hearing learners.

8.3.3.3 Findings on sub-research question 2

A user experience design (UXD) process was followed to create a set of guidelines for developing technology-supported lessons to teach basic programming principles to DHH learners. The UXD process included a user research phase. This research led to:

- Strategies to mitigate the learning challenges identified in answering sub-research question 2 (Chapter 2).
- UX design guidelines (section 3.5.4).
- Practical guidelines and best practices when designing media for DHH individuals (Chapter 4).

Through a process of extraction, adaption and adoption, a set of practical guidelines was developed. The guidelines were applied to develop a high-fidelity, fully functional prototype

– a set of lessons to teach basic programming principles to DHH learners. These lessons consisted of:

1. Two vocabulary lessons – MS PowerPoint presentations.
2. An introduction, which is a video clip (in mp4 format), explaining to learners how to use the vocabulary lessons. The explanation is signed in South African Sign Language (SASL).
3. One programming lesson – an MS PowerPoint presentation.

The words that were taught in the vocabulary lesson were either terms appearing in the interface of Scratch, or words needed in the explanation of programming principles and Scratch context.

A complete description of each guideline with indications of the way it was implemented in creating the prototype for this project were presented in Chapter 6. The complete guidelines to develop technology-supported lessons to teach basic programming principles to DHH learners are displayed in Table 8.1.

Table 8.1: Guidelines for the development of technology-supported lessons

Guidelines for interface and navigation
Guideline 1
Present information and components in ways that enable DHH leaners to recognise them, and to find it possible and desirable to use them, for example: 1.1. Make navigation visible, and controls recognisable and large enough to operate easily. 1.2. Use text and icons. If icons alone are used, explain them to the learners beforehand. 1.3. Be consistent with the layout of the pages.
Guideline 2
The design should be aesthetically pleasing and minimalistic, for example: 2.1. Use readable and understandable text. 2.2. Use clean typography. 2.3. Minimise distracting clutter. 2.4. Use colour contrasts to separate the foreground from the background. 2.5. Use visual and semantic white space. 2.6. Provide enough space between lines of text.

Guidelines for communication and support
Guideline 3
Use big screens, projectors and other visual aids to assist communication.
Guideline 4
When creating video clips, visual distractions that would interfere with the interpreter should be avoided; specifically. 4.1. The background should be monochrome and subtle. 4.2. An interpreter with a dark complexion should be placed in front of a lighter background and wear light-coloured clothes. Fair-skinned interpreters should be placed against a darker background, and wear darker clothes. 4.3. Gestures should be within a box parameter – not above the head, and not below the waist.
Guideline 5
When creating video clips involving sign language, use a local person who can sign the language used by the learners who will view the videos.
Guideline 6
Include multiple communication elements when explaining a new concept, for example: Text, fingerspelling, picture or animation, a SASL gesture, and a SASL sentence.
Guideline 7
Use visual organisers to review important information or display the order of steps to complete a task. Visual organisers can include animation, pictures or photographs.
Guideline 8
Language should be modified and simplified, and it must be easy to read and understand the text and content: Therefore: 8.1. Formulate fairly short sentences with a relatively simple structure. 8.2. Replace high-level carrier language with lower-level alternatives. 8.3. Use language that the learners are familiar with, or provide definitions. 8.4. Replace passive verbs with active verbs. 8.5. Remove superfluous (unnecessary) language. 8.6. Remove ambiguity. 8.7. Format text using bullets, spacing, brackets, and italics.
Guideline 9
Use colours, shapes and icons to organise information and educational units.

Guideline 10
Use animated cartoons for positive or negative feedback to learners.
Guidelines for the educator's role and attitude
Guideline 11
If learners have to use electronic learning material on their own, ensure that they are able to navigate the lesson.
Guideline 12
The educator and/or the interpreter should be skilled communicators and must be well-prepared. Therefore: 12.1. Ensure that learners and the educator and/or the interpreter are able to use specialised subject-related vocabulary using either signs or fingerspelling the words. 12.2. Interpreters need to have some subject knowledge – for example, basic knowledge of programming.
Guideline 13
Ensure that the learners follow the instructions and are able to carry them out in the correct sequence – provide explicit guidance: 13.1. If an interpreter is used, the educator should wait for the interpreter to finish before continuing, and allow sufficient time for learners to read the information (if applicable). 13.2. Maintain eye contact with learners to ensure that they follow the instructions. 13.3. Give instructions slowly, step by step. 13.4. Repeat instructions if some learners did not understand or follow. 13.5. Consider each learner's difficulties and deal with them individually.
Guidelines for the lesson structure
Guideline 14
Teach new vocabulary first, before presenting the programming lesson.
Guideline 15
Teach vocabulary related to programming by referring to concepts learners already know, and teach the words in context.
Guideline 16
The material presented to the learners must be linked to what they have experienced and seen before.

Guideline 17
Engage students cognitively. Therefore: 17.1. Use minds-on activities and apply active learning principles. 17.2. Add questions often during the lesson to ensure that learners are on track.
Guideline 18
Focus on providing practical information.

The lessons can be viewed in the electronic appendix supplied with this dissertation. (Documents 15 - 18).

8.3.4 Sub-research question 3

8.3.4.1 The question

To what extent did Deaf and Hard of Hearing learners and their educators have a satisfactory user experience during and after completing technology-supported lessons to teach basic programming principles?

8.3.4.2 Corresponding research objective

To evaluate the user experience of the learners and educators after completing the lessons.

8.3.4.3 Findings on sub-research question 3

A UX evaluation procedure was followed to create data collection instruments. Various UX models and UX evaluation best practices were reviewed. Taking the learning challenges, strengths and needs of DHH learners into consideration, the following were identified and created:

- The UX evaluation elements that were to be evaluated in this project. These elements were: Usability, accessibility, emotional user reaction, and hedonic aspects (sections 3.4.2; 3.4.3; 3.4.4).
- The type of evidence (UX evaluation questions) that need to be addressed for each UX element (section 3.6.2).
- The UX evaluation methods to be used (sections 3.6.3, and 5.6.6). It was decided to use questionnaires, semi-structured interviews, and observation notes.
- UX Evaluation instruments (section 3.6.4 and Table 5.6). Learners completed two questionnaires (one on the vocabulary lesson, and another on the programming lesson). A semi-structured interview was conducted with both the SASL educator, as well as the CAT educator, and the researcher observed the participants' behaviour during the

programming lesson. The semi-structured interview guidelines and questionnaires are available in the electronic appendix for this dissertation (Documents 8 and 12).

Learners at the school for the Deaf had access to the vocabulary lessons during the second term of the school year. They could view the lessons during various classes at the school. In the third term of the school year, the programming lesson was presented by the SASL educator after having received training from the researcher in the use of Scratch and the programming lesson. The evaluation instruments were used to obtain data. The data was processed through theme analysis and tabulating data. Details of the responses and analysis thereof are presented in Chapter 7.

After reviewing the results obtained from the learners' questionnaires, interviews with educators, and the observation notes of the researchers, it was concluded that the evaluation of the four usability elements – usability, accessibility, emotional user interaction and hedonic aspects – shows evidence of a satisfactory UX. Therefore, the guidelines that were developed and applied to create both the vocabulary and programming lessons to teach basic programming principles to Deaf and Hard of Hearing learners were appropriate.

8.4 Limitations of the study

Only learners from one school for the Deaf were involved in the research project.

Learners received assistance in completing the vocabulary lessons, and they had the opportunity to work on the lessons independently – either at home or during class time. However, no formal assessment was done to determine whether the learners mastered all the vocabulary before the programming lesson was presented.

The programming lessons contained questions that learners had to answer in class during the lesson (formative assessment). However, no formal, summative assessment was conducted to evaluate the knowledge and skills of learners after completing one programming lesson. At the end of the programming lesson, learners received complete programs with limited instructions. They could copy these programs, and their interaction with the programming language and one another was observed.

Therefore, the focus was on the UX of the learners – which included usability, accessibility, emotional user reaction and hedonic aspects (as identified in Chapter 3). Learners completed questionnaires to determine their UX of both the vocabulary as well as the programming lessons.

Informal observations were done by the researcher, and in the semi-structured interview with the two educators, they had the opportunity to express their opinions on the level of skills they observed during the programming lesson.

The various factors that can influence a person's UX were not taken into consideration when the UX of the DHH learners was evaluated. The guidelines that were developed did not intentionally make provision for any learning challenge, barriers to learning, or disability other than severe hearing loss.

8.5 Significance and contributions of the study

As explained in Chapter 4 (section 4.3), a number of researchers have reported on projects where e-learning projects for people with hearing loss have been created. However, most of these projects focussed on teaching sign language, or improving reading comprehension. The lessons were also implemented purely as e-learning, usually using specialised software and technology. The present research made provision for the South African context where limited technology is available at most schools for DHH learners, but where most educators have access to Microsoft Office applications – specifically MS PowerPoint.

Therefore, this research project provides guidelines on the way technology-supported lessons can be designed to:

- Mitigate learning challenges and
- Ensure a positive UX.

These guidelines refer to techniques and principles that can be followed to:

- Design the interface and navigation tools of a technology-supported lesson
- Enhance communication with DHH learners, and provide support for them to work independently;
- Specify the educator's role and attitude when facilitating or presenting programming lessons;
- Structure a programming lesson.

The research also contributes to the field of UX evaluation, since there are no specific evaluation criteria or formal best practices available to evaluate the UX of DHH learners.

8.6 Lessons learnt

The researcher is not able to use SASL. Therefore, it was of extreme importance to involve persons who are fluent in SASL and who would be considered as credible in the deaf community, to be involved in the project. The researcher believes the following are factors that contributed to the success of the research project, and should therefore be taken into consideration when a similar project is planned:

- The attitude of the head of the institution: The School of the Deaf had a very positive attitude regarding research. The principal supplied valuable information, and supported the educators involved to participate in the project.
- The attitude of the educators involved: The educators involved were enthusiastic and volunteered to be part of the project. They saw it as an opportunity to acquire new knowledge and skills themselves.
- Skills of the educators involved: Both educators were able to use SASL. One of the educators is a Child of Deaf Adults (CODA). She is a hearing person, but her first language is SASL, therefore she is extremely fluent in SASL, and was able to suggest signs for new terminology based on correct SASL grammar and rules. Both educators are computer literate, and have background knowledge of programming. It was therefore very easy to teach them to use Scratch.
- Collaboration with educators: While developing the prototype, the educators were involved in tasks such as confirming which words would most likely not be familiar to learners, writing the sentences for the vocabulary lessons, signing sentences and words for the SASL videos. They also provided valuable comments when they were trained to present the programming lesson.
- The technique used to complete learners' questionnaires: DHH learners have difficulty reading and interpreting questions, and therefore the use of skilled amanuenses was extremely successful.

Another important lesson learnt was that the way in which questions are presented to DHH learners in a questionnaire should be unambiguous. They should preferably be given a limited number of responses to choose from. The open-ended questions in their questionnaires did provide interesting comments, such as their appreciation for the way the educator explained the work and her patience, or the fact that they would like to learn more about programming so they could find work overseas. However, learners for example, found the following questions confusing:

What *helped* you most to learn the new words?

What did you *like* most about the vocabulary lessons?

The amanuenses also reported that it was difficult to interpret the words *helped*, and *liked* in SASL so the understanding was clear to learners.

It would therefore be more effective to rephrase and standardise the questions so that responses could be the same for every question. For example, use emoticons so that learners can indicate their feelings with regard to a statement. Examples of such questions are:

How would you feel if there were no videos of the SASL sign in the vocabulary lessons?	☹	😐	☺
How would you feel if there were no Afrikaans sentences in the vocabulary lessons?	☹	😐	☺

The researcher would then be able to obtain statistics about specific aspects instead of leaving it up to the learners to apply metacognition and indicate what might have been contributors of success.

8.7 Recommendations for future research

The lessons were only presented in one school for the Deaf, and the programming lesson included very basic skills. Future research can include the following:

- Presenting the lessons at another school for the Deaf and evaluating the UX of the learners and educators.
- Applying the guidelines to develop programming lessons including more skills, such as doing calculations using variables, apply decision structures (If … then … else statement), or creating animation using loops. This can provide an indication of the level of programming that DHH learners can accomplish.
- The vocabulary lessons can be taught to one group of learners, while a control group be taught the same vocabulary using 'traditional' methods. Formal assessment can then be done to evaluate the success of vocabulary lessons presented in the format used in this research project.
- Formative assessment can be conducted after presenting the programming lesson to determine the level of skills and knowledge of the DHH learners.

- The guidelines can be applied to create lessons on topics other than basic programming principles, and the UX can be evaluated. The researcher is of the opinion that the guidelines are not limited to teaching programming principles only.

8.8 Conclusion

The main research question for this research project was:

> *What are the appropriate guidelines for the development of technology-supported lessons to teach basic programming principles to Deaf and Hard of Hearing learners?*

The primary objective of this research project was to determine whether the guidelines that have been designed to develop technology-supported lessons to teach basic programming principles to Deaf and Hard of Hearing learners are appropriate.

The final chapter of this dissertation therefore provided answers to each of three sub-research questions that emanated from the main research question.

By having supplied sufficient answers and evidence to each question, it can be claimed that appropriate guidelines were developed to create technology-supported lessons to teach basic programming principles to DHH learners. It can therefore also be claimed that the research achieved the goal it set out to achieve.

Electronic appendix

The following link provides access to a Dropbox folder that contains the electronic appendix for this dissertation.

https://www.dropbox.com/sh/wmlkvqut4gfgjoy/AAByHc0Wtltdojl_kwtg0s7ca?dl=0

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