Ashesi University College

Enabling Sign Language Instruction with Technology: the Case of

Developing a Computerized Learning Tool for Ghanaian Sign

Language (GhSL)

Diana Dayaka Osei

2012

ASHESI UNIVERSITY COLLEGE

ENABLING SIGN LANGUAGE INSTRUCTION WITH TECHNOLOGY: THE CASE OF DEVELOPING A COMPUTERIZED LEARNING TOOL FOR GHANAIAN SIGN LANGUAGE (GhSL)

By

DIANA DAYAKA OSEI

Thesis submitted to the Department of Computer Science, Ashesi University College

In partial fulfillment of Bachelor of Science degree in Computer Science

APRIL 2012

DECLARATION

I hereby declare that this thesis is the result of my own original work and that no part of it has been presented for another degree in this university or elsewhere.

Candidate's Signature: ………………………………………………………………………

Candidate's Name: ………………………………………………………………………

Date: ………………………………………………………………………………………

I hereby declare that the preparation and presentation of the dissertation were supervised in accordance with the guidelines on supervision of thesis laid down by Ashesi University College.

Supervisor's Signature: ……………………………………………………………

Supervisor's Name: ………………………………………………………………………

Date: ………………………………………………………………………………………

ACKNOWLEDGEMENTS

ABSTRACT

Ghanaian Sign Language (GhSL) is a developing language in the sense that not much is known about it within or outside Ghana. The fact that GhSL is closely-related to American Sign Language (ASL) means that, knowledge of ASL can help one communicate with the Ghanaian Deaf. However, there exist Ghanaian-specific signs that are not available in ASL. This paper presents the Ghanaian Interactive Sign Language (GISL) Tutor, the first computer-based tutor for GhSL designed to teach GhSL vocabulary of Ghanaian-specific signs. Ghanaians who tested the tutor during its iteration stage expressed that they want more Ghanaian signs to be available on the tutor. The purpose of the GISL Tutor is therefore to make Ghanaian-specific signs accessible to anyone interested in learning GhSL for reception and expression.

Keywords: computer-based technology, Ghanaian sign language instruction, receptive/expressive learning, Ghanaian signs, hand shapes, signing, fingerspelling

CONTENTS

LIST OF ACRONYMS

Acronym	Meaning
ASL	American Sign Language
SL	Sign Language
GNAD	Ghana National Association of the Deaf
UEW	University of Education, Winneba
GhSL	Ghanaian Sign Language
CAI	Computer-aided instruction
CALL	Computer Assisted Language Learning
GISL	Ghana Interactive Sign Language

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

A sign language is a language which allows the user to communicate using the hands instead of sound - simultaneously combining hand shapes, orientation and movement of the hands, arms or body, and facial expressions to fluidly express a speaker's thoughts. The sign language remains nevertheless a fully-fledged language, with its own constructional method of the sentences.

Ghanaian sign language (GhSL), unlike American Sign Language (ASL), is a developing language and is yet to acquire the structure and form that will make it a fully-fledged language. The origins of GhSL can be traced to Rev. Jackson Foster, a Deaf[1] African American educator from Gallaudet University, who started a Special School for the Deaf in Ghana, located at Osu, in 1957 to teach Deaf Ghanaians ASL [37]. When he left the scene, Ghanaians adopted ASL. Mr. Oppong, author of a GhSL textbook, defines GhSL as ASL adapted to suit "local and cultural conditions" [37]. Equation 1.1 below summarizes the concept of GhSL:

$$GhSL = ASL + Cultural\ Variation \quad (1.1)$$

---

[1] The word "Deaf" is written with a capital D in line with conventions of describing persons in whom the sense of hearing is non-functional for the ordinary purposes of life.

Nevertheless, GhSL presently remains a developing language because as Dr. Akanlig-Pare[2] describes, it does not have the syntax and the other linguistic features needed to render it a complete language.

As Mr. Fiah Worlanyo, a teacher at the Demonstration School for the Deaf, stated during a phone interview, that some Deaf Ghanaians without formal education continue to use a crude form of sign language (SL). Without a standard way of communicating, the Deaf in Ghana have difficulty expressing their thoughts to members of the hearing community in Ghana. There is the need to standardize GhSL and make it an official lingua-franca for the Deaf in Ghana. Efforts are being made by institutions like the Ghana National Association of the Deaf (GNAD) and University of Education, Winneba (UEW) to promote the *correct* use of SL in Ghana and to train more people, especially hearing persons, in SL. GhSL instruction in Ghana is important because it will help lead to the creation of a more inclusive society as more Ghanaians gain awareness about Deafness and the benefits of SL (see Appendix A). Knowledge of SL among more hearing people in Ghana will also help mainstream schools that are implementing the Ghana Education Service's (GES) Strategic Plan of Inclusive Education by 2015 [38]. An inclusive society will help Deaf Ghanaians overcome the communication barrier they face.

Traditionally, SL has been taught from person to person or in a classroom setting. Effective SL instruction needs to teach sign recognition and sign

---

[2] Dr. Akanlig-Pare is a GhSL lecturer at the University of Ghana, Legon; see section 3.1

generation. Learning materials used in a traditional SL instruction setting include textbooks, charts and illustrations with arrows showing how to make the signs. UEW is the only institution in Ghana that trains teachers, parents, opinion leaders and other stakeholders in sign language, equipping them to serve as interpreters for communities of individuals that are Deaf and that are hearing [36]. The traditional means of GhSL instruction is limited in its capacity to reach many hearing Ghanaians who may be interested in learning SL. However, the potential for using technology as a tool for GhSL literacy has not been fully explored. According to Mr. Oppong, the first attempt to use videotape technology to complement classroom SL instruction at UEW was not sustainable because of the poor clarity of the signs demonstrated in the video. Research by Fourie showed that technology can increase the rate at which SL students learn sign vocabulary [20]. There is therefore a potential benefit in investigating other technological options for GhSL instruction. Technology provides a convenient, cost-effective and alternative way of acquiring SL knowledge. Its successful implementation will greatly help the work of the GNAD and UEW and contribute to the development of GhSL.

1.1 Objectives

The general objective of this study was to assess and enable GhSL tutelage with the aid of computer-based technology.

The specific objectives of this study are outlined as follows:

1. To investigate traditional methods of SL and GhSL instruction
2. To investigate existing types of computer-based SL learning tools
3. To examine how effective these tools are in facilitating SL learning
4. To evaluate what features make these tools effective
5. To propose a design for a computer-based tutor for GhSL

1.2 Problem Statement

Previous research has looked at how one method of SL instruction is more efficient than the other. None has considered the effectiveness of one method of SL instruction over the other. The traditional method (classroom or face-to-face) of SL instruction in Ghana faces challenges like the lack of adequate skilled signers, non-interactive learning materials, the use of crude forms of SL by some hearing Ghanaians, and the social attitudes towards the Deaf in Ghana. Although the traditional method of SL is more efficient, these challenges do not make it effective at scale. Thus, Ghana needs to have an alternative means of SL acquisition that is available to more people who cannot access the traditional means.

1.3 Research Questions

The research questions that guided this project are:

a) What features of existing computer-based SL tutors make them effective in providing SL instruction?

b) What type of computer-based technology can be used to effectively provide SL instruction in Ghana?

c) How does one build a computer-based SL tutor for GhSL?

1.4 Scope and Limitations

The scope of this study is Ghana, using Deaf people in Madina, a suburb of Ghana's capital Accra, as a setting. Madina was chosen because the researcher had access to research participants living in this area. One limitation of this study is that the researcher did not have access to any of the computer-based SL tutors described in the literature. This may have affected her perception of the effectiveness of those technologies.

1.5 Outline of Thesis

This research project sought to investigate alternative ways of providing SL instruction in Ghana using technology. It is organized into five chapters. Chapter one (1) introduced the research project to the reader. It contained research objectives, problem statement, research questions, scope and limitations and document conventions.

Chapter two (2) has the literature review. This chapter gives information about the nature of SL, the traditional means of SL acquisition, existing computer-based SL tutors, and a discussion about developing a computer-based tutor for GhSL.

Chapter three (3) deals with the methodology used to address the research questions. Chapter four (4) presents the results and findings of the research project. The conclusions and recommendations of the research are detailed in Chapter five (5).

CHAPTER 2

LITERATURE REVIEW

This chapter discusses previous research on SL instruction and technology. It starts with a description of the nature of SL and continues with a discussion of the traditional means of acquiring SL. Then, it moves on to an examination of the features of existing computer-based SL tutors. These features are described in terms of what makes them effective in providing SL instruction. It will also discuss what type of computer-based technology can be used to effectively provide SL instruction in Ghana. Finally, it discusses how a computer-based SL tutor for GhSL can be built.

2.1 The Nature of Sign Language

Sign languages (SLs) are spatial and temporal in nature. Signing involves finger spelling or gestures that represent whole words [24] and a sign "can express entire concepts and complex phrases [9, 25]." According to Fourie, "some kinds of signs such as the symbolic are more difficult for hearing individuals to learn than other signs" [20]; however, Ms. Maravich, a hearing person who has been teaching for 30yrs at the Western Pennsylvania School for the Deaf in Pittsburgh, PA, suggested in an e-mail that hearing people do not have any difficulty recognizing signs and simply need to practice more.

Figure 2.1 The Sign for "Father"

Signs with complex visual representations are referred to as symbolic because they are "premised on entirely arbitrary signification" [10]. An example of a *symbolic* sign is FATHER where the thumb is placed against the forehead while the hands are kept open (see Figure 2.1 above). In contrast, an *iconic*, less complex, easy-to-learn sign would be BABY where the arms are in a baby-cradling position or *book*, "which mimics opening a book with two hands" [27]. Similarly, signs made with body contact are easier to learn than signs made without body contact because they give tactile feedback to the signer. To illustrate, "a *body-contact* sign like MINE is made with the fist held against the chest (palm towards signer); a *non-body-contact* sign like EUROPE is made with small circling movements by an open hand at arm's length (palm away from signer)" [20]. Table 2.1 compares SLs to spoken languages.

Table 2.1 Sign Languages vs. Spoken Languages

Spoken language	Sign language
Have own rules for pronunciation, word order and complex grammar	Have "own rules for pronunciation, word order and complex grammar" [17]; e.g. the phrase 'Letter me finish write', for example, is grammatically correct in ASL [34]
Spoken languages vary from country to country	Signs vary from country to country
Form words by combining units of sound using your mouth	Form words by combining units of shapes produced using the hand, called handshapes [33]

The handshapes mentioned in Table 2.1 above are "the most recognizable and memorable aspect of a sign" [14] and constitute the fundamental elements of SL. In GhSL, the handshapes are mainly the ASL alphabets (see Appendix A); however, there are other hand configurations used in signing such as the index finger example in Figure 2.3 below. The ASL alphabet for A, X, and E (shown in Figure 2.2 below) represent the handshapes that combine to form the word AXE.

Figure 2.2 The Handshapes in the Word, AXE

According to Ellis and Blashki, each sign consists of five (5) parts; namely, handshape, location, orientation, and movement [10]. An example of

handshape is "an open hand or closed fist". Hand location could be "on the middle of the forehand or in front of the chest". Hand orientation could be "the palm facing up or out"; and an example hand movement is "upward or downward" [33]. The non-sign components are mainly the facial expressions and the body language. Figure 2.3 shows the ASL sign for, "Are you Deaf?" and is used to demonstrate the various parts of a sign:

Hand shape: index finger

Location:

Starting location: On the *cheek* near the ear

Ending location: On the *cheek* near the mouth.

Orientation: If done with the right hand, the right palm can face either left or somewhat forward.

Movement: Small arc.

 Facial expression: Raised eyebrows

Figure 2.3 The ASL sign for "Are you Deaf?" and the various parts use in signing this phrase

The different parts of the sign, "Are you Deaf?" clearly illustrate the spatial and temporal nature of SLs. In the next section, we look at how SL is acquired and what factors affect SL acquisition.

2.2 The Traditional Means of Acquiring Sign Language

This section looks at how SL is acquired and what factors affect SL acquisition. In SL instruction, the following pointers are worth noting:

1. The hearing student needs to be "shown how to execute a sign and how certain modulations affect the meaning of signs" [15]

2. The hearing student may have difficulty in mentally rotating the person signing in order to follow a SL conversation [14].

3. The hearing student needs to be given feedback on their signing clarity, correctness and facial expression/ mouth movements [20]

4. The hearing student must perform both receptive and expressive tasks. Receptive tasks are those that test the student's ability to recognize handshapes or to identify basic sign concepts (e.g. happy). Expressive tasks include fingerspelling, sentence drills and other tasks aimed at boosting the SL student's practice and articulation [27].

5. The hearing student needs to have interest in SL in order to progress. Mr. Worlanyo[3], during a phone interview, commented that a self-motivated hearing person can pick up SL in few weeks.

The traditional method of learning SL is in a classroom with a teacher demonstrating the signs for students to practice, textbooks and other SL text-based learning materials to supplement the classroom sign lessons [15, 14]. Unfortunately, books and dictionaries are not effective for SL

---

[3] Mr. Worlanyo is a teacher at the Demonstration School for the Deaf.

teaching and learning because such non-interactive media do not help to convey the dimensions of signs [20].

Notwithstanding these issues, the major advantage of learning SL in a classroom is that the SL student can see the sign forms in its entirety; the teacher provides "a clear three-dimensional, close-up view of the signs" [20]. In training a female chimpanzee, Washoe, in sign language vocabulary, three teaching techniques were used that are of interest to this research (see Table 2.2 below).

Table 2.2 Strategies for Chimpanzee SL instruction

Technique	Scenario Description
Imitation	It was easy to get Washoe to imitate human gestures but getting her to repeat a gesture after a command like, "Do this!" was a challenge. [18].
Babbling	Washoe was encouraged to repeat random movements that she had not been trained to do but would do spontaneously by means of clapping, smiling and repeating her gesture [18].
Instrumental conditioning	The use of tickling and a game helped to teach Washoe the sign for "more", such that anytime she wanted more tickling when the tickling had stopped or when she wanted the game to continue, she would do the "more" sign to ask for more [18]

The teaching techniques provided in Table 2.2 above describe strategies that the SL teacher or computer tutor also can utilize to motivate learners on the path to SL acquisition. The principle of babbling is about encouraging a hearing student to have confidence in practicing signs in the presence of

others, without the fear of embarrassment or of making a mistake. Imitation is like giving the SL student receptive tasks whereby the student is assessed by how well they emulate a particular sign or several signs. The instrumental conditioning technique can be applied to traditional SL instruction in the form of a learning game, for instance, where players would have to answer a receptive question about SL to move to the next stage in the game. Using these three techniques: imitation, babbling and instrumental conditioning, Washoe acquired 30 ASL signs over a period of twenty-two months [18].

Fourie [20] found that it is more effective to learn sign vocabulary from a human teacher than from video. However, in the traditional way of learning sign language, "instructors and other signers are not always available to demonstrate signs for students, and the demonstrations may vary due to fatigue, signing idiosyncrasies, and other considerations" [14]. What this problem calls for is some kind of technology that can maintain the integrity of signs, that is, either video instruction or avatar technology. Computer-mediated learning also provides a way to simulate the one-to-one teacher-student relationship that is desirable for language learning and which was also used in Washoe's case.

In summary, factors that affect SL acquisition are the expressive and receptive learning tasks, the proficiency and consistency of the signing teacher, the clarity of sign demonstrations and the use of interactive learning materials. In the next section, we examine existing computer-based SL tutors and how they apply the concept of receptive and expressive learning.

2.3 Existing Computer-based Sign Language Tutors

"Computer-based SL instruction began in the 1980s during which SL teaching has actually anticipated major shifts in teaching methodology" [32]. Computer-aided instruction (CAI) was criticized for being too much like drill-practice and not any different from existing instructional programs in terms of design [32]. Fortunately, an improved version of CAI led to the creation of Computer Assisted Language Learning (CALL) which consisted of more intelligent software packages that went beyond drill-practice. "At present, integration of technology into language education has become an everyday occurrence" [4]. Using technology, one can maintain the integrity and clarity of signs and can achieve the other factors, summarized in section 2.2 that affect SL acquisition. Some of the computer-based technologies that have been developed to facilitate SL instruction are discussed in the subsequent sub-sections.

2.3.1 Videodisc and CD-ROMs

Both of these media help the user to "access the information in a non-predetermined sequence by typing commands into a computer" [20]. Videodisc is a high-density, visual storage medium that can hold up to 30 minutes of motion video which translates into 54,000 individual frames of information [28]. Although expensive, it is very useful for expressive language learning [20]. CD-ROMs can also show video recordings of human signers that teach various sign vocabulary.

2.3.2 Virtual Classroom using Networking Technology

In online environments, SL lessons consist of videos that show dialogues among Deaf signers. The use of video technology for SL instruction in online environments is cost-effective and interactive. For example, language laboratories can help SL students communicate with native signers via videoconferencing [15]. Davidson reasons that videotape-based SL course materials may not be effective because rewinding to review signs from specific video segments "distracts the student from the learning process" [14].

2.3.3 The Case of PAULA

PAULA, (Practicing ASL Using Linguistic Animation), shown in Figure 2.4, is the product of sign synthesis, a system that tries to produce animations of a 3D avatar signing as an alternative to "video recordings of a human signer" [8]. It is a SL tutor that was designed to help hearing people better recognize signs during a face-to-face sign language conversation. It does this by enabling the user to view the avatar signing from three different angles: front, side and top.

Figure 2.4 PAULA: Sign Language Instruction with Avatar Technology

2.3.4 The Case of SignGenius

SignGenius [23] is software that teaches South African sign language (SASL) by grouping a bunch of signed vocabulary words under special categories like people, food and fruits that can be accessed by video. Users of the software can take a quiz after practicing all the vocabulary words in a particular category. The quiz questions are made up of videos of a human signing and the user is asked to identify the sign in the video from a list of multiple-choice answers.

2.3.5 The Case of Auslan Kids

Auslan Kids [10] is a multimedia software program designed to teach kindergarten children Australian sign language (Auslan). The software encouraged both receptive and expressive learning using activities like an interactive storybook, a signed song and a game. In developing the program, the researchers made several considerations such as the graphical user interfaces (GUI) design [13, 19] and the "children's preferences for characters and learning activities" [10]. In the receptive assessment, the children were prompted by pictures and asked to identify the correct sign from a list of multiple choice answers. Figure 2.5 shows the sign for "No" in Auslan Kids' receptive assessment. It was interesting to note how the expressive assessment was conducted: a video script with a phrase like, "Can you make the sign for *Pause*" was used (see Figure 2.6 for use of alternative video script).

Figure 2.5 Auslan Kids' Receptive Assessment

Figure 2.6 Auslan Kids' Expressive Assessment

2.3.6 The Case of DeSIGN

DeSIGN is an educational software application developed to reinforce the meaning of English vocabulary words for Deaf children using ASL signs. The ASL signs and finger spelling are shown specially produced ASL videos. What makes DeSIGN unique is its ability to adapt test questions to the learner's level using a knowledge tracing algorithm which ensures that test questions whose answers are known to the learner are not always repeated. In essence, it helps Deaf students build (i.e. learn and retain) vocabulary. DeSIGN only supports the recognition of ASL signs. It tests receptive skills rather than generation; recognition rather than recall. Furthermore, the application allows the user to modify the content of the software via a separate interface.

2.3.7 Computer Vision

Another example of computer-based technologies that have been developed to facilitate SL instruction is computer vision. Computer vision is a technique that allows computers to recognize complex visual images such as the hand gestures found in sign language. This recognition is made possible by

technology known as Hidden Markov Models (HMM) [24]. The HMM-based system uses a single color camera to capture the hand shape, hand orientation and hand movement of a signer wearing inexpensive colored gloves. Clearly, this technique has the potential of enabling expressive learning of sign language. The HMM is based on a very complex algorithm and for the purposes of GhSL tutor, it will not be implemented. Besides, Parton [1] explains that recognizing the start and end location of signs remains a problem in computer vision. Furthermore, motion-capture data is "too inaccurate and is recorded in numerical terms that are hard to modify" [1].

2.3.8 The Case of CopyCat

CopyCat is a computer-based game that is designed to help deaf children improve sign clarity by encouraging them to construct phrases in ASL to communicate with characters in the game. The game is an example of computer vision application because it uses HMM to verify "an entire, continuously signed ASL phrase" [29]. To facilitate the phrase verification, the child wears special gloves that send gesture information to the computer via a video camera. After experimenting with the ASL game, it was found that CopyCat is able to verify ASL phrases in real time albeit not as accurately as a human would. Nevertheless, the gesture recognition feature of CopyCat encourages expressive learning of signs and tests students' ability to comprehend and sign sentences. Gesture recognition also helps to reinforce the spatial nature of signed languages because each signer has their "signing space" which they maintain in front of them [22].

The table below, Table 2.3, summarizes the examples discussed above of existing computer-based technologies that have been developed to facilitate SL instruction. It goes on to indicate and explain whether their features support receptive and expressive learning of signs.

Table 2.3 Effectiveness of Existing Sign Language Technologies

SL technology type	Teaches both expressive and receptive skills?	Comments
Computer vision [22]	No	The ability of a camera to pick up signing produced by a human and analyzing the input shows that HMM technology is good for expressive learning only [22].
Videotape [20, 10]	No	No feedback regarding the correctness of signs. Teaches receptive skills only; not interactive, just passive although self-recorded sign videos provide personal feedback on one's sign output [15]
Videodisc [20]	Yes	"Provides interactive learning especially useful for visual information" [20]. Provides random access to sign videos to practice sign recognition. Teaches expressive skills as well.

Virtual Classroom [15]	Yes	The computer uses the internet to mediate the interaction between the SL teacher and the SL learner, whether or not they are spatially dispersed. The learner can study online SL-based material in their personal time, do the exercises and send the tutor personalized videos for feedback or CMC video-based software.
Auslan Kids [10]	Yes	It is a multimedia software program designed to teach kindergarten children Australian sign language vocabulary using activities like an interactive storybook, a signed song and a game.
PAULA [14]	Yes	Teaches the hearing student to recognize signs produced by a 3D graphical avatar. Viewing the avatar from the top helps user internalize the mental models for expression and reception.
AST CD-ROM [2]	No	A video-taping of human signers producing sign terminology for an Administrative Support Technology (AST) sign language self-instructional material. Teaches receptive skills only because it provides random access to AST sign vocabulary
DeSIGN [13]	No	Builds the English vocabulary of Deaf children using special lessons and tests in ASL so that they can improve their reading comprehension skills. Teaches sign recognition only

CopyCat [22]	No	Uses a game-based interface to teach ASL to Deaf children. Games provide motivation for the learner and encourage the learner to sign sentences which the computer will capture and verify. Teach expressive skills only
SignGenius [23]	No	The ASL vocabulary contents of SignGenius are arranged in categories and the learner may proceed with one category at a time and move on to take the test of knowledge. Teaches receptive skills only

The second column in Table 2.3 above, asks whether the SL technology under consideration teaches both receptive and expressive skills. The significance of this is that a very effective SL tutor is one that fosters both receptive and expressive learning. "Effective" means "producing a desired result", and for this context, refers to the ability of the hearing SL student to recognize various signs and have fluent conversation in sign after a period of using a computer-based SL tutor. "Effective" also means that the student is able to learn at their own pace given their learning needs and learning styles [8]. An application of "effectiveness" of a computer-based SL tutor is the user's ability to repeat/ replay the SL video lessons as often as they need to.

The literature reviewed in this section focused on computer-aided language learning (CALL), SL instruction, SL technologies, and proceedings on language- learning. It was found that features that make existing computer-based tutors effective in providing SL instruction are video recordings of

signs, videoconferencing between SL student and SL teacher, avatar technology and presentation angles, grouping vocabulary words under categories, GUI, learner's preferred learning activities, knowledge tracing of language vocabulary acquisition, computer vision and learning games. The next section discusses how a design for a GhSL tutor can be developed using features of the existing computer-based SL tutors that were found to be effective.

2.4 Developing a Computer-based Tutor for GhSL

The previous section discussed the features of existing SL technologies that make them effective in providing SL instruction. This section discusses what computer-based technology can be used to effectively provide SL instruction in Ghana.

Given that one of the specific objectives of this study is to propose a design for a computer-based tutor for GhSL, it would be helpful to borrow features from existing tutors that have been found to be effective. Section 2.3 listed some of the features, including, video recordings and presentation angles. The literature study, section 2.2, has also postulated that effective SL instruction requires receptive and expressive tasks. Table 2.3 provided an overview of existing computer-based tutors that support both tasks. Using this information, a design for a computer-based tutor for GhSL was proposed based on the features of DeSIGN, PAULA and Auslan Kids. The video technology used in DeSIGN and Auslan Kids was adopted for the GhSL tutor because videos, unlike avatar animations, are easy to create and modify.

Video recordings are also able to maintain the integrity of signs. The concept behind Auslan Kids is also very creative and effective and provides evidence that multimedia, besides gesture recognition, can be used to reinforce expressive skills in SL [10].

In the next section, the methodology of this research project is discussed. More information on the development of the GhSL tutor is given in section 3.3.

CHAPTER 3

METHODOLOGY

This chapter describes how the study on enabling SL instruction in Ghana was conducted. This includes a discussion of research, development and testing methodologies. The methodology section of any research paper is very important to the reading audience and to policy makers because it helps establish the credibility of the research and enables the study to be repeated in other contexts. This study employed both the quantitative and the qualitative research approaches to addressing the research problem. Qualitative data was obtained from literature reviews and interviews while quantitative data was gathered during field work on testing the computer-based tutor developed for GhSL. Part of the study was qualitative because the researcher set out to assess people's reaction to and preferences for a computer-based tutor for GhSL. Interviews and questionnaires were used to obtain original information that enhanced the study and that will be used to improve subsequent versions of the GhSL tutor. The research design was also informed by time and financial constraints.

3.1 Selection of Research Questions

The research questions of this study came out of an observation of how a visitor to a Deaf school learned to communicate with the Deaf students and/or teachers. The researcher visited Cape Coast School for the Deaf and got by with a basic knowledge of the American Sign Language alphabets. In one

of the lower primary classrooms, the pupils were eager to point new words on the board and demonstrate how they are signed. Thinking this was how SL was acquired, the researcher, upon further interactions, went on to find that the ASL alphabets, also known as the basic hand shapes, provided a platform for improving one's SL vocabulary in GhSL. The researcher found previous research on how technology has been used elsewhere to facilitate SL instruction. However, no previous research has addressed the question of how technology could improve GhSL instruction for hearing beginners.

3.2   Research Methodology

The main aim of this study was to investigate how technology can enable SL instruction in Ghana. As such, the main research method that was used concerned reviewing other research sourced from credible academic journals, conference publications and other relevant journals. The literature reviewed focused on the following areas: computer-aided language learning (CALL), SL instruction, SL technologies, and proceedings on language learning. It provided perspective on the research questions for this study. It also brought to light information about how technology has previously been used in SL instruction. So, the first stage of this research was the literature review.

As part of the literature review phase of the project, five (5) people were interviewed for their expert opinions on how technology can enable SL instruction in Ghana. Interviews were necessary because it was found that there was no previous research on how technology can be applied to GhSL instruction. Three (3) of the interviews were conducted over the phone while

the remaining two (2) interviews were face-to-face. The interviewees' names and positions are detailed as follows: Mr. Fiah Worlanyo, Social Studies Teacher at Demonstration School for the Deaf, Mampong; Mr. Anthony Mensah, Learning Disability Specialist at UEW, Winneba; Mr. Acheampong M. Oppong, SL lecturer at UEW; Mr. Robert Sampana (Deaf), Advocacy Officer for GNAD; and Dr. George Akanlig-Pare, Senior Lecturer in the Department of Linguistics (GhSL), University of Ghana, Legon. Two of the questions posed them during the interview are "How does GhSL compare to other sign languages?" and "How best can technology facilitate the process of teaching and learning SL in Ghana?" Kindly refer to Appendix B for the complete interview guide questions.

The researcher also had the opportunity, upon invitation, to observe a SL training session for hearing nurses[4]. In this natural setting, certain phenomenon about SL instruction for non-signers was uncovered. Some of these observations supported previous research while other observations gave alternative interpretation to existing research findings on SL instruction to the hearing. For example, it was observed that non-signers pick up signs fastest when they are given good description (see Figure 2.3) of how to make the sign. As such, the provision of presentation angles in SL instruction is not always necessary. The training session was part of GNAD's effort to promote the use of SL in communicating with the Deaf in Ghana.

---

[4]This Basic Sign Language Training for Selected Medical Assistants and Nurses in GA East District Hospitals was organized by the Ghana National Association of the Deaf (GNAD) in collaboration with the Participatory Development Associates (PDA), Madina, 5 - 10 Mar. 2012

The second stage of this research used findings from the literature about features of current SL technologies and information from the interviews to come up with the concept for the computer-based tutor for GhSL (see section 3.2.1 for details).

The third stage of this research was the design and development of the GhSL computer-based tutor. It was decided that the design of the GhSL computer-based tutor be modeled after PAULA, DeSIGN and Auslan Kids and eventually developed into a web application. A web application is a software program that is accessible over a network (i.e. the Internet or an intranet) and executes with the help of common web browsers. A web application would allow the GhSL tutor to have more useful features like a search function for finding signs and a log-in function for adding new SL lesson content. The researcher took into consideration the availability and knowledge-level of existing technologies before arriving at the choice of technology for implementing the tutor concept. The initial prototype of the GhSL tutor was developed in Hypertext Markup Language (HTML) and JavaScript using existing image content from the internet and newly-generated content from the researcher (see Appendix E for sample code). Future development of the GhSL tutor will implement crowdsourcing[5] as a means of improving the quality and quantity of the lesson and the quiz contents of the tutor. Section 3.2 provides detail on the development methodology.

---

[5] Crowdsourcing is a process that involves the participation of different field experts in a problem-solving endeavour. When applied to this research project, it means that various SL experts and stakeholders in the affairs of the Deaf community in Ghana can collaborate to produce authentication information about GhSL that can be available online and that will help promote and develop the language.

The fourth stage of this research was testing. This was done with prototype 2 (See Figure 3.4) of the tutor. Five (5) male research participants took handshape and Ghanaian signs lessons and quizzes on the tutor. The quizzes were designed to make participants think about their answer instead of just guessing. Thus, there were no multiple-choice answers and participants quiz scores are a true reflection of their level of SL acquisition using the GISL Tutor. Then, they answered questions about the user experience. The results of test findings were used to improve upon prototype 2 to create prototype 3, shown in Figure 4.2. The test findings were also analyzed using previous research findings. Chapter 4 discusses the results and findings of this study.

3.3 Development Methodology

Recall that another objective of this study was to investigate how to build a computer-based tutor for SL so as to obtain a concept for the development of the GhSL computer-based tutor. As mentioned in section 3.1, information from literature about features of current SL technologies and information from the interviews conducted were used to create the concept for the computer-based tutor for GhSL. Some useful features of existing computer-based SL tutors were adopted and adapted for the design of the GhSL computer-based tutor (see subsection 3.2.1). Recall from section 1.2 that certain features are needed for the effective delivery of SL instruction using technology in the non-traditional environment.

3.3.1 Concept for GhSL Computer-based Tutor

The useful features of existing computer-based SL tutors were adopted and adapted for the design of the GhSL computer-based tutor and that are needed for effective SL instruction with technology, are:

- ▸ The SL student needs to be shown how to execute a sign and how certain modulations affect the meaning of signs [15]
- ▸ The SL student must not view only their hands when signing; they need a whole picture of themselves signing [15, 14] presentation angles achieve this
- ▸ Availability of both receptive and expressive tasks

The GhSL tutor is called GISL to emphasize the importance and benefits of interaction to SL instruction. The logo of GISL (see Appendix D) is an adinkra symbol called "Nea onnim no sua a, ohu", which means "He who does not know, can know from learning. It therefore stands for knowledge and life-long education.

The design of the GhSL computer-based tutor was modeled after PAULA, DeSIGN and Auslan Kids, for three reasons. First, the DeSIGN Tutor showed that "videos allow for great flexibility because they are easy to capture and clip into the necessary segments" [13] of the program. Besides, videos can maintain the integrity of signs. Second, the PAULA SL tutor encouraged the presentation of signs from different angles. Third, Auslan Kids demonstrated a way to provide expressive assessments without the use of computer vision techniques. Other development goals of the GISL Tutor are as follows:

- Expressive learning and receptive learning of ASL alphabets and the Ghanaian signs, complete with memory cues

- Create positive user experience e.g. audio voice-over, feedback on user's progress, video lessons play almost instantly on click

- Implement crowd sourcing for lesson videos

- Have presentation angles, where necessary

- Be informative e.g. Deaf culture, learning strategies, GhSL grammar

The overall objective is to have a huge database of Ghanaian-specific signs that will be available and useful to the Ghanaian community.

3.3.2 The Current Iteration of GISL Prototypes

The GISL Tutor prototype implemented some of the concepts described in section 3.2.1, but not all. It was developed as a static website with its web pages stored in a *gisl* directory below the main *htdocs* directory that contains the other files (see Appendix G). The web pages contain Windows Media Audio (WMA) files, text, images and animated GIF files which play instantly on click. The tutor was primarily coded in Hypertext Markup Language (HTML). However, there is one JavaScript function that creates a new window for selected pages to display. The <img></img> tag was used to insert the video clips in the tutor like this: , where h_alphabet.gif is the file name of the video clip showing the ASL alphabets from A - Z. All the Ghanaian signs lessons come with textual descriptions of the sign demonstration in the video clip. For example, Figure 3.5 shows a description of how the sign for "Ampe" is

expressed in GhSL. The researcher chose to use HTML not only because of its familiarity, but also because it facilitated the collection of information on participants' quiz scores and their reaction to the tutor. Although the current version of the GISL Tutor is in HTML, preparatory work has began towards developing the next version of the tutor as a web application. Thus, a web application framework called WordPress has been used to support some of the Tutor's content; namely, the "About GISL", "Deafness", "Ghanaian Sign Language" and "Volunteer" pages. Appendix E shows snapshots of the WordPress implementation of the GISL Tutor.

The site structure of GISL 1.0 is illustrated below, showing how the different web pages connect to each other:
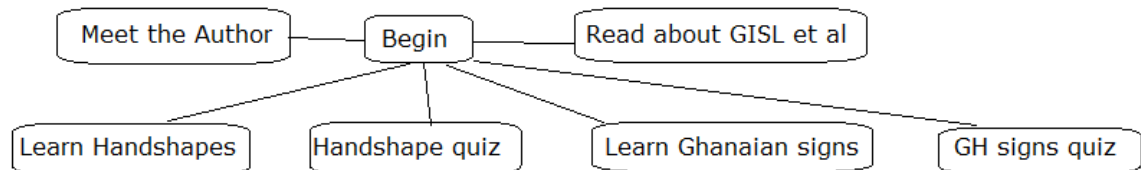
Figure 3.1 Site Structure of GISL 1.0

3.4 Testing Methodology

This study also aimed to first investigate how well some people in Ghana will receive a sign language computer-based tutor and whether they could learn GhSL on the computer tutor. To do this, five (5) participants were selected at random and invited to use GISL. Then, they had to answer some questions about the GISL Tutor. The tutor was made up of lessons and quizzes. Six (6) GhSL signs and the ASL alphabets were used for the testing of the tutor.

31

Participants took the lessons and the quizzes and their scores were recorded. Then, they answered questions about the tutor and about sign language. The evaluation form used to solicit feedback from the research participants is shown in Appendix C. Either participant had no previous knowledge of SL.

3.4.1 Participants and their Demographics

Five (5) hearing persons were chosen from Madina West and invited to use GISL and provide feedback on improving the tutor. They were all males because the researcher could not find willing female research participants. The ages of the male participants are as follows: Participant 1 (P1): 13; Participant 2 (P2): 16; Participant 3 (P3): 22; Participant 4 (P4): 25; and Participant 5 (P5): 32. Each participant was also required to ascertain their previous knowledge of sign language before proceeding to use the GISL Tutor. It was found that all five (5) participants did not have previous knowledge in sign language.

3.4.2 Study Setup and Procedure and Tasks

After the participant consented to taking part in the study, a summary of the testing procedure was described to them as follows: -

Step 1: Learn sign language alphabets

Step 2: Take the alphabets quiz

Step 3: Learn Ghanaian signs

Step 4: Take Ghanaian signs quiz

The test was structured in the above steps because knowledge of the sign language alphabets is a pre-requisite to learning the Ghanaian signs effectively. The alphabets illustrate the hand shapes required to make the Ghanaians signs correctly. The quizzes were therefore provided to help participants test their understanding of how to make the signs correctly. Testing took between 15 and 30 minutes per participant. A use-case diagram illustrating the main features of the GISL Tutor prototype is presented below:
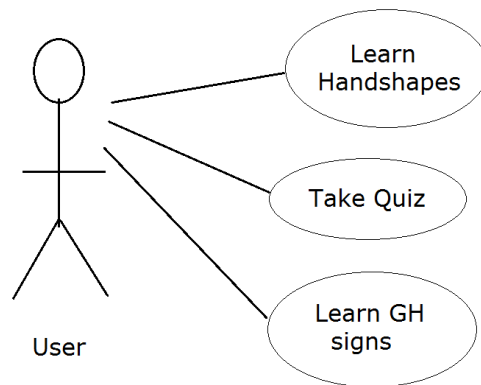
Figure 3.2 Use-cases of GISL Prototype 2

The sign language alphabets lesson page, shown in Figure 3.4, consisted of a video clip of a hand demonstrating how to make the signs for A to Z in sign language. Participants were required to watch the video and repeat after it as a way of practicing the signs. Similarly, the Ghanaian signs lesson page, depicted in Figure 3.5, has a video clip showing how to make specific signs in GhSL. Examples of the specific signs used for the GISL prototype demo version include "Ampe", "Madina", and "Accra". All video clips have been programmed to loop continuously, giving the user the freedom to practice the signs with both hands without having to select "replay video" every time.

33

Participants took the lessons at a comfortable pace, and then proceeded to take the quizzes when they were ready.

Figure 3.4 Handshapes Lesson

Figure 3.5 The sign for "Ampe" in GhSL

As mentioned earlier, the quizzes were designed to help the research participants test their understanding of how to make the signs correctly. There were two quizzes; namely, alphabets quiz and Ghanaian signs quiz.

Each quiz had two parts as shown in Figures 3.3 and 3.4 respectively. Recall from 1.2 that effective sign language instruction involves receptive and expressive learning.

Figure 3.6 GISL 1.0: Sign Language Alphabets Quiz

Part one (1) of the alphabets quiz was an expressive test (see Figure 3.6 above) made of up three (3) questions which prompted participants to make the sign for a given letter of the alphabet. Only P1 articulated all three (3) signs correctly. P2, P3, and P4 attempted to make the signs but with mixed success. Part two (2) of the alphabets quiz was a receptive test. It had pictures of three (3) alphabets in sign language and participants were required to identify each picture by letter. Here, no participant was able to correctly identify all three (3) alphabets. Results of the alphabets quiz for all participants, P1 – P5, are shown in Table 3.1 below.

Table 3.1 Quiz scores for alphabets quiz

	P1	P2	P3	P4	P5
Part 1	3	1	0	0	0
Part 2	1	0	0	0	0
Total	4	1	0	0	0

Source: Field work, March 2012

Table 3.1 shows that P1 obtained a score of 3 out of 3 for the expressive aspect (part 1) of the alphabets quiz. It also shows that P1 obtained a score of 1 out of 3 for the receptive aspect (part 2) of the alphabet quiz. The same description can be applied to the other participants' quiz scores shown in the table. A score of zero in part 1 meant that participants were not able to articulate the alphabet signs correctly whereas a score of zero in part 2 meant that participants were not able to recognize and provide the correct name of the alphabet signs shown.

Still on quizzes, the participants proceeded to take the Ghanaian signs quiz after taking time to learn the Ghanaian signs provided in the tutor. For testing purposes, the six (6) Ghanaian signs provided in the tutor were for the words Ampe, 37, Berekuso, Madina, Circle and Accra. As with the alphabets quiz, part one (1) of the Ghanaian signs quiz was an expressive test consisting of three (3) questions while part two (2) of the Ghanaian signs quiz was a receptive test consisting also of three (3) questions (see Figure 3.7).
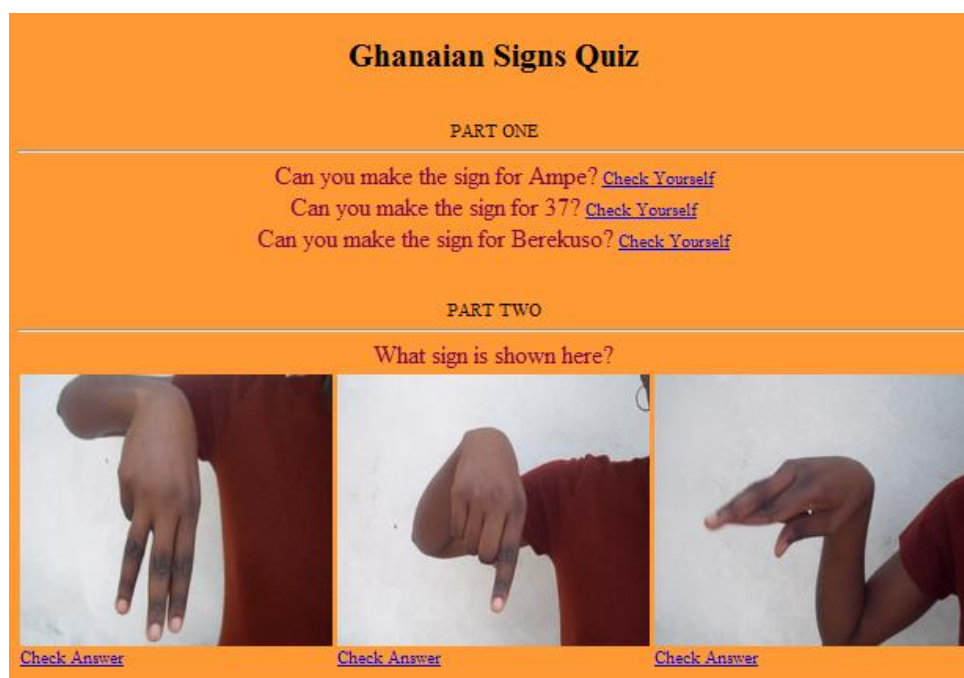
Figure 3.7 GISL 1.0: Ghanaian Signs Quiz

Again, only P1 articulated all three (3) signs in part one (1) correctly. For part two (2) of the quiz, P1, P2 and P5 were able to correctly identify all three (3) Ghanaian signs demonstrated in the video. Results of the Ghanaian signs quiz for all participants, P1 – P5, are shown in Table 3.2 below.

Table 3.2 Quiz scores for Ghanaian signs quiz

	P1	P2	P3	P4	P5
Part 1	3	0	0	0	0
Part 2	3	3	1	1	3
Total	6	3	1	1	3

Source: Field work, March 2012

Table 3.2 shows that P1 obtained a score of 3 out of 3 for the expressive aspect (part 1) of the Ghanaian signs quiz. It also shows that P3 obtained a

score of 1 out of 3 for the receptive aspect (part 2) of the Ghanaian signs quiz. The same description can be applied to the other participants' quiz scores shown in the table. A score of zero in part 1 meant that participants were not able to articulate the Ghanaian signs correctly whereas a score of zero in part 2 meant that participants were not able to recognize and provide the correct name of the Ghanaian signs shown. In summary, the testing procedure (see section 3.3.2) of the GISL computer tutor consisted of five (5) people taking lessons and quizzes on sign language from the tutor and reflecting on their user experience. The testing procedure also involved getting expert feedback on the tutor from Mr. Sampana (Deaf) of GNAD and from Dr. Astrid T. Larssen, a user experience expert and research supervisor.

3.4.3 Methodologies of the Testing done by Previous Research

When previous researchers discussed how technology could effectively be applied to SL instruction, they used diverse methodologies to support their research objectives. The testing methodology of the GISL Tutor is closely related to that of previous research because of the presence on receptive and expressive tasks. The following selected examples of previous research on SL instruction and technology illustrate this:

Henderson-Summet et al created a web application to teach "80 basic ASL vocabulary signs" to 20 parents of deaf children. The parents were taken through "five trials of 80 multiple choice selection tasks during the first session" of using the application. "After a week hiatus, [they] were asked to

perform 40 [expressive] tasks and 40 receptive tasks using the vocabulary from the previous session" [20].

Ellis and Blashki developed a "purpose specific software program to teach 4-5 year olds Austrailian sign language (Auslan). The children used the software "for 10 minutes per week for nine weeks" by completing various learning activities [10]. Then, the final session was used to assess their Auslan vocabulary acquisition in terms of both expressive and receptive skills.

The authors of CopyCat, Lee et al, combined "an interactive computer game with SL recognition technology" to help Deaf children improve their signing clarity in ASL. They conducted several pilot studies to help them validate their design for the game interface and the gesture recognition system.

To investigate how a hearing person would learn SL vocabulary from video, CD-ROM, booklet of signs and a teacher using newsprint, Fourie employed "a single-subject, time-series, control-versus-multiple-treatments design" whereby a single hearing adult learned 80 carefully-selected signs in South African Sign Language (SASL) from the four media. The subject was also tested receptively and expressively.

Although the implementation of receptive and expressive tasks makes previous research methodologies similar to the testing methodology of this study, the differences in methodology lie in the time factor used in each study. While some previous studies engaged in a pilot phase before the

actual testing, others were set-up over a period of months; and while some took a couple of weeks to complete, others got results after two (2) sessions. The testing methodology of this study is perhaps more similar to that of Henderson-Summet et al in the way their web application was designed to provide initial ASL vocabulary instruction. In the end, the conclusions reached were identical: technology can enable SL instruction.

The findings of this study also showed that technology can be used to facilitate the teaching and learning of SL in Ghana. There have been some concerns that technology may not be able to provide the feedback necessary for the SL student to improve their signing clarity; however, the findings of previous research speak to the effectiveness of CAI for non-signers and lend further support to the findings of this study. The testing methodology for GISL was significantly different from previous research in the sense that it measured participants' ability to learn signs specific to GhSL by first learning the ASL manual alphabets.

As mentioned earlier, the evaluation form that contained the guiding questions used to solicit verbal feedback from the five (5) participants is shown in Appendix C. The next chapter will discuss the feedback obtained from five (5) participants using this form and will provide details of the results and findings of the testing. It will also include the feedback given by Mr. Sampana and by Dr. Larssen.

CHAPTER 4

RESULTS AND FINDINGS

In chapter 3, we looked at the methodology of this research project: how the research was conducted, how the GISL Tutor was developed and how it was tested and evaluated. This chapter builds on the results and findings presented in chapter 3 and goes on to detail and discuss the feedback received from each of the five (5) research participants, Mr. Sampana and Dr. Larssen.

4.1 Details of Test Results and Findings

This section summarizes the quiz scores per research participant and makes inferences on the test results and findings in the study. Recall that five (5) hearing males in Madina were invited to participate in the study. Participant 1 (P1) was 13 years old; Participant 2 (P2) was 16 years old; Participant 3 (P3) was 22 years old; Participant 4 (P4) was 25 years old; and Participant 5 (P5) was 32 years old. The tables containing their quiz scores on the alphabets quiz and the Ghanaian signs quiz have been combined and reproduced as Table 4.1. Table 4.1 shows higher total scores per participant on the Ghanaian signs quiz (i.e. Total QG) than on the SL alphabets quiz (Total QA).

Table 4.1 Quiz scores for the alphabets quiz and for the Ghanaian signs quiz

Quiz scores for alphabets quiz (QA)					
	P1	P2	P3	P4	P5
Part 1	3	1	0	0	0
Part 2	1	0	0	0	0
Total QA	4	1	0	0	0
Quiz scores for Ghanaian signs quiz (QG)					
	P1	P2	P3	P4	P5
Part 1	3	0	0	0	0
Part 2	3	3	1	1	3
Total QG	6	3	1	1	3

Source: Field work, March 2012

The figure below, Figure 4.1, illustrates the quiz results provided in Table 4.1 above. It is clear to see that all participants score at least one (1) out of three (3) on the second part (part 2) of the Ghanaian signs quiz. This is significant because it shows a high learning rate of Ghanaian signs (see Total QG) as compared to the sign alphabets (see Total QA). Recall that part 2 of each quiz proposes receptive tasks. So, high scores on part 2 of either quiz suggest that participants have good receptive skills. Alternatively, high scores on part 1 of either quiz suggest that participants have good expressive skills and can articulate the signs correctly. The results of this testing procedure reveal that P2 – P5 need to work on their expressive skills because they scored low marks in part 1 of either quiz. The quiz results also reveal that all five (5) participants have good receptive skills for Ghanaian signs.
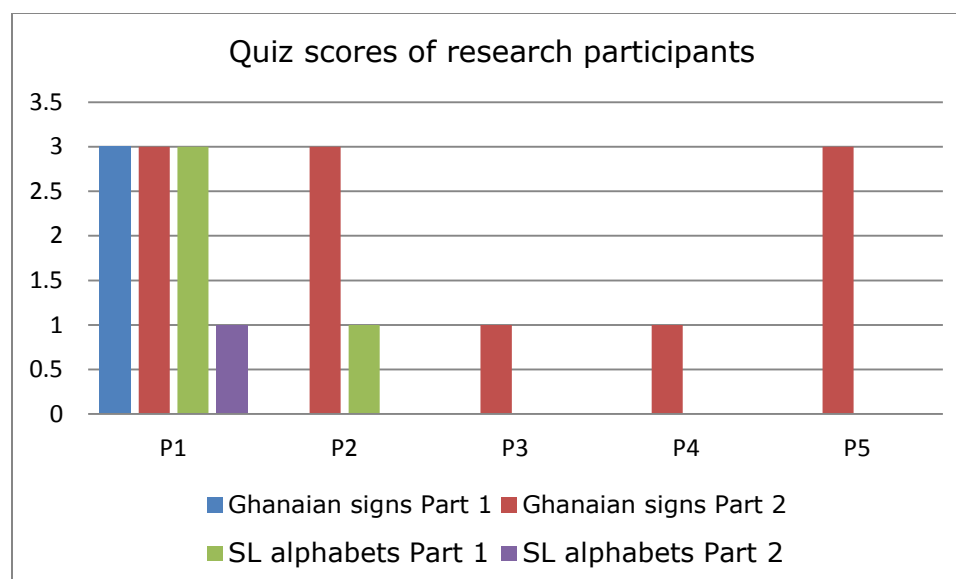
Figure 4.1 Quiz scores of research participants

One major inference from these quiz results was that all five (5) research participants preferred learning the Ghanaian signs of GhSL and were not too keen on learning the SL alphabets. However, as indicated in section 4.5, knowledge of GhSL signs without knowledge of the alphabets is not a good long-term learning strategy. Information from the literature on SL instruction and from the interviews conducted further suggests that knowledge of the sign alphabets is important for beginners of GhSL as it builds receptive and expressive skills. The GhSL student could opt to finger spell a Ghanaian word when in doubt about the sign equivalent. One way to turn this observation about participants' preference of Ghanaian signs into an advantage is as follows:

As research participants demonstrated more appreciation and enthusiasm for learning the GhSL signs, the GISL Tutor could use these Ghanaian signs to

43

whip up the interest of potential GhSL students and get them hooked onto the tutor. For example, one user may be interested in sign vocabulary about Ghana while another user may want to learn about sign vocabulary to describe items that can be found in a school. Once their interest keeps them coming back to the tutor, they would then be required to master the hand shapes so as to be able to learn more advanced level signs within their category of interest. When hearing Ghanaians learn about signs they are interested in, it will motivate them to use SL more often, thus, promoting the use of SL in Ghana.

Another inference from these quiz results was that younger research participants had better memory than older participants and were thus able to perform better on the quizzes. For example, the 13-year-old participant (P1) had good memory as indicated by the high scores he had on all quizzes. Another possibility could be that younger men are better able to learn signs from a computer than older men.

On another note, it can be inferred that all five (5) research participants are more comfortable learning signs that are iconic. To illustrate, the sign for "Circle", a suburb in the Greater Accra region of Ghana, made by turning the index finger of the dominant hand round and round, was articulated correctly by four (4) out of the five (5) participants. This finding goes to support previous research that "iconic signs are easier to learn than symbolic ones", where a symbolic sign would be the sign for 37 (see section 4.4.2).

4.2 Feedback from Research Participants

The feedback received from research participants about the GISL Tutor was generally positive. Participants commented on the significance of the research project and all indicated that they would recommend the GISL Tutor to their friends. Their feedback is as follows:

4.2.1 Participants' Feedback on Methods of SL Instruction

When participants were asked whether they would like to take sign language lessons from a computer or from a human being, they all went for "computer", save P4 and P1. The reasons provided for choosing the computer method are:

- A computer gives you privacy

- You can learn at your own pace

- Videos are good; you can replay them. A human being may not want to repeat their sign demonstration

- Videos depict symbolic meaning of signs

P4 was of the view that SL instruction from a computer (i.e. the videos) versus from a teacher had the same effect as both methods involved a human being. Similarly, P1 expressed that "a human being   is like you".

4.2.2 Participants' Feedback on the Usefulness of the GISL Tutor

All five (5) research participants were of the view that the GISL Tutor was useful and gave these supporting reasons:

- The videos show signs clearly

- The tutor is user-friendly

- The videos can be repeated many times

- It is useful for beginners to start learning with the computer

Three (3) out of the five (5) participants gave the sign descriptions (see example in section 3.2.2) a rating of 1 (best) which further adds to reasons why the GISL Tutor was considered effective.

4.2.3 Participants' Feedback on Additional Features & Improvements

- P1, P3, P4 and P5 recommended implementing voice-overs to accompany the video demonstrations. P2 was of the view that clearer video demonstrations of signs would do a better job than audio voice-overs.

- Have a beginner level with improved handshapes lesson and an advanced level for learning phrases and short sentences in SL

- Add text to the handshape video lesson and make video slow

- Make video speed consistent

- Start video with a demonstration of making the handshape

- Have more brightness in the video

- Females may appreciate more color for the user interface (UI)

- Increase number of Ghanaian signs in the tutor

- Include tips on how to introduce yourself in SL

- Add more videos of conversations in SL with English sub-titles

4.3 Expert Feedback

The feedback received from Mr. Sampana and Dr. Larssen concerning the GISL Tutor is as follows:

4.3.1 Feedback from Mr. Sampana, Advocacy Officer at GNAD

As a native user of sign language, Mr. Sampana's feedback was useful in validating the contents of the sign videos and providing suggestions on sign clarity and length of a sample video on introducing yourself in SL. His recommendations enabled the tutor to move from the figure shown in 4.1a to that shown in 4.1b.

Figure 4.1a "Meet the Author" page before feedback

Figure 4.1b "Meet the Author" page after feedback

4.3.2 Feedback from Dr. Larssen, a User Experience Expert and Research Supervisor.

Dr. Larssen provided expert evaluation on how to improve the interface of the GISL Tutor. She commented on reducing the amount of text per page and how to make the navigation more visible and descriptive. Her evaluation helped to enhance the look of significant pages on the tutor and got the interface shown in Figure 4.2 looking like the one shown in Figure 4.3.

Figure 4.2 Second Prototype of the GISL Tutor

When feedback from the experts and from the five (5) male participants was implemented, the GISL Tutor prototype arrived at a more user-friendly interface. The current version of the GISL Tutor prototype is shown among Figure 4.3.

In addition to the verbal feedback, the researcher took cues from the non-verbal feedback of the research participants' conduct to know what additional features would be useful. To illustrate, given the challenges participants faced in articulating the sign for 37, the researcher decided to include pictures of the handshapes for 3 and for 7 as a form of improvement.

"Home" page

"Tutor" page

"Learn Handshapes" page

"Handshape Quiz" page

"Ghanaian signs" page

"Ghanaian signs Quiz" page

Figure 4.3 Current Version of the GISL Tutor Prototype

Now that the feedback on the GISL Tutor has been discussed and the changes to the tutor have been presented, let us turn our attention to the details of the feedback received from each of the five (5) research participants, Mr. Sampana and Dr. Larssen. The next session is a discussion of salient elements of the additional features and improvements proposed.

4.4 Discussion of proposed Additional Features & Improvements

This section discusses the feedback received on crucial aspects of the GISL Tutor such as the video clips on the SL lessons and the lesson content. It will go on to list improvements and features that will be implemented in subsequent versions of the GISL Tutor.

4.4.1 Video clips and Content of the GISL Tutor

- P3 expressed that "*The video clip for the sign language alphabets and hand shapes is too fast*" and so they could not follow the lesson. P2, P4, and P5 agreed with him.

Thus, participants were of the view that an accompanying audio or some kind of indicator of the letter would help them know where they have gotten to on the lesson. For example, the video clip for "F" should be shown with an audio of "F" or the letter F should be shown on the screen as the video clip.

On the researcher's part, implementing the voice-over for the SL alphabets lesson was a challenge due to two (2) major limitations:

Poor synchronization: - as the tutor prototype was developed in HTML, the <embed src="a-z.wma"/> tag was used to add the accompanying audio of the sign language alphabets so that it plays at the same time as the animated GIF when rendered in the browser. Unfortunately, there was a six (6) second delay, ± 1s, in the playing of the audio which affected the synchronization of the video and the audio. Without good synchronization of the video and the audio, such as when the sign for F in the video is played with the audio for M, the SL student will be misled.

Looping: - the Windows Media Audio (WMA) file, once started, played once and stopped. It was expected that the audio played continually until the user closed the window. Looping is important because the participant is expected to remain on a particular page for as long as it takes them to grasp the lesson. Having the audio looping therefore frees up time for the user to focus on practicing the signs rather than focusing on when to refresh the video for a repeat of the audio.

Time constraints also did not allow the researcher to investigate other alternatives for synchronization and looping. Notwithstanding these challenges, the voice-over feature will be implemented in version 1.2 of the GISL Tutor. Audio was successfully implemented for the Ghanaian signs lesson page because having the WMA file start at the same time as the video clip was not significant.

- P2 suggested that each alphabet should have a separate video clip. Essentially, participants would have scored high on the sign language

alphabets quiz if they were not overwhelmed by the speed of the video and thus unable to keep track of what letter was being demonstrated in the video.

- P3 was of the view that more Ghanaian signs be added to the GISL Tutor.

Apart from the need to improve synchronization and looping, users of the tutor also need to be shown the parts of a sign in order to enhance their learning experience.

4.4.2 Features of a Sign

Four (4) out of five (5) participants had difficulty articulating the sign for 37 correctly. 37 was the second question on part one (1) of the Ghanaian signs quiz. For other Ghanaian signs, the problem was mostly with the orientation of the hand. Hand shape was often correctly articulated but with the wrong hand orientation. So this feedback suggests that the GISL Tutor needs to add features that help people learn correct orientation.

4.4.3 Improvements to be made to the Next Version of GISL, GISL 1.2

All areas of improvement of the GISL Tutor prototype suggested by the five (5) research participants, Mr. Sampana and Dr. Larssen have been noted. They will be implemented to help the GhSL student gain receptive and expressive mastery of the manual alphabets and hand shapes. This is important because the hand shapes are the fundamental aspects of GhSL. Knowledge of GhSL signs without knowledge of hand shapes is not a good

long-term learning strategy. This section will recap the current features of the first version of the GISL Tutor (see section 3.2) and will go on to list and describe the proposed features that will be added to the new version, version 1.2.

Elements of the current prototype of the GISL Tutor, shown in Figure 4.2:

- Alphabets lesson & quiz

- Ghanaian signs lessons with audio

- Ghanaian signs quiz

- A page about the author

Elements and prospects on the next prototype of the GISL Tutor, GISL 1.2

- Incorporate more Ghanaian signs, including those that are iconic, symbolic, non-body contact, and body contact, to build a Ghanaian signs' vocabulary bank or database that can easily be queried
- More quality videos and audio voice-overs implemented with synchronization and looping, where necessary
- Crowdsource the lesson contents of the GISL Tutor and test it on more Ghanaians
- Provide different knowledge levels (e.g. beginner, intermediate, expert) to accommodate different learning styles and enable users track their progress
- Provide tips to teach how to make correct hand orientation of a sign and improve expressive signing skill

- Implement a handshape game to enable beginners master the fundamentals of SL because "handshape …is the most recognizable and memorable aspect of a sign" [14]. Build on this with a fingerspelling game.

- Have audio voice-overs like "Good job!" that urge the SL student on as they progress on the practice assignments.

- Features like the game interface described in CopyCat, see sub-section 2.3.8, are effective because "successful technological learning should be based on self-selected and independent modalities that include learning by means of play" [31]. So, GISL 1.2 will include learning games for expressive and receptive tasks.

- Videoconferencing or network video technology

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

The aim of this research was to investigate whether technology could enable sign language (SL) instruction in Ghana. First, the researcher investigated the types of computer-based SL learning tools that already exist. It was found that the main tutors are PAULA, which uses avatar technology; CopyCat, which uses computer vision; Auslan Kids, which is a multimedia application and DeSIGN, an intelligent tutor for SL. Then, the researcher investigated features of these existing tutors that made them effective for SL instruction. Interviews were conducted with SL experts in Ghana to get their opinion on the application of technology to GhSL instruction. Information from the interview sessions and findings from the literature were used to design a prototype, a web page, for GhSL instruction. Then, the design was tested on five (5) hearing persons, one Deaf person and one user experience expert. The main outcomes of this research study show that there is much potential in using a computerized or interactive tutor to teach GhSL.

The literature reviewed postulated that mastery of the handshapes is a pre-requisite to effective acquisition of GhSL [20]. To this effect, non-signers need to practice sign recognition and expression of signs in the following areas: Hand shape, hand location, hand orientation, hand movement; facial expression and mouth patterns; and body language. Another research outcome was that viewing a sign from different angles can be useful for

improving recognition and expression skills in SL [14]. However, this researcher's observation of a SL training session for hearing nurses showed when presentation angles in SL demonstration may or may not be necessary. Equally important was the finding that SL grammar is different from that of written English, so "I went to the store" in English is equivalent to "Me go store" in SL. Interestingly, the outcome of the testing of the GhSL tutor showed that hearing non-signers need more practice with expressing themselves in SL than they do in understanding signs. This is contrary to previous research that stated that hearing students need more practice with receptive skills in SL. A balance of expressive and receptive learning materials is therefore required and will be made available in the next version of the online tutor.

It is hoped that this GhSL tutor will contribute to the development of GhSL given that it is a developing language and not much is known about signs specific to the Ghanaian context. The traditional method of GhSL instruction is not available to most of the hearing community in Ghana because of the lack of time, interest, travelling money or tuition fees needed to be invested into the personal acquisition of the language. Yet, personnel at the Ghana National Association of the Deaf (GNAD) and the University of Education, Winneba (UEW) are on a mission to promote the use of SL in Ghana to help bridge the existing communication gap between the Deaf community and the hearing community in Ghana. It will therefore be useful to have Ghanaian SL tutorials available online for interested individuals and other stakeholders

(e.g. hearing parents of Deaf children) to use to acquire the language for free.

Although some previous research has shown that the traditional methods of SL instruction – classroom and person-to-person – are the most efficient methods of acquiring the language, other researchers have been able to show that technology can serve as an alternative means to SL acquisition. Despite the small sample size of five (5), the test findings of the GhSL tutor that was developed for this study affirmed that technology can enable SL instruction in Ghana. The additional features and improvements recommended by the testers will be implemented in subsequent versions of the tutor that will be made available online. What is needed presently is for more Ghanaians to develop interest in sign language and to choose an instruction method that works for them. The propagation of GhSL across the country, with the help of this online tutor, will lead to a more inclusive society and make life for the Deaf community in Ghana more comfortable. This is because knowledge of SL helps to transform society's attitude toward the Deaf.

5.1 Conclusion

In response to the research questions of this study, the following can be concluded:

- Features of existing computer-based SL tutors that make them effective in providing SL instruction are video clips of sign demonstrations, audio voice-overs, sign descriptions in text, expressive and receptive practice exercises.

- To effectively provide SL instruction in Ghana, a web application can be used because it is easy to maintain, easy to update and is more accessible. Moreover, it is compatible with most web browsers so Ghanaians, and non-Ghanaians, in different parts of the world can access it.

- The development of a computer-based SL tutor for GhSL will have to be a collaborative effort of different stakeholders (parents, teachers, and opinion leaders). The GhSL curriculum content, for instance, has to be approved by the few SL experts in Ghana.

5.2 Recommendations

This research project was motivated by the researcher's passion for sign language and the growing need for the hearing community in Ghana to relate to the Deaf community in SL. The development of an alternative means of SL instruction via technology is only a step towards promoting the use of SL in Ghana. The benefits of this technology will only materialize when more people use it. The recommendations below suggest how SL knowledge can be made more pervasive in the Ghanaian community in the year 2015 and beyond.

- **Use GISL at a School**: the GISL Tutor 1.0 can be experimented in regular schools with inclusive orientation to test how well it teaches signs to the hearing school children. The advantage that school children in an inclusive education setting will have with using this tutor

is more opportunities for practicing SL with their Deaf classmates. When school children in Ghana start using the tutor and practicing SL, it will increase the number of people using SL in Ghana. This could facilitate the Ghana government's decision to make GhSL an official language in Ghana.

- **Promote Crowdsourcing Efforts:** Other stakeholders in SL; namely, teachers, parents, and opinion leaders should be encouraged to patronize the tutor and help contribute content on GhSL to propagate the language to Ghanaians within and outside the country. The content on the GISL Tutor would therefore be regarded as reliable information on GhSL learning materials.

- **Improve Deaf Awareness:** Most Ghanaians have a misconception about the Deafness which makes them reluctant to learn sign language.

- **Motivate Special Education Teachers:** Incentives should be given to teachers in special education, including those who teach the Deaf and give them skills to help them fit into society. This is important because of the lack of qualified signers in Ghana.

5.3 Future Work

This study has extended previous research by providing data on how technology can enable GhSL instruction. Participants in the study not only scored high on the Ghanaian signs quiz provided but went on to describe the study as laudable. Given this initial feedback, there are many possibilities for what the tutor could look like in the future. The first step would be to get other stakeholders interested in the project. Then, professional SL interpreters in Ghana will be employed to film the sign videos professionally for version 1.2 of the GISL Tutor. Some features that have been considered for future implementation are:

- Use of network video technology to connect GhSL students remotely to SL experts or Deaf students across Ghana
- Provide a full-fledged GhSL curriculum to the general public
- Teach GhSL grammar as the language develops

The proposed interface for the final version of the tutor is shown in Figure 5.1.

Figure 5.1 User Interface Design for GISL Version 1.2

Further studies could be done to investigate how hearing non-signers would acquire SL from a Deaf SL teacher as compared to a hearing SL teacher, among others.

References

1. B. S. Parton, "Sign language recognition and translation: a multidisciplined approach from the field of artificial intelligence," *Journal of Deaf Studies and Deaf Education*, vol. 11, no. 1, pp. 94-101, Winter 2006

2. F. Caccamise, M. L. Basile, V. Ortolani, C. Aidala, C. Dorn, and D. Feigel, "Administrative Support Technology (AST) Sign Vocabulary CD-ROM Project: A Self-Instructional Sign Language Resource for Faculty, Staff, & Students" in *International symposium on instructional technology and education of the deaf: supporting learners, pre-school—college*, June 2003, pp. 1-11.

3. H. Beyer and K. Holtzblatt, *Contextual Design: Defining Customer-Centered Systems.* USA: Academic Press, 1998.

4. H. Hashim and M. M. Yunus, "Learning via ICT: 'TELL ME MORE,'" *The International Journal of Learning*, vol. 17, no. 3, pp. 211-223, 2010.

5. J. Einshemerin, "The importance of sign language - what you must know!" Oct. 14 2010. http://ezinearticles.com/?The-Importance-of-Sign-Language---What-You-Must-Know!&id=5203966

6. J. F. Andrews, M. A. Gentry, M. DeLana, and D. Cocke, "Bilingual students—deaf and hearing-- learn about science: using visual strategies, technology and culture," submitted for publication in *Language Learner*, March 2006.

7. J. Intsiful, P. F. Okyere, S. Osae. "Use of ICT for education, research and development in Ghana: challenges, opportunities and potentials," presented at Round Table on Developing Countries Access to Scientific Knowledge, Trieste, Italy, 2003.

8. J. Schnepp, R. Wolfe, B. Shiver, J. C. McDonald, and J. Toro, "SignQUOTE: A Remote Testing Facility for Eliciting Signed Qualitative Feedback," presented at SLTAT 2011, Dundee, UK, 2011.

9. J. Toro et al. "A graphical environment for transcription of American sign language," 2001, pp. 1-4. http://asl.cti.depaul.edu/papers/Toro2001.pdf.

10. K. Ellis, and K. Blashki. "The digital playground: Kindergarten children learning sign language through multimedia," *AACE Journal*, vol. 15, no. 3, pp. 225-253, 2007.

11. K. Mangesi. "ICT in Education in Ghana," *Survey of ICT and education in Africa: Ghana Country Report*, pp. 1-9, Apr. 2007. www.infodev.org.

12. K. Mullamaa, "ICT in Language Learning - Benefits and Methodological Implications," *International Education Studies*, vol. 3, no. 1, pp.38-44, Feb. 2010. http://www.africandl.org.za/.

13. L. Xu, V. Varadharajan, J. Maravich, R. Tongia, and J. Mostow, "DeSIGN: an intelligent tutor to teach American Sign Language," in *Department of Engineering and Public* Policy, 2007, pp. 1-5, http://repository.cmu.edu/epp/121.

14. M. J. Davidson, "PAULA: A computer-based sign language tutor for hearing adults," M.S. thesis, DePaul University, Chicago, IL, n.d.

15. M. Mertzani, "Networking for sign language learning and teaching," *The International Journal of Learning,* vol. 14, no. 6, pp. 95-101, 2007.

16. M. S. Nyarko. "Report of First Meeting for Ghanaian Sign Language Development," *Ghana National Association of the Deaf*, 4 July 2011. http://gnadgh.com/news/?page_id=14. [Accessed 7 Oct. 2011].

17. National Institute on Deafness and Other Communication Disorders, "American sign language," June 2011, http://www.nidcd.nih.gov/health/hearing/pages/asl.aspx#d. [Accessed Oct. 6, 2011].

18. R. A. Gardner and B. T. Gardner, "Teaching sign language to a chimpanzee," *Science*, New Series, vol. 165, no. 3894, pp. 664-672, Aug. 1969. [Online]. Available: http://links.jstor.org/sici?sici=0036-8075%2819690815%293%3A165%3A3894%3C664%3ATSLTAC%3E2.0.CO%3B2-Z. [Accessed Oct. 7, 2011].

19. R. Cole, D. W. Massaro, D. Jurafsky, and L. J. Barker, "Interactive learning tools for human language technology," in *ESCA workshop and research workshop. Interactive dialogue in multi-modal systems*, 1999, pp. 1-4.

20.   R. J. Fourie, "Efficiency of a hearing person learning sign language vocabulary from media versus a teacher," *Deafness and Education International,* vol. 2, no. 1, pp. 45-60, 2000.

21.   R. Ladner, "Why American Sign Language is Important to the University,"
http://www.cs.washington.edu/homes/ladner/LinguisticsVideo.pdf.

22.   S. Lee, V. Henderson, H. Hamilton, T. Starner, and H. Brashner. "A gesture-based American sign language game for Deaf children," in *CHI 2005*, pp. 1-4, Portland, Oregon, USA, Apr. 2005.

23.   Sign Language Software – American and South African. [CD-ROM]. http://www.signgenius.com/.

24.   T. Starner, and A. Pentland, "Visual Recognition of American sign language using hidden markov models," pp. 1-6, 1995, http://www.cc.gatech.edu/~thad/p/031_10_SL/visual-recognition-of-asl-using-hmm-95.pdf.

25.   T. V. Malloy, "Sign Language Use for Deaf, Hard of Hearing, and Hearing Babies - The Evidence Supports It," *American Society for Deaf Children*, pp. 1-28, July 2003, http://www.deafchildren.org/resources/49_Sign%20Language%20Use.pdf.

26.   V. Hallet, "Learn sign language," U.S. News & World Report, vol. 142, no. 23, p. 62, Dec. 31, 2007. Available: Academic Source Complete, EBSCOhost. [Accessed 7 Oct. 2011].

27.   V. Henderson-Summet, K. Weaver, T. L. Westeyn, and T. Starner, "American Sign Language Vocabulary: Computer Aided Instruction for Non-signers," in *ASSETS'08*, 2008, pp. 1-2.

28.   V. L. Hanson, and C. A. Padden, "The use of videodisc interactive technology for bilingual instruction in American sign language and English," *The Quarterly Newsletter of the Laboratory of Comparative Human Cognition*. vol. 10, no. 3, pp. 92-95, Jul. 1988. http://lchc.ucsd.edu/Histarch/jl88v10n3.PDF.

29.   Z. Zafrulla et al. "American sign language phrase verification in an educational game for Deaf children," International Conference on Pattern Recognition, pp. 3846-3849, 2010.

30.   *The ASL Synthesizer Project at DePaul University*. [Videorecording]. http://asl.cs.depaul.edu/.

31. M. Vesisenaho, "ICT Education and Computer Science Education for Development - Impact and Contextualization," in *40th ASEE/IEEE Frontiers in Education Conference*, 2010, pp. 1-6.

32. M. R. Salaberry, "The Use of Technology for Second Language Learning and Teaching: A Retrospective," in *The Modern Language Journal 85*, pp. 39-56, 2001.

33. J. Dei-Kusi, "In Ghana hearing people have rights to communicate on Ghanaian sign language (GSL) in deaf community," http://www.ghanaweb.com/GhanaHomePage/ blogs/blog.article.php?blog=4586&ID=1000011536.

34. L. M. Everett-Haynes, "Sign language is popular with hearing students," Feb 19, 2003. http://www.seattlepi.com/news/article/Sign-language-is-popular-with-hearing-students-1107893.php#ixzz1dD85iVUL.

35. "Deaf association urges all to learn sign language," *Ghanamama*, 26 Sept. 2011. http://www.ghanamma.com/news/2011/09/26/deaf-association-urges-all-to-learn-sign-language/. [Accessed 11 Oct. 2011].

36. "Diploma in Sign Language," *University of Education, Winneba*. http://www.uew.edu.gh/index.php/academics/201-faculty-of-educational-studies-academic-programmes/undergraduate-programmes-sandwich/faculty-of-educational-studies/312-diploma-in-sign-language. [Accessed 15 Nov. 2011].

37. Oppong, Acheampong M. *Fundamentals of Sign Language: a textbook for college and university students*. Vol. 1. Department of Special Education, University of Education, Winneba: Paul Unique Printing works, 2006.

38. G. Y. Gadagbui, "Inclusive Education in Ghana: Practices, challenges and the future implications for all stakeholders," in Ghana National Commission for UNESCO, pp. 45-53, http://www.natcomreport.com/ghana/livre/inclusive-education.pdf.
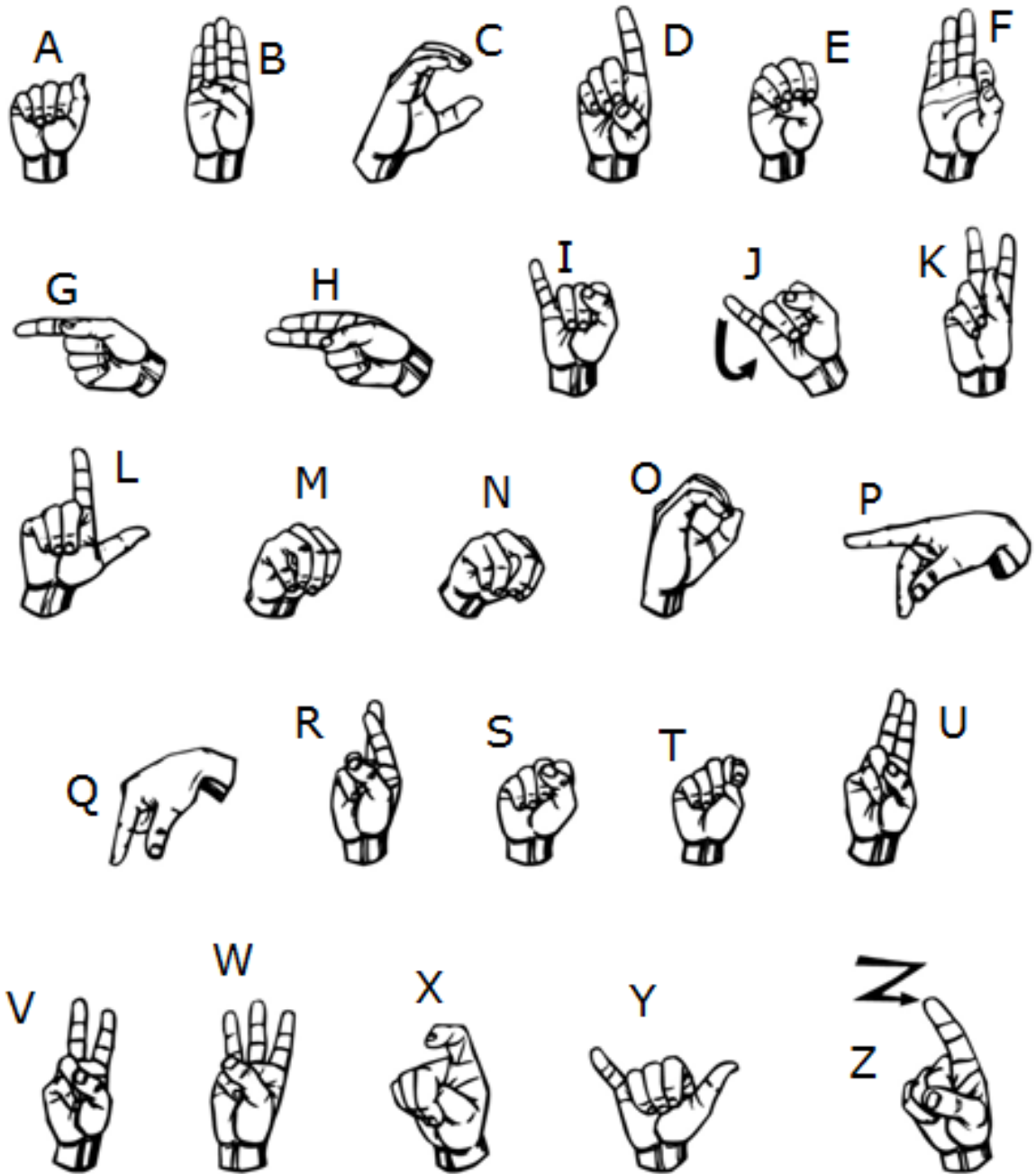
Appendix

Appendix A: Benefits of SL Acquisition

Everyone can benefit from learning how to sign because one could encounter a Deaf person socially, at work, at school or even in an emergency situation. Some of the reasons why people learn SL are discussed below:

1. *Early language development*	Research shows that when hearing children are exposed to sign language at an early age, they increase their English vocabulary. They also become more self-confident [25]. Furthermore, "sign language is an effective environmental stimulus thus enhancing brain development, promoting brain growth, and increasing brain activity …" [10].
2. *Alternate means of communication*	It provides an alternate means of communication in "noisy stadiums, concerts, through windows and underwater" [26] or even for two hearing persons who speak different spoken languages but know a common SL, like ASL [33]. Hearing people become multi-lingual when they learn SL; knowing more than one language is an advantage and helps to improve one's social circle.
3. *Professional Need*	Careers in speech and hearing sciences, special education, hearing educators of deaf children, social work, nursing, medicine and dentistry, to name a few may require one to balance their communication skills with sign language [21].
4. *Improves Deaf-Hearing Relations*	The "hearing community has historically been unforgiving to Deaf people," [34] which has led to increased stigmatization, among others. Today, hearing persons can acquire the language of the Deaf so that they do not always need to hire the services of a professional interpreter. Their effort to communicate with the Deaf via sign language would not only ease the hostility but also would make the Deaf feel welcomed in society and encourage them to focus on reaching their highest potential and contributing to societal development [5].
5. *National Cohesion*	When SL knowledge improves Deaf-Hearing relations (see 5 above), it will lead to national cohesion because SL knowledge can remove the communication barrier between the Deaf and the hearing in Ghana and facilitate mutual understanding and co-existence. "The Deaf have been learning the language of the hearing for the past 150 years,…now it is time for the hearing to learn the language of the Deaf" [34], to lead to a more inclusive society. Hearing persons learn the language of the Deaf to foster unity.

Appendix B: ASL alphabets from A – Z
Source: Lifeprint.com

Appendix C: Interview guide questions for the unstructured interviews

This section shows the guiding interview questions used for the interviews

1. Please state your full name and position at the Deaf organization.

2. For how long have you been in this position?

3. How do you use sign language (SL) in your line of work?

4. What is your approach to providing sign language instruction?

5. How developed is Ghanaian sign language (GhSL)?

6. How does GhSL compare to other sign languages?

7. What are some of the challenges facing SL teachers in Ghana?

8. What are some of the challenges facing SL students in Ghana?

9. How can a computer help people acquire knowledge in sign language?

10. What lessons are contained in a SL introductory course?

11. How best can technology facilitate the process of teaching and learning SL in Ghana?

12. What are some of the benefits of SL to Ghana?

13. Please provide other suggestions and comments you may have.

Appendix D: Evaluation Form for GISL

Dear participant, thank you for taking time to provide feedback on your use of the GISL Tutor. Your information will be used for research purposes only.

Demographics:

1. What is your gender? (circle one) Male/ Female
2. How old are you? _____

Tutor Evaluation:

3. Would you prefer to learn SL from a human or from a computer? Explain _____
4. Did you find the GISL Tutor effective in providing SL instruction? Explain _____
5. On a scale of 1 (best) to 5 (poor), please rate the usefulness of the sign descriptions provided
6. What did you like about the GISL Tutor? (Circle all that apply)
      a) User interface
      b) Color scheme
      c) Videos
      d) Other _____
7. What did you NOT like about the GISL Tutor? (Circle all that apply)
      a) User interface
      b) Color scheme
      c) Videos
      d) Other _____
8. How can the GISL Tutor be improved?
      _____
9. What other aspects of SL would you like the GISL Tutor to focus on in the future?
10. Would you recommend this tutor to a friend?
11. Please, provide other comments and/or suggestions you may have:
      _____
      _____
      _____ Thank you.

Appendix E: Sample HTML and Jscript Code for GISL Prototype

(Source page: Figure 3.7)

```
<html>
<head>
<TITLE>GISL - Ghanaian Sign Language Tutorials</TITLE>
<script type="text/javascript" language="JavaScript">
function openWindow(url)
{newWindow = window.open(url,"inset",
'toolbar=no,location=no,directories=no,status=no,menubar=no,scrollbars=yes,resize=no,cop
yhistory=no,width=650,height=300');}
</script>
</head>
<body bgcolor="FFFFFF " background="./ASLhandsBKGND.jpg">
<center>
<h1><font   color="FF9933"><bold>Ghana   Interactive   Sign   Language   </bold>(<font
color="FF0000          ">G</font><font          color="FFFF00          ">I</font><font
color="000000">S</font><font color="00CC00 ">L</font>) Tutor</font></h1><br>
<table><tr>
<td><img src="adinkra.jpg" width="50" height="50"></td>
<td>
<center><font color="FF0000">NEA ONNIM NO SUA A, OHU</font><br><bold>
"He who does not know can know from learning"</bold></center>
</td>
<td><img src="adinkra.jpg" width="50" height="50"></td>
</tr></table><br>
</center>
<a       href="Tutor.html"><button       type="button"       ><font       size=+1>Go       to
Tutor</font></button></a>
<div align="center">
<table width="980" bgcolor="FF9933"  height="300">
<tr>
<h1>Ghanaian Signs Quiz</h1><br>PART ONE<br><hr>
<font   color=#7b074b   size=+2>Can   you   make   the   sign   for   Ampe?</font>   <a
href="javascript:openWindow('GSL/Ampe.html')">Check Yourself</a><BR>
<font    color=#7b074b    size=+2>Can    you    make    the    sign    for    37?</font>    <a
href="javascript:openWindow('GSL/37.html')">Check Yourself</a><BR>
<font   color=#7b074b   size=+2>Can   you   make   the   sign   for   Berekuso?</font>   <a
href="javascript:openWindow('GSL/Ber.html')">Check Yourself</a><BR><br>
PART TWO<br><hr>
</tr>
<font color=#7b074b size=+2>What sign is shown here?</font><br>
<tr>
<td><img src="GSL/015.gif" width="300" height="260">  <br>
<a href="javascript:openWindow('Madina/index.html')">Check Answer</a></td>
<td><img src="GSL/018.gif" width="300" height="260">  <br>
<a href="javascript:openWindow('Circle/index.html')">Check Answer</a></td>
<td><img src="GSL/016.gif" width="300" height="260">  <br>
<a href="javascript:openWindow('Accra/index.html')">Check Answer</a></td>
</tr><br>
</table></div>
<table>
<tr><br>
<a   name="bottom"></a><center><font   face="Verdana"   size="1">GISL   is   Proudly
Ghanaian<br> GISL was developed by Diana Dayaka Osei<br> Ashesi University College ©
June 2012</font>
</tr>
</table>
</body></html>
```

Appendix F: Snapshots of GISL Implementation on WordPress
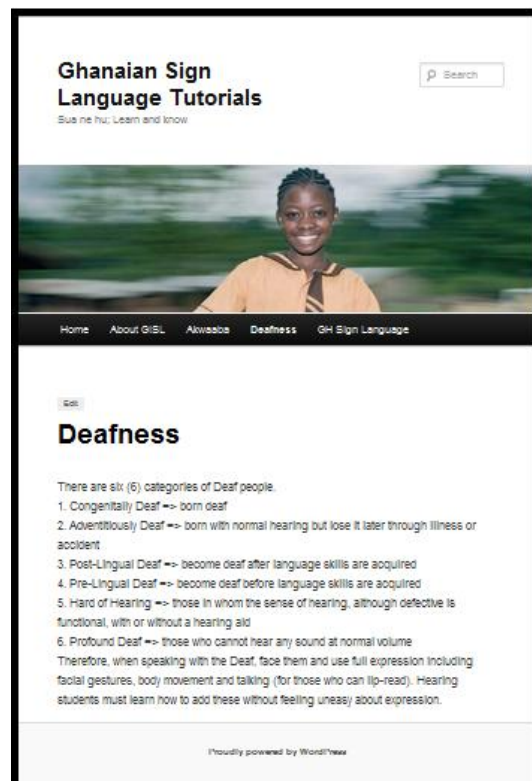
Appendix G: CD Contents

The CD attached to this thesis contains …

- ❖ Readme file

- ❖ Developed GISL software with source code

- ❖ XAMPP required to run application