ADDIS ABABA UNIVERSITY

SCHOOL OF GRADUATE STUDIES

DESIGN AND DEVELOPMENT of HYPERMEDIA LEARNING TOOL FOR ETHIOPIAN SIGN LANGUAGE

(Specially Designed for Amharic Speakers)

SUBMITTED BY **ENDALE ASEFA**

A THESIS IN ACCORDANCE TO THE REQUIREMENTS FOR THE DEGREE OF MASTER'S OF SCIENCE IN INFORMATION SCIENCE (MSC.I.S.)

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SCHOOL OF GRADUATE STUDIES
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DESIGN AND DEVELOPMENT OF A HYPERMEDIA LEARNING TOOL FOR ETHIOPIAN SIGN LANGUAGE (SPECIALLY DESIGNED FOR AMHARIC SPEAKERS)

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DEDICATION

To

All Deaf People of Ethiopia.

ABSTRACT

Though the degree varies, deaf people in different parts of the world are facing challenges to communicate with hearing people. The situation in Ethiopia is similar except there has been no remedy tried to bridge the gap. As per the investigation of this research, deaf people face communication problems of various kinds in perusing their day to day activities with their hearing acquaintances. It has been observed that the deaf people are denied so many advantages because of the communication gap they have with the hearing people. The problem was more serious in public service areas like hospitals, police stations, etc.

In other countries, different options have been suggested and used to resolve communication gap between the deaf and hearing people. Teaching sign language to hearing people has been considered as one of those ways of bridging the communication gaps between the hearing and the deaf people. Bearing in mind that Ethiopian Sign Language (ESL) is used as an effective mode of communication for deaf people in Ethiopia, the main aim of this study was intended to bridge /minimize the existing communication gap between deaf and hearing people (taking health environment as a case), by creating hypermedia software that can be used to teach ESL. The software is supposed to help health professionals to learn basic health related Ethiopian Sign Language, so that they can communicate to their deaf customers.

In order to achieve the aim of the study, this research first reviews the various related literatures. Then user research was done using questionnaire in order to have a good input to the design of appropriate tool. Based on the analysis of the user research, a prototype of the hypermedia learning tool was developed.

The tool was designed using a UML based hypermedia designing methodology. The whole process of developing the tool, including the design, was based on the ISO-13407 standard for user centered design.

The prototype was developed based on continuous evaluation of the intended users. More over final evaluation was done using a co-discovery method of usability testing and it has been observed that, the tool was developed to the appropriate skill and need of the intended users.

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1. INTRODUCTION

This section deals with the background information, objective, scope, limitation and problem statement of the study. The contribution and organization of the thesis are also presented at the end of this section.

1.1. Background

As indicated in (1), each day, we communicate—at home, in the car, in the classroom, in the workplace, or in public venues. Those of us who can speak and hear normally have little trouble asking or answering questions, supplying vital information, or engaging in effective two-way communication. However, these simple acts can be a struggle for persons, who are deaf. Access to acoustic information and communication with the hearing people are challenges these individuals face daily.

For the purpose of this research, the word "deaf" will be used to refer to all age groups and to the complete range of hearing loss including people who are deaf, hard of hearing and deaf-blind, unless otherwise stated.

As statistics showed (2), hearing people get about 75% of their information through aural means such as radio, television and other people's conversations, while, about 25% of information acquired is through other methods. Of this 25% receivable information, deaf people acquire only half and some times even less.

According to the 1994 report of Housing and Population Census of Ethiopia (3), there are more than 250,000 deaf people in Ethiopia. That is, at least one among 280 people in Ethiopia is deaf. Nearly all of these deaf people currently use sign language as their primary language.

Even though there is little variation among sign languages used in different parts of the country, there is what is known as Ethiopian Sign Language (ESL). ESL, as any other sign languages, although different in form, serves the same function as a spoken language for the deaf community.

Large numbers of hearing people need to communicate with the deaf people starting from family members to employers of the deaf in a work place. But lack of awareness and

understanding of the ESL on the part of employers, service providers and local and national government personnel has created a huge communication gap between hearing people and the deaf. Moreover, there exist lack of personnel with appropriate linguistic skills, education and qualifications: these include ESL interpreters, tutors of ESL, and bilingual/multi-lingual professionals with fluency in ESL as well as the relevant spoken language(s). Lack of resources and materials, such as ESL learning tools, signed and subtitled public information videos and TV programs, signed and subtitled curriculum and assessment materials is also another factor to maximize the gap.

This communication gap has made the deaf people to have a very much restricted knowledge about the basic information of their day to day lives and surroundings and have inadequate knowledge, unfavorable attitude and undesirable behavior towards so many social aspects like sexual and health issues (4, 5, 6, 7).

In other countries, different options have been suggested and used to resolve communication gap between the deaf and hearing people. Among those options, the following are some of the most acceptable, ethical and IT related solutions:

- Creating the chance for and training the deaf to use Minicoms or Typetalk. When hearing people want to meet somebody, they normally telephone and make an appointment. However, deaf people do not have sufficient hearing to use a standard telephone. Instead deaf people can use text phones (Minicoms), which consist of a small screen and a keyboard. Messages are typed in, and the reply is displayed on the screen. However, in Ethiopia, this service by itself is in its infancy stage.
- Using software tools that are capable of converting spoken language to sign language and vice versa. Such kind of tools can solve the problem perfectly. However, this solution is very costly in terms of time, money, and human power (personal communication with professionals who had exposure on similar projects, especially Dr L. Van Zill from Stellenbosch University, South Africa and Professor R. J. Wolfe (PhD) from DePaul University, United States of America)
- Training the hearing people to be aware of and learn sign languages. It is clear that the nature of deafness restricts deaf people to learn spoken languages. But it is not as such difficult for hearing people to learn sign language so that they can communicate with the deaf easily. This can be achieved using either the traditional way of sign language learning in formal classes or using self-learning methods.

Implementation of any solution to any problem depends on the place where it is going to be implemented, condition and time. Accordingly, it may be difficult to implement the first two solutions in Ethiopia because of the economic, awareness, and etc factors. Instead, the third option could be appropriate and timely solution. It will be possible to bridge the gap between hearing and deaf people of the country if those people who have close relationships to the deaf citizens learn the appropriate element(s) of ESL, which is the communication media for the deaf in the country.

Anybody wants to learn any language; be it Amharic, Afan Oromo, Tigrigna or any other; to communicate, to gain understanding of another culture and to build and/or maintain friendships. Bearing this in mind, research shows that, today, many hearing people are asking to be included with the deaf students' education and learn ESL to communicate, to gain understanding of the deaf culture and to build and/or maintain friendships across the sound barrier. (8).

But those who are asking to learn and others who need to know ESL have very much limited opportunity to attend formal ESL courses due to various reasons, where formal in this context means teacher and class room based. Among the reasons, one is shortage or absence of schools offering such courses in the country. The numbers of schools specifically for the deaf are only restricted in towns. Therefore, those who need to learn sign language, including the deaf children, in rural areas have no chance to do so. Even in the towns, the situations of most people especially parents and other caregivers of the deaf, are not convenient to attend the formal ESL classes. Moreover, since ESL has no way to take lecture notes (writing system), learning ESL has been a great challenge. That is sign language writing system is not in use in Ethiopia.

Self-learning systems have never been tried on ESL. The literature shows that, self-learning computer aided hypermedia systems can overcome the problems with formal sign language learning methods. Such learning tools also can help formal sign language students for revision and supplementary home study. Also, we know that people learn language best by watching and doing (8). Therefore, self learning hypermedia learning tools would make it possible for students to see ESL in action in their own homes – something which an ordinary textbook can never hope to do. This research was therefore to contribute in this area by designing and developing a user centred hypermedia-learning tool for ESL so that those who can write and read Amharic (the national language of Ethiopia) can learn ESL.

1.2. Statement of the Problem and Justification of the Study

There are several groups of people who, even in these fervent days of equal rights and political correctness, consider that their needs have not been addressed. One such group is the deaf.

> The European Union Guidance Note states, disabled people are particularly affected by and are vulnerable to HIV and AIDS as they are the most marginalized and poorest in society. They have inadequate access to information, health care and treatment. Information is rarely available in appropriate formats..... As only very few of the world's disabled people obtain any form of education, illiteracy is also widespread. There is lack of information provided in sign-language for deaf and hearing impaired people.....The sexuality of disabled people in general ..... is .....unknown and stigmatized and is therefore infrequently discussed.....which is yet another reason why information about HIV and AIDS does not reach these groups (9).

This note and other similar literature indicate that deaf people, as part of disabled people, often miss out on everyday chances to learn about topics such as health, eating, smoking or exercise because of the lack of sign language use and/or interpretation on TV or at community events, and for some deaf people, written languages can be like a foreign language.

People who are deaf find it very difficult to communicate with most people including their own family who have not learned their language. Their written communication is often limited by educational difficulties, not from lack of intelligence. They may need skilled interpreters to cope with the problems of everyday life such as filling in forms, or simply communicating with their doctor or when out shopping. But, this is very difficult especially for the poor people in countries like Ethiopia.

The potential contributions, which deaf people can make to Ethiopians life, are currently being wasted or diminished because of communication gap between the deaf and the other members of the society. If appropriate systems were in place, deaf people would be able to access information and thus participate more fully in the society. One way to accomplish this is training hearing people to sign ESL.

Teaching sign language to hearing people has been considered as one of the ways of bridging the communication gaps between the hearing and the deaf people. Examples of such efforts included The Signtel Interpreter, HyperSign, PC-Fingers, The American Sign Language Dictionary, Personal Communicator (10, 11, 12, 13, 14, 15). These teaching aids have achieved success and improvements and are being made on a continuous basis. Such tools are relatively cheaper to design, fast to develop, and revise, and easy to deploy. It seems reasonable that it would be more effective if such systems are designed taking into account existing problems and the relevant requirements of the user group for whom they are designed.

This study was aimed at designing and developing a web-based hypermedia learning tool for ESL for the hearing people who can read and write Amharic so that the communication gap between the deaf and hearing people can be bridged. In doing so, existing communication problems and the relevant requirements of the user group for whom the tool is designed were thoroughly studied.

1.3. Objectives of the Study

1.3.1. General Objective

This research was carried out to create a hypermedia-learning tool, which can be used to teach ESL for Amharic speaking people with the aim of addressing the communication gaps between the deaf and hearing people. The intended users of this tool would be those hearing people who can read and write Amharic language.

1.3.2. Specific Objectives

The specific objectives of this study were:

- Reviewing the related literature
- Identifying existing communication problems and the relevant requirements of the user group for whom the software is designed
- Designing, developing and evaluating the hypermedia learning tool

1.4. Scope of the Study

To implement a full-fledged hypermedia tool, which incorporates all the signs and/or elements of ESL, would take a long time and resources. So, to be able to finish this master's thesis within the appropriate time frame, a prototype was created. The study also used health centers at Addis Ababa city as a case. The software was called a Medical Ethiopian Sign Language Learning Tool (MESL^{2}T). Using MESL^{2}T, a medical staff can learn ESL at his/her convenience so that he/she can better communicate with the deaf patients. Though, deaf people have as much contact with every person as any hearing person do, the study has made to focus on health centres, for the sake of narrowing the scope of the research, and bearing in mind that health is the primary issue for any body.

1.5. Contribution of the Research

A great number of programs and websites are available which are intended to teach various sign languages around the world. There is no similar program or website on ESL. The output of this study therefore will help learning basic ESL at one's own pace and convenience. Apart from teaching ESL the tool may also be used by linguistic researchers. Moreover, since this work is the first in the area, it indirectly will play a great role in creating deaf awareness in the country.

Hence, this work will be the first step in supplying the growing public demand of sign language. This tool is suited for hypermedia incorporating video clips accompanying text into easy user interface allowing the user maximum control over the video play back. The tool is not intended to teach ESL for the deaf. Designing a learning tool to teach the deaf to sign would be analogous to designing a "Learn to Speak Amharic" course for Amharic speakers.

1.6. Thesis Organization

This thesis is divided into six chapters. The first chapter is introduction, which covers about the basic aspects of the research including, background, statement, objectives, scope and significance of the study. The second chapter incorporates review of related literature. It is divided in to five sub sections. The third chapter deals with the methodologies followed to conduct the research. In the fourth chapter, presentation, analysis of data and discussion of

survey results are presented. Discussion of prototype design is presented in the fifth chapter. Finally, chapter six covers conclusions and recommendations.

2. Review of Related Literature

2.1. Deafness and Sign Language

2.1. 1. Brief Historical Background to Deafness and Sign Language

Deafness is part of the human condition and exists throughout the world (2). It is probably as old as humanity itself. Deafness is present in all races, in both genders and from preliterate hunter/gatherer tribes to the most highly industrialized societies.

Information about deafness and deaf people was extremely limited well into modern times. The earliest recorded history of the communication and education of deaf people was in the sixteenth century (16).

In the early ages deaf people were cruelly shot of education and information for many centuries and their human rights were seriously violated by some unfair decisions over them. This especially was clearly observed during the age of Aristotle (384-322 BC). Aristotle was a well known Greek philosopher. He had a thought that "language and speech are same things." He thought that those who cannot hear and speak could not have language and cannot learn. Due to this fact, the deaf people were not beneficiaries from all information of the time and those parents who had deaf children were forced to expose their children to the forces of nature like water and fire to die (17,18).

In the sixteenth century, the Italian person Girolano Cardano started to question Aristotle's reasoning. At the same time, Pedro Ponce de Le'on used finger spelling and signs to teach reading to the deaf children in Spain monasteries. The philosophical and practical foundations for education of the deaf were further developed in seventeenth century through the work of individuals such as Bonet of Spain, Dalgarno of Great Britain, and Amman of Holand, who set the stage for the latter establishment of schools for the deaf (18).

In the recorded history of mankind the first public school for the deaf was opened in Paris in 1755(19). The method used to teach the deaf was using manual signs (17). After this time sign language was used as a medium of instruction in the education of the deaf in France, Spain and America. Oral method, which was not effective as compared to sign language, was used in German and England.

The year 1880 was the darkest age in the history of deaf education and sign language. A conference in Milan (Italy) on deaf education by European and American teachers and educators that exclude deaf people, decided that sign language should be abandoned and that deaf pupils should be taught to lip-read and speak. The decision was made by the hearing teachers and it had devastating effects on deaf person all over the world.

After this time it has been observed that by suppressing the sign language one seriously damage the deafs' ability for applying language skills on all level of life. The lip-reading (oralism) techniques could neither fill the void left by the use of signs, nor could deaf persons reach a high level regarding speech.

Hence the sign language survived within the deaf group only and slowly some teachers became aware that without accepting the visual sign language as the natural mother tongue or first language of the deaf persons, one could not succeed in the education and teaching of life skills (18).

In 1960 an American Professor of English language called William Stoke made a breakthrough scientific research on American Sign Language (ASL) which showed that sign language was a natural human language with its own grammar, independent of any spoken language. At that time some other linguists doubted Stoke's idea but subsequent researches on sign languages in different countries of the world supported the rich linguistic structure of sign language and sign language gets re-birth. When switching back to sign language as the language in education, deaf pupils did start to achieve academic results equal to their hearing peers. After this time the development and dissemination of effective methods and assisting tools of educating the deaf become in great reality worldwide. Especially nowadays many nations are accepting sign language as the natural language of the deaf community as a medium of communication and instruction in the schools for the deaf.

Most African countries have imported ASL (personal communication with Ethiopian National Association of the Deaf (ENAD)). As a result it has been observed that the majority of African deaf people use ASL. In Ethiopia, even though most deaf people are using ESL, in schools the sign language in use is not pure ESL. This has happened because sign language education was started by missionaries that came from different countries who were teaching their own SL. In addition, the "ሀ መጽሀፍ", which is the only textbook for SL students in Ethiopia, was prepared by those Ethiopian scholars who had learned sign languages of

different countries. Hence, in preparing the textbook, they used most of the signs from sign languages of those countries they had been taught rather than the ESL (20). This book has been prepared before 26 years and no research has been done about its effectiveness. However, as per the information got from leaders of ENAD, the book was wrongly prepared without the wish and language of Ethiopian deaf and not efficient. Due to this fact, currently the ENAD is trying to formulate a manual dictionary of ESL, which may help to replace the existing sign languages used in schools by ESL in the near future so that Ethiopian deaf pupils can learn by their native language. This action might have contribution for making practical the "nothing about us with out us" slogan of the deaf people.

In the country, there are few elementary schools specifically for the deaf. There also are few elementary and high schools that have special need departments for the deaf students. But there is no sign language use, even a course about it, in all the universities and colleges of the country except at Addis Ababa University. Addis Ababa University and ENAD have started to train some volunteer students about deaf awareness and some basic signs of the ESL. This program has started in 2004 and I was one of the trainees of this year's batch.

2.1.2. Alternate and Primary Sign Languages

By definition, an alternate sign language is a system of gestures developed by speakers for limited communication in a specific context where speech cannot be used. The user of an alternate sign language has another first (spoken) language. In contrast, a primary sign language is the first language of a group that does not have access to a spoken language (19). According to the above measures the ESL is a primary sign language for Ethiopian deaf.

2.1.3. Methods of Instruction and Mode of Communication in Deaf Education

2.1.3.1. Oralism

In the oral method, also called the oral-aural method, students need to receive input through speech reading (lip-reading) and the amplification of sound, and express themselves through speech. This means the students need to practice spoken language speech sounds and develop lip-reading skills. This method had dominated deaf education for a century. However, most deaf children could not achieve very much with this method. Its existence was not because the

deaf people accepted it but due to unfair belief of some teachers and educators of the time (18).

2.1.3.2. Total Communication

When parents are not sure whether to use only the oral method of communication with their deaf children, they can use total communication. Total communication is a combination of many means of communications – sign language, voice, finger spelling, lip-reading, writing, gesture, and visual imagery (pictures). With this method the deaf receive input through speech reading, signs and finger spelling. Total communication can ensure that a person has access to some means of communication. For example, one who cannot communicate well orally gets the additional support of sign language and vice versa.

According to some critiques, total communication is not effective in teaching deaf pupils because the effort to sign and speak at the same time results in a poorer quality of sign language. Not only that, some people believe that total communication results in deaf children failing to develop fluency in either spoken or sign language because of the imperfect use of both (19).

Generally for many years it was thought that total communication would meet the needs of deaf children who need sign language and voice. Now, as scientific evidence continues to pile up that sign language is the natural language of deaf children, the pendulum is swinging again in another direction – towards bilingual bicultural (19).

2.1.3.3. Bilingual Bicultural Method

This is the most recommended and recent method of teaching deaf pupils. This method involves the teaching of sign language as a subject and a written language (18). With this approach, written languages like Amharic are taught through sign language. Deaf pupils are taught sign language and written language side by side; hence sign language is used for all "through – the - air" communication and uses written language for reading and writing.

2.1.4. Signed Amharic

This basically is the same concept as signed English and it essentially is a means of producing signs (in this research context, signs implies to signs of the ESL), which correspond to the

words in an Amharic sentence, in Amharic order. In many ways, signed Amharic is used to facilitate interaction between the deaf and the hearing community. Signed Amharic could have various basic uses such as the following:

- It seems to present a much less formidable learning task for the hearing parent of a deaf child and provides that parent with a language to use with the child.
- Hearing teachers in deaf education can make use of signed Amharic when they sign at the same time as they speak (known as the simultaneous method).
- It is easier to use for those hearing sign language interpreters who produce a simultaneous translation of public speeches or lectures for deaf audiences.

Note that signed Amharic is neither Amharic nor ESL since it doesn't follow structure of any of the two.

2.1.5. Sign Language Phenomenon

Sign language is a deaf persons' language. It is a visual language. Communication is done by means of hands, face, head and upper body. Sign language is not international. Hence, different sign languages have been developed in different countries where deaf communities exist. Examples of such sign languages include American Sign Language (ASL), British Sign Language (BSL), South African Sign Language (SASL), and Ethiopian Sign Language (ESL). Sign Language users perceive the world through skilled and practiced eyes (19). Sign language is an integral part and an identifying feature of membership in the deaf culture. It has its own grammatical structure independent of any spoken /written language.

2.1.5.1. Sign Language Characteristics

Sign languages, like ESL, have some features that spoken languages lack. These characteristics are:

2.1.5.1.1. Simultaneity: - sign languages have the ability to make sign (produce and receive) more than one word simultaneously. This feature can help sign languages to express wide ideas in a very short way and time.

Example: the following single sign can express the sentence" Are you hungry? (እረቦሃል(ሻል) እንዴ ?)"

Form a shape as shown in the figure and see the person you are asking. Here the face expression plays great role.

2.1.5.1.2. Localization: - localization is about describing the placing or positioning of objects in signing space in a certain situation or a story in sign language. When a deaf person is signing, he/she may point or indicate spaces to define any object situated on that area.

2.1.5.1.3. Movement: - signers may use movement of their eyes, mouth, hands, face and body to clarify some thing. This is linguistically known as non-manual signs. Or, in other words, meaning not transferred through the hands. It is important to note here also that non-manual signs convey meaning. Without non-manual signs, the signs made by the hands may become meaningless.

2.1.5.1.3. Iconicity: -with this method signers will try to trace real objects by using descriptive signs.

2.1.5.2. The Notion of Signs

The notion of signs deals with the way signs are created or formed or made. Deaf people create signs from things they see or the way things (objects) behave, move, or look like. Signs will make a direct (whole) picture or part picture of an object. Sign languages involve simultaneous manual (that is, hand shape, hand orientation, hand position and motion) and non-manual (that is, posture of the upper torso, the orientation of the head and facial expressions) components for conveying meaning (16).

The manual components of signs are constrained to occur within signing space. Signing space is the three dimensional space in front of the signer which extends vertically from above the signer's head to the body to at arm's length in front of and to the side of the signer (21).

Generally, signers help themselves to four key aspects of visual information in producing signs for sign languages: hand forms (shape), location, movement and orientation (16,19).

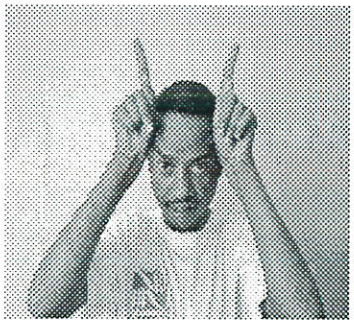
- Hand forms: - are the different shapes that the hand takes.
- Location: - is about the areas where the hand forms are placed such as the head, chest, and the natural space in front of the body.
- Movement: - in every sign there is movement.
- Orientation: - refers to the orientation of the palm in relation to the body.

Bearing in mind the above important aspects, some of the ways signs are created are discussed below with their ESL equivalent figure and description.

2.1.5.2. 1. Iconicity

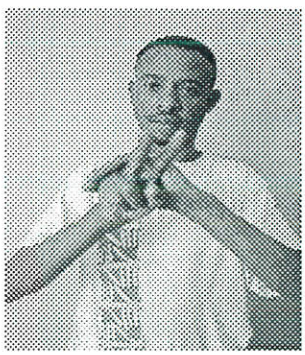
- **Direct picture: -** some signs are totally iconic. Their signs look like or represent the way the objects look like or act.

Example: Snail (ቀንዳውጣ)



(a)

Fold all your fingers except index finger and form a shape as shown in the figure (left). Put your hands beside your eyes. Then move your hands up.

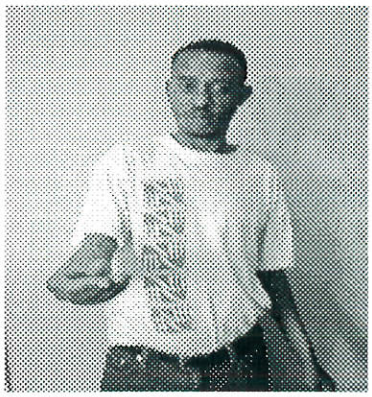


(b)

This is another way of signing snail. Form a "V" shape using your two fingers as shown in the figure (left) using your one hand. Move your fingers from bottom to up under the other hand.

- **Part picture: -** some objects are signed taking some part of their action.

Example: Cat (ድመት)



Using your one hand form a shape as indicated in the figure (left) at the same time forming a shape of calling a cat (tu-tu-tu..) using lips.

2.1.5.2.2. Action Based: - some activities are represented by signing their equivalent actions.

Example: Walking (መራመድ)

Move your hands up and down at the same time looking a walking person.

2.1.5.2.3. Pointing at an Object: - some times signers use to communicate by pointing to the object about which they are talking. For example one can say" put the TV on the table" by pointing both objects and showing a "put" sign.

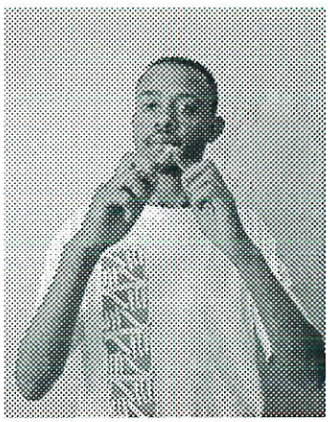
2.1.5.2.4. Touching an object: - most body parts (example: eye, ear, nose etc) are signed by touching them.

Example: Ear (ጆሮ)

Touch your ear using your hands to say "ear".

2.1.5.2.5. Alphabetical signs: - refers to using the first or last letter of a written language word for signing some thing.

Example: Kebelle (ቀበሌ)



Form the letter "ቀ"(KA), first letter of the term "kebelle", using both hands as shown in the figure (left), touch the two tip fingers each other, separate the tip fingers slowly.

2.1.5.2.6. Finger spelling: - name of places or people and words with out signs may finger spelled.

2.1.5.2. .7. Sign borrowing: – when people travel to other countries they learn new signs, which they import to their countries.

Example: United States of America (አሜሪካ) as borrowed from ASL.

Intertwined your both hands' fingers as shown in the figure (left) and move your hands in circle way.

2.1.5.2.8. Sign change: – refers to modifying others' sign languages because of wrong signing, difference in culture, age or time, when new signs created, and sign borrowing.

Example: Christmas (ገና (የክርስቶስ ልደት))

In ASL Christmas is signed by forming a "C" shape and move the hand from front to outside. In ESL the only change is using Amharic alphabet "ገ" (GA) instead of "C" to say "ገና" (genna) which is Christmas in Amharic.

2.1.5.3. Written Sign Language

The fact that a sign language exploits the visual medium in quite subtle ways makes it difficult to represent accurately in the page. The best way to capture Sign Language (to take notes during a course, for example) is to use videotapes. During a sign language lectures students without videotapes are always challenged to take notes. I have assured this situation when I was attending the ESL class arranged by Addis Ababa University and ENAD this year. Hence in such situations sign languages need to have a way to take notes; that is, there must be a way to write in sign language and this can be done using motion pictures.

There is no universally accepted written form of sign language at the present. No record is present for the deaf people with their native language; instead anything the deaf people sign has been translated into the dominant spoken language in which they are not necessarily

fluent. There is no way to accurately transcribe anything a person signs, except for a system using invented symbols called SignWriting.

Sutton SignWriting, or SignWriting, was created in 1974 by Valerie Sutton (22).SignWriting is a writing system which uses visual symbols to represent the hand shapes, movements, and facial expressions of signed languages. It is an alphabet - a list of symbols used to write any signed language in the world. In the same way, the symbols in the SignWriting alphabet are international and can be used to write any sign language (23). With SignWriting, different kind of deaf people can:

- Write their language of sign. This ability increases independence in communication.
- Communicate across great distances without relying on interpreters, relay operators, or telecommunication/video equipment.
- Record their stories, poetry and other artworks on paper. In this way, signed artworks can be saved and appreciated by future generations (24).

The very problem of SignWriting is that it relies on non-ASCII symbology.

2.1.5.4. Sign Language Grammar

Researches indicate that sign languages, as any natural language have their own grammar. As discussed in (19), a sign language does have its own:

- Morphology:- the way signs are put together to form a sentence
- Phonology:- the way in which phonemes are combined
- Syntax: - the grammatical arrangement of signs in a sentence.

To clearly describe these elements of a Sign Language research must be done regarding its grammatical structures. In the case of ESL, there is no research done regarding this fact of the language.

2.1.5.5. Gestuno

As it is indicated before, sign language is not international. Because of the variations of culture and background, different countries do have their own sign languages. Even at a country level there may be some variations of signs for same object at different places. For example in Ethiopia, the sign used by the deaf for fish around the capital Addis Ababa (making a front zigzag with one hand) is different from the sign used for the same object in Arba Minch, a town in the southern part of Ethiopia,(putting one hand over the other and wagging the two thumbs).

Therefore, deaf people from different sign language background definitely face a problem of communicating each other without interpreters. The world federation of the deaf had tried to solve such problems especially for international meetings among the deaf. Gestuno is the sign language that the world federation of the deaf devised to unify sign languages. "Gestuno "is an Italian word meaning "oneness of sign languages". It contains almost 1500 signs.

2.1.5.6. Manual Alphabets versus Signs

Manual communication can use two different ways to present a word: finger spelling and signs. Finger spelling in sign language is the way in which letters of alphabet are made on the hands. (16). Communication through finger spelling alone would not be part of sign languages.

The second way to present a word or a concept is through a sign, which represents a complete idea. As discussed before each sign has position, configuration, and movement of hands.

2.1.6. Communication Gap between Deaf and Hearing People

Deaf people in Ethiopia have no direct access to the flow of information, as do hearing people. There is no use of specialized or adapted Telecommunication devices freeing them from dependence on face-to-face communication or the intervention of a third party. Moreover, it is very challenging for most deaf people in terms of economy to hire a private sign language translator. Even for those who have capacity to hire translator, Good Sign Language translators are in high demand and are not always available. That means that

communication among hearing and deaf people is almost impaired or nonexistent, to the detriment of both groups.

For persons with hearing loss, one of the greatest obstacles to workplace integration, for example, is finding convenient and accurate methods of communication for a variety of work-related settings. Communication difficulties overshadow many aspects of employment for these individuals, including whether they find employment in the first place. Because most human resource managers have little or no experience with this disability group, concerns about communication frequently prevent applicants with hearing loss from being hired.

Let's see the case of health centers as another example. If a hospital fails to provide a qualified interpreter, a deaf or hard of hearing person who has no Sign Language translator may have to make critical health decisions without being able to adequately communicate with his or her doctor. This communication gap could place some deaf patients at risk. Since it is difficult to get interpreter easily, sadly, hearing children of deaf parents are often used to interpret during medical consultations. This is obviously dangerous for the patient and also places inappropriate responsibility on the child. Alongside ethical considerations, with sign language we cannot assume that friends and relatives of a deaf person can sign to a sufficient level.

Bearing in mind that having a sign language interpreter is challenging for most deaf citizens of the country, I saw as it is essential that someone who is member of staff in public service areas (for example, doctors, nurses, etc, in hospitals) with the proper level of interpreting skills is used. If staff members learn ESL they can bridge the gap between themselves and the deaf community (see chapter 1).

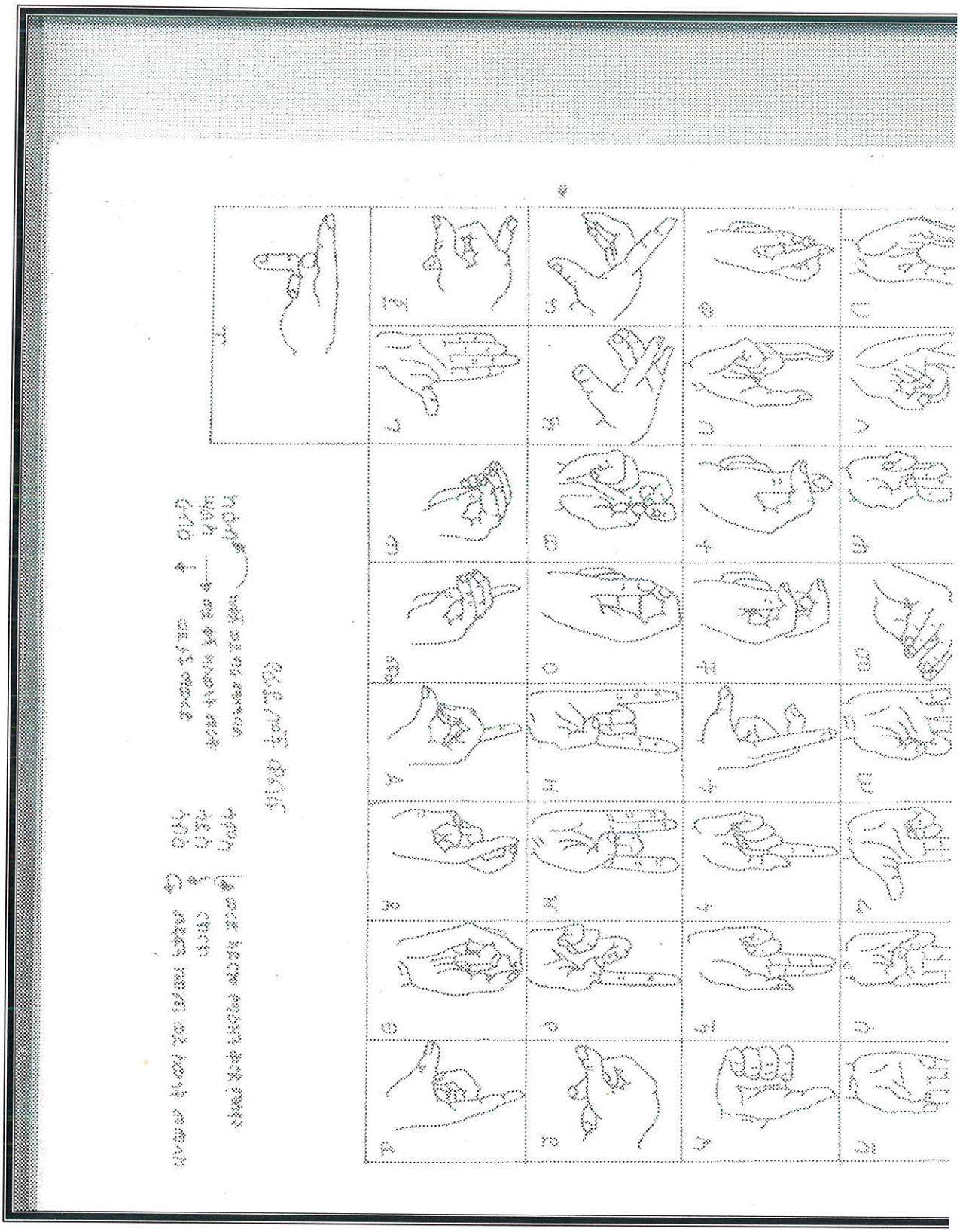


Figure 2.1: Ethiopian Sign Language Representation for Amharic Alphabets (20)

2. 2. Computer Aided Instruction

2.2.1. Introduction

Bostock indicated that, the purpose of software for education or training is to promote learning. According to the author, this is quite different from the function of business software such as accounts packages or decision support systems, and much more difficult. This is because with educational or training software the requirement is to change the capabilities of human learners, so analysis and design must involve their learning process, which are not completely understood, and are different in detail from one person to another (25).

The evolution of computers in learning has not occurred in isolation. Rather, it is an iterative hyper product of ongoing developments in psychology, pedagogy and technology. At times, technology has been at the forefront of these developments, helping to shape our understanding by demonstrating heretofore untested teaching and learning methods. At other times, technology has enabled widely held notions about teaching and learning (26).

Though Computer Aided Learning is an all-encompassing term to describe any educational use of computers, varieties of other terms like computer aided instruction, computer based learning, computer based training, computer management instruction, etc. are also used to describe the educational use of computers and each has slightly different meaning (27).

In this research, computer aided instruction (CAI) is the main focus and is used to refer to the use of (personal) computers for education and training. Software designed to be in educational programs is termed as courseware.

CAI grew into greater favor in the mid-1990s, when the US Department of Labor-sponsored National Alliance of Business reported small and mid-sized companies should embrace new technologies such as CAI, so they may use technology to cause needed change; rather than reacting as technology changes affect them. Their report showed that, CAI can assist in increasing worker knowledge, as it can be designed to provide consistent training in new standards, such as the quality standard ISO 9000. They also reported benefits from the individualized pace of training, and a better ability to accommodate an increasingly diverse workforce (28).

2.2.2. Advantages of CAI

Computer-aided instruction has definite advantages including the following:

- CAI offers multi-media enhanced state-of-the art teaching and learning materials.
- If made online, CAI provides an enriched worldwide learning environment.
- CAI is Learner-Centred, not teacher centred. Learning is interactive, hence is more usable and attractive.
- Taking the course on computer increases computer skills necessary for success in the workforce (25, 26, 27, 28, 29).

2.2.3. Learning Theories

There are three main learning theories: Behaviourism, Cognitivism and Constructivism.

2.2.3. 1. Behaviourism

Behaviourism is the oldest learning theory, which threats the learner as if he/she is a black box. Behaviourism is similar to a machine that produces responses when exposed to stimulus. It is related to student modeling. The task of learning is to teach the student a particular response to be made when a particular stimulus is presented, process known as conditioning. Repeatedly presenting the stimulus and reinforcing correct responses while punishing incorrect responses is one means of achieving this. Instructional goals based on behaviorism are characterized by being specified, quantified, terminal behaviors. For example a student is said to have mastered the domain when he/she scores more than 90% on a test (29).

2.2.3.2. Cognitivism

The concern or emphasis of Behaviourism is observable indicators that learning is taking place. Contrasting this view of learning is the emphasis of cognitive psychologists who equate learning with the mental processes of the mind. Cognitive theorists recognize that much learning involves associations established through continuity and repetition. In other words, cognitivism explains learning as the formation and reformation of mental representations of the domain knowledge. So the cognitivist learner is definitely not a black box, and cognitivist models describe this internal representation. Cognitivism also is related to student modelling (29).

2.2.3. 3. Constructivism

The term constructivism refers to the idea that learners construct knowledge for themselves each learner individually (and socially) constructs meaning as he or she learns. Whereas behaviourism and cognitivist are objective theories of learning, in which predetermined behaviours and/or cognitive structures are transferred to the student, constructivism is a subjective theory in which learners are said to construct their own reality based on experience. This implies, this model is not related to student modelling. New knowledge is formed, rather than transferred, from the learners' previous experiences. Moreover, constructivism says that domain knowledge should not be decomposed and presented to the student in parts; instead should take place in realistic settings with all the ambiguities and extraneous details that entails. As a result the student will be able to construct knowledge better adapted to the context in which they will apply (29).

2.2.4. Approaches to Instructional Design

There are a number of established approaches to the systematic and effective creation of training courses. As Dr Vicars cited, some of the more popular approaches include: Performance-Based Training (PBT), Criterion-Referenced Instruction (CRI), and Instructional System Design (ISD). These systems all share a similar emphasis on the importance of tying instructional objectives to the knowledge, skills and abilities that a learner needs in order to accomplish the job or task he/she is preparing to do. Instructional models based on these approaches promote the logical development of sequential lessons using material that can be tracked, evaluated, and updated to reflect current information and best practices (30).

As Dr Vicars stated, the ISD method of instructional development (analysis, design, development, implementation, and evaluation) first became popular during World War II when the United States government needed to train huge numbers of people quickly and efficiently. Since then, models based on the ISD approach have provided a systematic and reliable method of designing curriculum, materials, and content delivery systems (30).

2.2.4.1. The DDD-E Model

A type of ISD model that has worked well for multimedia projects is the Decide, Design, Develop, and Evaluate (DDD-E) model. This model, developed by Karen Ivers, an Assistant

Professor at California State University, Fullerton, California, and Ann Barron, an Associate Professor of Instructional Technology at the University of South Florida, provides a good scaffold for multimedia projects and is flexible enough to adapt to today's rapidly changing technology (30).

2.2.5. Types of Courseware

Note that, courseware is software designed to be in educational programs. In other words, courseware are software designed for a CAI purposes. There are different types of courseware each one having different characteristics (27, 28, 29, 30, 31). The most common are:

2.2.5. 1. Hypermedia

Hypermedia takes the basic informational material and supplements with other materials. It is very flexible and open ended. Users can access as much or as little as they wish. Hypermedia requires careful consideration of the logical structure. Hypermedia is one of the easiest kinds of courseware to do with Revolution but one of the hardest to do well.

2.2.5. 2. Tutorials

Tutorial courseware involves formal and usually linear presentation of materials. These CAIs often followed by quiz, tends to be less flexible and open ended. In such courseware the programmer controls the path through the program so that less complicated structure exist.

2.2.5. 3. Simulation

Simulation models a real life problem or situation. It presents user with problems to solve, requiring skills that the user is supposed to be learning. Such a courseware is often very flexible.

2.2.5. 4. Drill and practice

Drill and practice (or drill and kill) tends toward less flexible, but some have sophisticated adaptive features that determine the user's level and adjusts difficulty of questions accordingly. This approach, which is currently somewhat out of favor in CAI development

circles, is helpful for learning tasks requiring lots of repetition, rote learning; e.g. grammar practices and vocabulary learning (29, 31).

2.2.6. Web-Based Instruction

Today we hear all kinds of talk about the Information Superhighway, the World Wide Web (WWW), and the Internet. One of the best features of this new communications tool is the amount of information available to anyone on almost any topic.

Generally, materials on the WWW can be categorized into either informational or instructional. Informational sites may be developed by anyone on any topic. There are literally millions of these sites.

A growing use of the WWW is to support and deliver instruction. Instruction, in this environment, is viewed as any WWW page that is designed to support an educational activity. This support might be seen through additional information, assignments, instructions, or the lesson itself. This information is collectively known as web-based instruction (WBI).

Hence, WBI is a method of delivering instruction over the World Wide Web. Typically, students participating in WBI are found in many locations across diverse areas. WBI includes hypermedia elements and use of the World Wide Web.

Generally the features and components that WBI might include are:

- **Interactivity.** Students, teachers, experts communicate among each other, providing support, feedback, and guidance.
- **Online searches.** Students can find online resources to support course content and resources.
- **Device, distance, and time independence.** Students can participate in this learning environment at times convenient to them, on their own equipment at their home, school, or business.
- **Cross-cultural interaction.** WBI lets students and teachers communicate with people all over the world to explore ideas, cultures, and civilizations

2.2.6. 1. Advantages of Web-based Instruction

The general benefits of Web-based training when compared to traditional instructor-led training include all those shared by other types of technology-based training. These benefits are that the training is usually self-paced, highly interactive, results in increased retention rates, and has reduced costs associated with student travel to an instructor-led workshop.

Web-based training yields additional benefits:

- **Access is available anytime, anywhere, around the globe.** Students always have access to a potentially huge library of training and information whether they are working from home, in the office, or from a hotel room. As cellular modems become more popular, students will even be able to access training in a place that doesn't have a traditional phone line or network connection.
- **Student tracking is made easy.** Because students complete their training while they are connected to the network, it is easy to implement powerful student-tracking systems.
- **Content is easily updated.** This is perhaps the single biggest benefit to Web Based Training. In today's fast-paced business environment, training programs frequently change. With this technology it is a simple matter of copying the updated files from a local developer's computer onto the server-computer. The next time students connect to the Web page for training; they will automatically have the latest version.

2.3. Hypermedia

As indicated above, hypermedia is one of the methods of constructing courseware.

2.3.1. Hypertext, Multimedia, Hypermedia

The different ways in which Information and knowledge are organised and stored can significantly influence their meaning and the purpose for which they can be used. Two basic approaches are often used for organising and presenting information and knowledge:

- **Linear structure** in which corpus of knowledge is organised into several units which are designed to follow each other in sequence. Some jumping back and some stepping ahead is usually allowed and each of the basic units from which a linear structure is composed has just single entry point and single exit (27).
- **Non linear structure** in which the basic units of information that make up the knowledge corpus are joined together in many complex ways that allow them to be processed in a variety of different non linear pathways. Each of the modules used has single entry point but any number of exit points so that a user can jump to any of a number of other units from within the body of one unit depending up on his/her information interests and requirements (27).

Hypertext (a term coined by Ted Nelson) stands usually for a network of interconnected pieces of textual information. It is a non-sequential/non linear method for displaying text. Normally, the prefix hyper usually means "more than", so we may begin by asking what that hypertext that makes it more than text is. The simple answer to this is that as well as text, hypertext has these features: nodes or chunks of information, links between nodes, organisational structure that describes network of ideas, dynamic user control, and multi user access (26, 32).

Multimedia is the integration of media such as text, graphics, animation, sound and video (32).

Hypermedia is the combination of both, a network of pieces of multimedia information. It is the dynamic relationship between a group of documents (text, images, sounds, video clips and animations) that can often be accessed in a non linear fashion (33). Hypermedia can be viewed as a database, which contains pictures, digitised videos, sound and animations in addition to text.

Though, quite often the terms hypertext, multimedia and hypermedia, are freely interchanged and are used as synonyms, for this research purpose I will use the terms as defined above.

2.3. 2. Brief Historical Background to Hypermedia

Hypermedia systems can be distinguished in to two generations:

- **First generation** hypertext systems were mainframe based, text-only systems for augmenting the performance of information processing, storing the whole world's literature or for supporting traditional writing and reading (34).
- Transition from hypertext to hypermedia took place with the **second generation** systems. These systems were quite similar in concept with first generation hypertext systems, but they were workstation and PC based, with more sophisticated graphics interfaces and support to other forms of information such as graphics, sound, animation, and video (34).

The precedent usually invoked for hypertext is Bushe's Memex that could organise information in such a manner that a user would be able to follow a trial of associations through the information (35). Vanevar Bush who was the science advisor of US president Roosevlet and over server of all wartime research, including the Manhattan projects (36) raised his ideas because he was frustrated that important scientific researches were ignored because of the increasingly large amounts of information available. Memex is a kind of massive personal library in which an individual stores his/her books, record and communications, and which is mechanised so that it may be consulted with exceeding speed and flexibility. (35). Bushe's ideas were visionary, but the technology of the time was incapable of supporting them (36).

The Memex path gave to some "hypertext" ideas/systems around the mid 60's: the NLS/Augment system by Dauglas Englbart; and the Xanadu project of Ted Nelson. Although the origins of hypermedia are popularly attributed to Bush, Englbart and Nelson, it is only in recent years that it has become widely known (37, 38).

2.3. 3. Hypermedia Systems

Hypermedia Systems (HMS) are non-sequential and non-linear methods of displaying text, graphics, sound, and video. They use interface design and advanced navigational tools, and assume that the student's interpretation is more meaningful than the expert's. Hypermedia Systems use a constructivist approach to learning (see section 2.2.3. 3), where learning is regarded as the formation of "constructs" of understanding by the learner. The learner builds the knowledge based on previous understanding by interacting dynamically with the domain structure. HMS provides a suitable means for this approach because they allow the learner to take control.

HMS allows the learner to make an informed decision regarding where to proceed in the material. The hypermedia is a node-link structure, which allows the user to move through the information using advanced navigational tools. The structure and the sequence are expert-defined, but the learner defines his own path to follow. This provides the students with the greatest opportunity to learn on their own.

HMS development is a new and still evolving discipline. Its development differs from the developing process of traditional software in several dimensions. Moreover, a hypermedia developed using a design method rather than by taking an ad hoc approach has various benefits.

A method for HMS development is a set of phases, which guide the developers in their choice of techniques that might be appropriate at each stage of the project. There are specific list of aspects that has to be covered by a chosen methodology.

Basically two techniques of system development, entity.-relationship (derived from database design models) and object oriented techniques, are applied for hypermedia design. For a hypermedia design People with different skills are involved in the process such as, authors, layout designers, programmers, multimedia experts, and marketing specialists (39).

When designing hypermedia products three different design elements: content, structure and presentation are considered (40). As Shwabe and Rossi described, hypermedia applications are seen as systems that are built to function as part of a man-machine team. These writers verified that the part of the problem to be solved by the machine uses whether techniques that are appropriate databases, knowledge based systems, hypermedia, information retrieval systems, etc. The part of the problem that is solved by the human being uses a hypermedia framework to aid the human being in managing the stored knowledge (41).

2.3.4. Links, Nodes, anchors

As indicated in section 2.3.1 above, links, nodes and anchors are features of a hypermedia application. Node represents 'chunk' of information corresponding to a natural 'semantic unit'. They are created by parsing the originating text, images, sound or video clips into nodes. Nodes represent the documents or primary content containers. A node should express a complete idea. It should not be dependent upon any external information for understanding, in

other words a person should be able to read the node and understand its meaning regardless of how the reader navigated to the node. This is critical because in a hypermedia system, a reader can typically enter a node from many different external points. The author can make no assumption on what the reader has read prior to entry to the node and additionally can make no assumption about where the reader is to go when leaving the node (41).

Link is an association between nodes and anchor represents a link on a node. Hence anchors and links are objects, which bind together concepts expressed within an information space. By performing some action on an anchor point in the media the user traverses a link to some other related concept in the hypermedia database (another anchor point). Examples of anchor can be buttons, bolded text, "hotspots", images etc. The whole node might be an anchor but should be able to designate a sub-region as a source or destination of a link.

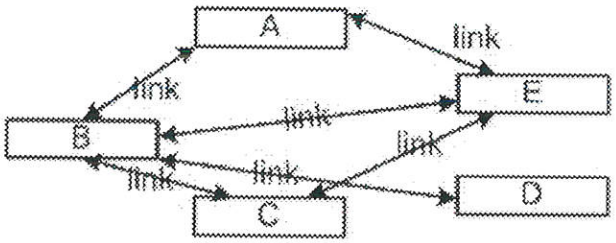


Figure 2.2: Nodes and Links in a Hypermedia System

It is necessary to distinguish the underlying link anchor from the manifested link marker displayed on the screen. Link markers visibly indicate a link's presence. Link anchors contain parameters and other internal information, which users do not see (41).

2.3. 5. Information Organization of Hypermedia Products

There are three main ways in which information in a hypermedia product can be organised (42):

- **Linear format.** With this format, the nodes are linked in a linear sequence. These structures can be used in a number of ways within a hypermedia application. They can be used to retain the sequential structure of an original paper document. Hypermedia application developers sometimes implement link applications that bind a series of nodes together in a sequential manner. These are sometimes referred to as Guided Tours or hypertrails. They are commonly used as

instructional aids. Since this linear type of format allows users to progress in a sequence set by the author however, under utilises the non-linearity power of hypermedia.

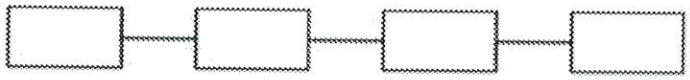


Figure 2.3: Linear Information Organization

- **Hierarchical.** Such structure can be used to retain the original structure of the information contained in a hypermedia application. This hierarchical structure can be replicated within a hypermedia database through the use of hierarchical links. A reader can go to a hypermedia application's table of contents or index and select a point within the information space to read in the same way as is done in the paper domain. This organisation is recommended for representing the structure of manuals or other paper based publications.

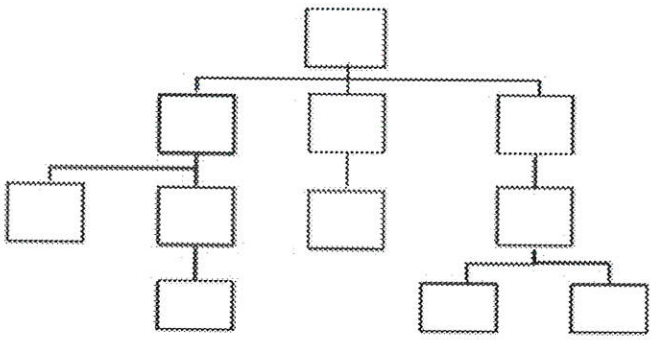


Figure 2.4: Hierarchical Information Organization

- **Network.** This structure consists of associative links, which are semantic or

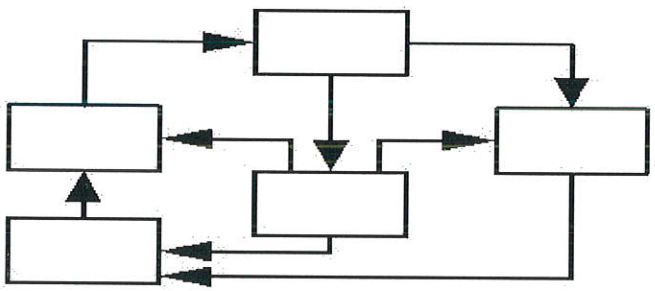


Figure 2.5: Network Information Organization

pragmatic in nature and truly non-sequential. They bind common or related concepts together within the information space. The ability to utilize these associative links and the resultant network in effective browsing of the information space is one of the major advantages of hypermedia applications.

To a large extent hierarchical links are used to represent information structure whilst network links are used to represent semantics. In practice a combination of these is often used to form a hybrid structure.

2.3. 6. Educational Applications of Hypermedia

Hypertext has played a role in teaching and learning since the mid 1980's when the first version of HyperCard appeared (38). This extremely popular environment and authoring tool presented hypermedia as a technology capable of resolving some of the needs of learners and educators using instructional technologies.

In hypermedia applications, the volume of actual code produced in scripts is relatively low and emphasis is put in user interface design, link structure design and definition of contents entry as the different multimedia components.

2.3. 6. 1. Hypermedia Applications for sign language Learning

There exist numerous hypermedia-learning tools and researches regarding various Sign Languages around the world. Among these the following are only a few.

2.3. 6. 1. 1. Learning Sign Language through Multimedia

This paper presents the key technological and contents requirements for learning to sign from a point of view of deaf as well as hearing persons. The technological requirements are then measured up with the current Multimedia PC Level 2 specifications. An alternative representation for sign language based on edge images derived from sequences of video frames is proposed to achieve higher video compression ratios. The fulfillment of contents requirements is demonstrated by an example of Sign Language Dictionary and Tutor (77)

2.3. 6. 1.2. Signing SASL: CD Rom Supplement and Basic SASL lexicon

This is a thesis work on South African Sign Language (SASL) by H. Fourie at Stellenbosch University of South Africa. The project covers roughly 20 topics ranging across cultural awareness, grammatical features, the lexicon, finger spelling and its role, and practice with SASL conversational skills (that is, interacting with deaf people, politeness, interruptions and name signs) (8).

2.3. 6. 1. 3. ASL Online: The Design and Implementation of a Web-Based American Sign Language course

This PhD thesis of Dr Vicars, examined the development and implementation of an Internet-based introduction level course in ASL. The study is intended to teach those hearing caretakers of deaf children and other children who communicate visually and have no chance to attend traditional ASL course (30)

2.3. 6. 1. 4. Serious Signing Software

Serious Signing is a sign Language instruction package. It is prepared for teaching novices at ASL. It has two parts:

- The first part is a computer tutorial written in the popular multimedia package, HyperStudio. With it, one can learn and practice the signs, then learn how to sign whole sentences. Some of the tutorials allow to proceed at ones own speed. Others give the option of having HyperStudio present the signs to the user at speeds anywhere from slow to hot!
- The second part consists of Acrobat files that one can open and then print out from Acrobat Reader. The printouts consists of a sign language instruction and lesson book that has lots of examples one can sign to him/her self or another person, a reference manual of all the signs in the tutorial, plus a booklet that lets users practice reading the actual signs in sentence form.

The layout of the package is easy to understand, with users' choices and the appropriate sign. The signs are well drown, with a written explanation for any signs that require hand movement (43).

2.3. 6. 1. 5. A closer Look: Signs for American National Government

A Closer Look: Signs for American National Government is a serious of interactive CD-ROMs of the Arkansas State Outreach and Technical Assistance Center. The goals of this project are to improve both interpreting services in educational settings and Deaf students' comprehension of specialized English terminology for better comprehension of course material and improved test scores.

With the CDs of the serious, for each term a video clip shows the concept in ASL. Along with the video, the user also sees the English definition and the concept used in the context of a sentence.

A user can view specific signs and terms in the sequence he/she chooses. Replaying a specific video is as simple as clicking the "play" button (44)

2.3. 6. 1. 6. American Sign Language for Kids

American Sign Language (ASL) for Kids is a great way for children ages 2 and up to begin learning ASL, the third most used and fastest growing language in U.S.A. ASL for kids is specifically designed with ease of use in mind. Video is used so that one can see each sign clearly, slowdown or increase the word delivery to learn at his/her own pace (45).

2.3. 6. 1. 7. Hypersign Interactive Dictionary of American Sign Language

While this product is centered around a video dictionary of approximately 2000 basic ASL signs, many features have been included to enhance the learning experience and increase the potential for success in learning, retaining, and using ASL. The features included are:

Full Motion Video- The full motion video of ASL signs include the suprasegmental features (facial expressions or gestures accompanying the sign) which change their meanings. Each sign has a base sign representing the one most commonly used in daily conversation. If there is more than one sign, which fits that word, the dialectical or semantic variations of the signs are also available.

Age Level Specific Vocabulary- Since vocabulary varies with age, HyperSign provides access to the video dictionary at three levels. Users of the adult's dictionary have access to all 2000 signs. The teen dictionary is a subset of the adult dictionary. The child's dictionary was

specially designed for nonreaders and pre-readers with each word accompanied by an easily recognizable picture.

Spanish and English- Since Spanish is the second most commonly used first language in USA; the program is designed to provide instructional text in either Spanish or English. **Activities-** Games are fun. They also enhance the learning experience and increase retention. Games are included for children (Matching Game, and Tic-Tac-Toe), and teenagers and adults (Crossword Puzzle, Name That Sign, What's My Sign?, and You First!). Other equally important features include: Custom Word Lists Everyday Phrases ASL Conventions Online Bibliography (78)

2.3. 6. 1.8. Survival Sign Language vocabulary

Survival Sign Language vocabulary was designed for people who need to keep their signing skills sharp, or need to learn new signs in order to communicate with deaf students. The software is great for parents, teachers, students, medical workers, police and family.

To use this product, quickly lookup a sign from 700 words and phrases using the 3 search options (index, dictionary, and category), then play the movie clip to begin learning. As the sign is viewed the text representation is captioned above the movie, also the word is played audibly before the sign is demonstrated. If a trouble with a particular sign happened, the clip can be played in slow motion, forward or reverse. This helps users by tracking exact movements of fingers or hands (46).

2.3. 6. 1.9. The American Sign Language Dictionary

The American Sign Language Dictionary combines text, video examples, and animated illustrations to create a rich reference tool that makes learning ASL easy, intuitive, and fun. It takes a guided tour to get started! The Award-Winning Original Version Has Been Improved! It incorporates Fingerspelling Games and Quizzes Searching capabilities in five languages. With his system one can learn the History of Sign Language Build his/her Vocabulary and Practice more than 2600 signs with video demonstrations and illustrations, then listen to audio explanations or read the descriptions on-screen. VCR-like controls can be used to rewind, move forward, or enlarge the video window (79).

2.3. 6. 1.10. Getting Started in Signing

This tool is an ultimate Multimedia Guide to Learn Sign Language Faster. It enables one to learn everything he/she need to begin using sign language in practical, everyday situations like talking about family, planning a party, or shopping. This 60 minute DVD is taught by Dr. Elaine Costello, an educator and author that has been associated with the deaf community for over 20 years. Webster's Millennium Getting Started in Signing DVD provides versatile, family-friendly content that delivers (80).

2.3. 6. 1.11. American Sign Language Learning System

The American Sign Language (ASL) Learning System combines four of the best multimedia tools for learning, improving and mastering both ASL and fingerspelling. Dr. Martin Sternberg's award-winning American Sign Language Dictionary joins three other great teaching and reference tools to bring users the best multimedia sign language learning experience available. This 4-CD Deluxe edition includes:

ASL Dictionary - This is the classic multimedia-learning tool for students, teachers, individuals and groups. As indicated above, this award-winning ASL Dictionary is the fastest and best way to learn signing and fingerspelling at every skill level.

101 Basic Signs - Gives the skills and confidence one will need to learn and instruct ASL. 101 Basic Signs offers beginner and advanced settings that let users learn at their own pace and control the lesson.

Fingerspelling & Numbers - With the help of extraordinary photographs and animated hands, Learning Fingerspelling and Numbers comes quickly and easily. Create custom vocabularies such as medical and legal terms.

Hypersign 4.0 - Includes over 2,000 signs with instructional text on American Sign Language in English and Spanish. As indicated above, Hypersign 4.0 offers full-motion video, age-level specific vocabulary, everyday phrases, and a host of games (81).

2.3. 6. 1.12. Sign Language Tutor

This ASL tutor combines all the elements of multimedia including full motion video, sound, illustrations, and text. It allows practicing signing by watching full motion video clips of

hearing-impaired people. This tool has the best video quality on the market and has ability to fully control movies' playback speed. The sound quality is fantastic .it consists of complete sign language course in 27 lessons. Lesson topics are grouped into similar categories such as family, animals, food, etc. the tutor contains extensive lists of verbs, nouns, pronouns, adjectives, and function words. It permits users to access any word in any order. This course acts like a teacher that never gets tired of repeating the same movements over and over again (82).

2.3. 7. Hypermedia Systems Interfaces and Databases

One of many interface decisions in hypermedia design is how the application program responds and reacts to user input. User inputs today most commonly take the form of keyboard keystrokes, mouse or trackball clicks and drags, or touches on a touch screen. Responses to those inputs by a hypermedia application may take several forms:

- The application can simply execute the command.
- A visual cue can indicate that a particular command has been received. (It is common, when a user makes a choice, for that choice to become visually highlighted for a moment before the command is executed. This is thought to give the user a sense of communicating with the system).
- An auditory cue can indicate that a command has been received.

Databases have traditionally been accessible through search strategies such as keyword search, full text search, Boolean structures of AND/OR/NOT; word frequency, word proximity and so on. Hyper mediated databases provide search methods, which are tailored to the particular information in that database. They may add visually appealing, content specific layout. They may add a metaphor, such as a space ship control with a window for navigating a database about outer space. The interface may add value or meaning to the database. Hypermedia database interfaces help make sense out of the content and interrelationships of the database entries (41).

2.4. User-Centered Design (UCD) for Hypermedia Software Development

2.4.1. Introduction

The design of everyday objects is not always intuitive and at times it leaves the user frustrated and unable to complete a simple task. During the past more than a decade years, the human-computer interaction (HCI) community developed a large variety of user-centered design (UCD) techniques. However, these methods are still underused and difficult to understand by software development teams and organizations. This is because these techniques have been developed independently from the software engineering (SE) community, which has its own techniques and tools for managing the software development lifecycle including usability concerns (47).

The obvious question is: Isn't it possible to design systems that are more usable by considering UCD techniques and knowledge in the existing software development life cycle? Answering this question will lead to maximize benefits gained from both SE and UCD (47).

'UCD' is a broad term to describe design processes in which end-users influence how a design takes shape. It is both a broad philosophy and variety of methods (48). There is no sole and exact definition of UCD. The expression is interpreted slightly differently even within the HCI community. Yet there is an ISO standard on the subject - ISO/IS 13407- Human-centered design processes for interactive systems, but the standard is more of a description than a definition. The following definitions are taken from (49) which the authors collect from different literature.

- "UCD is an approach which views knowledge about the users and their environment in the design process as a central concern."
- "User-centered design emphasizes that the purpose of the system is to serve the user, not to use a specific technology, not to be an elegant piece of programming. The needs of the users should dominate the design of the interface, and the needs of the interface should dominate the design of the rest of the system."
- "UCD is an adequate label under which to continue to gather out knowledge of how to develop usable systems. It captures a commitment the usability community

supports - that you must involve users in system design - while leaving fairly open how this is accomplished."

- "A user centered design process is one that sets users or data generated by users as the criteria by which a design is evaluated or as the generative source of design ideas."

There is a spectrum of ways in which users are involved in UCD but the important concept is that users are involved one way or another. For example, some types of UCD consult users about their needs and involve them at specific times during the design process; typically during requirements gathering and usability testing. At the opposite end of the spectrum there are UCD methods in which users have a deep impact on the design by being involved as partners with designers throughout the design process. With all methods, however, the role of the designer is to facilitate the task for the user and to make sure that the user is able to make use of the product as intended and with a minimum effort to learn how to use it (48).

UCD can improve the usability and usefulness of everything from "everyday things" to software to information systems to processes anything with which people interact. As such, User-Centered Design concerns itself with both usability and accessibility (50).

2.4.1.1. Usability

The term "usability" refers to a set of multiple concepts, such as execution time, performance, user satisfaction and ease of learning ("learnability"), taken together. It is the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use (50, 51). But usability has not been defined homogeneously, either by the researchers or by the standardization bodies. The term has been defined in three distinct standards as in the following.

- The capability of the software product to be understood learned, used and attractive to the user, when used under specified conditions." (ISO/IEC 9126-1, 2000)
- "The extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use." (ISO 9241-11, 1998)

- "The ease with which a user can learn to operate, prepare inputs for, and interpret outputs of a system or component." (IEEE Std. 610.12-1990)(52)

The attributes which a product requires for usability depend on the nature of the user, task and environment. A product has no intrinsic usability, only a capability to be used in a particular context. Usability cannot be assessed by studying a product in isolation. Therefore, there are three potential ways in which the usability of a product could be measured:

- By analysis of the features of the product, required for a particular context of use. Usability could be measured by assessing the product features required for usability in a particular context.
- By analysis of the process of interaction. Usability could be measured by modeling the interaction between a user carrying out a task with a product. However, current analytic approaches do not give very precise estimates of usability. As the interaction is a dynamic process in the human brain, it cannot be studied directly.
- By analyzing the effectiveness and efficiency which results from use of the product in a particular context and measuring the satisfaction of the users of the product. These are direct measures of the components of usability. If a product is more usable in a particular context, usability measures will be better (51).

The ISO has developed different standards on usability, and two major categories can be distinguished:

- Product-oriented standards (ISO 9126, 2001; ISO 14598, 2001)
- Process-oriented standards (ISO 9241, 1992/2001; ISO 13407, 1999)(50)

Limited usability is a problem endangering technological progress. The enormous technological revolution over recent years has also introduced some unexpected problems, one of them being poor product usability. With more complicated products coming onto the market, with ever more different and creative designs of displays and controls, technological progress may sooner or later get stuck at a point where nobody can handle the new devices. In addition, growing globalization and international travel have heightened this development. It should be noted, too, that the properties that software usability takes on might vary, depending on the target audiences of the software system. A candidate audience for a software

system might include end-users, managers and software developers. For each of these audiences, usability is defined from a different viewpoint:

- For the end-user, software usability is essential because it is a determinant of performance: an application, which features good usability, will allow the user to perform the expected task faster and more efficiently.
- For managers, usability is a major decision point in selecting a product, as this decision will have a direct influence on the learnability of the chosen system, and hence on the productivity of those who use it.
- For software developers, usability describes the internal attributes of a system, including issues like design quality, documentation maintainability (52).

Generally the important features of usability are effectiveness, efficiency and satisfaction. The achievement of these features can be resulted by an in-depth, clear-cut understanding of the context of use and the expected nature of user (53).

- **Effectiveness:** is how well the user achieves the goals they set out to achieve using the system.
- **Efficiency:** is the resources consumed in order to achieve their goals.
- **Satisfaction:** is about how the user feels about their use of the system

2.4.1. 2. Accessibility

Accessibility is a measurable characteristic that indicates the degree to which a system is available to users. It is an essential part of a system's overall usability. A user centered system designed to achieve accessibility:

- Offer users a few ways to find information (such navigational elements, search functions, site map, etc). However, don't offer too many options at once as this confuses many users.
- 'Chunk' information into small, digestible pieces and organize them into some type of schema or hierarchy that is meaningful to the user.
- Enable skimming; provide clues that allow users to find their 'nugget' of information' by scanning rather than reading (50).

2.4.2. Users

It is necessary to think carefully about who is a user and how to involve users in the design process. Obviously users are the people who will use the final product or artifact to accomplish a task or goal. But there are other users as well like those persons who are affected in some way by the use of the artifact or use the products and/or services of the artifact. The needs and expectations of all these must be taken into consideration in the design process.

Authors of "User-Centered Design" discussed three types of users identified by Eason: primary, secondary, and tertiary. Primary users are those persons who actually use the artifact; secondary users are those who will occasionally use the artifact or those who use it through an intermediary; and tertiary users are persons who will be affected by the use of the artifact or make decisions about its purchase. The successful design of a product must take into account the wide range of stakeholders of the artifact. Not everyone who is a stakeholder needs to be represented on a design team, but the effect of the artifact on them must be considered (48).

2.4.3. Economic Importance of UCD

Companies can ultimately pay double or more for poorly designed products (54). According to Soderston and Rauch, most organizations need to see that there are economic reasons to put the user at the center of the design and development process. The authors have cited the following advantages from different literature (49):

2.4.3. 1. Reduced Development Time and Costs

- Usability engineering has demonstrated reductions in the product-development cycle by 33-50%.
- 63% of software projects overran their estimates, with the top 4 reasons related to usability.
- The percentage of software code devoted to the interface has been rising over the years, and is currently averaging 47-60%.
- Typically the return on investment for usability engineering is 50-100 times the cost. Other benefits are also important, such as the immediate ability to use a product to perform a task in an emergency situation.

2.4.3. 2. Decreased Training and Support Costs

- Large companies are finding the cost of end-user computing to be higher than expected; they spend an average of $48.4 per workstation over a 5-year period. The significant issue, however, is that 40.8% of this is spent on end-user labor to install, learn to use, troubleshoot, get help using, etc., Most of which could be reduced if Software were better engineered for users and intended uses.
- One Company released a product with confusing and misleading error messages, which accounted for almost 40% of the support calls, at a cost of $100.00 per call.
- In a 90-day help desk study by IBM™ 87% of all calls were usability-related issues.
- Design changes from one usability study at Ford Motor Company reduced the number of calls to the help line from an average of 3 calls to none, saving the company an estimated $100,000.

2.4.3.3. Reduced Maintenance Costs

- 80% of maintenance is due to unmet or unforeseen user requirements; only 20% is due to bugs or reliability problems.
- 80% of software lifecycle costs occur during the maintenance phase.
- The cost of change is 1 unit in the definition phase, 1.5-6 units during the development phase, and 60-100 units after release.

2.4.3.4. Increased Sales and Revenues

- An increased average of 11.2 usability-related comments per software review article.
- InfoWorld assigns between 18-30% of its software review articles on usability factors: ease of use, ease of learning, and quality of the documentation.
- 'Ease of Use' is now equivalent to 'Function & Performance' as the primary reason for selecting software.

2.4.3.5. Increased Productivity

- Design changes due to usability work at IBM resulted in an average reduction of 9.6 minutes per task, with a projected internal savings at IBM of $6,800,000 in 1991 alone.
- Design changes due to usability work on one project at IDS/American Express resulted in estimated savings of $7,300,000 to clients. What is becoming more and more apparent, is that good design of everything users see and touch is crucial to success in today's marketplace (49).

The rule of thumb says: every dollar invested in ease of use returns $10 to $100. In today's market, usable products are desirable products. Ease of use differentiates them in a highly competitive market place. Ease of use brings an added value that culminates in a higher degree of customer satisfaction, continued business and higher revenues. It is far less expensive to prevent a problem occurring in the first place than to fix it later. And one of the best ways to prevent problems from occurring, and to protect development investment at the same time, is to keep users/customers involved through the entire development cycle.

2.4.4. User-Centered Design Process

User-centered design is an approach to design that puts those users in the middle of the process, working with them throughout the process to understand their requirements and to evaluate the success in meeting the usability goals defined for the product. Although there are many detailed methodologies, most follow the general outline of the international standard, ISO 13407(55, 56). This outline consists of the following steps:

- Plan the human-centered development process for IT products
- Specify the context of use
- Specify user and organizational requirements
- Produce design solutions
- Evaluate design solutions against user and organizational requirements

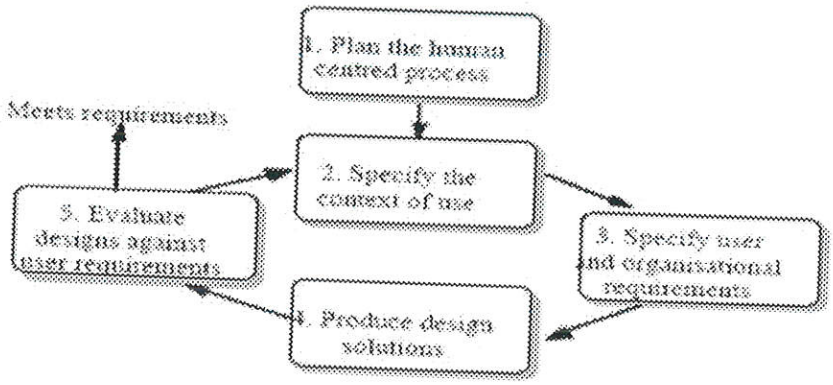


Figure 2.6: The ISO 13407 UCD process

2.4.4. 1. Planning

The first step is to plan which methods are expected to be used at different stages of development. This will depend on the business case for usability, and will take account of the budget, timescales, resources, skills and other constraints.

For each potential method, when the method should be used, the type of results provided, the number of usability experts and users required, and the typical range of person days involved are essential information. Planning may also include assessing the usability capability maturity of the organization and identifying where improvements are required. (57).

2.4.4. 2. Context of Use (CoU) Analysis

Designing for usability involves establishing user requirements for a new system or product, developing design solutions, prototyping the system and the user interface, and testing it with representative users. However, before any usability design or evaluation activity can begin, we have to avoid the assumption that we know what the user wants. It is necessary to understand the Context of use for the product, that is, the goals of the user community, and the main user, task and environmental characteristics of the situation in which it will be operated [54].

Context is an important concept in everyday life. People often provide context when writing postcards referring to the weather or holiday atmosphere. Knowledge of context can also help to explain why an art object such as Donatello's bronze statue of David was produced. Context can also explain the background to an historical event, such as the assassination of

the Archduke Ferdinand in Sarajevo, which triggered war in Europe in 19142 and, of course, words taken out of context often distort the speaker's intended meaning (58)

When a product (or system) is developed, it will be used within a particular context. It will be used by a user population with certain characteristics. The user will have certain goals and wish to perform various tasks. The product will also be used within a certain range of technical, physical and social or organizational environments that may affect its use [54].

When assessing a product from Human Factors point of view, there is a tendency to forget about the Context of Use. Information Technology products are often simply divided into those which are usable and have ergonomic features and those which are not. In fact, it is incorrect to describe a product as ergonomic or usable, without also describing the context in which the product will be used in other words, whom the product was designed for, what it will be used for and where it will be used. A manufacturer might, for instance, claim to have a very usable wristwatch. In fact, it may only be usable in a certain range of contexts. The visual nature of the display might exclude people who are visually impaired. If the watch face lacks numbers and minute markings, this would make it unsuitable for tasks that require precise timings at a sports meeting. Without luminous or illuminated dial markings, the watch would not be suitable for use in the dark, whereas the use of reflective glass could impede viewing in bright light. Unless it is a watertight watch, it may be affected by rain and would certainly not work under water. This example shows the pitfalls of classifying a watch or any other product, as usable without referring to the context for which it is intended (58)

2.4.4. 2. 1. User Goals and Characteristics

The central part of the Context of Use analysis of a system focuses upon the users of the product. A stakeholder analysis should be performed to identify all the different users of the system, and also those who are affected by it, i.e. have a stake in its success. If the user population is composed of more than one user type, then an analysis should be completed for each type. Relevant characteristics of users also need to be described. These can include knowledge, skill, experience, education, training, physical attributes and motor and sensory capabilities (54).

2.4.4. 2. 2. Tasks

Tasks are the activities undertaken to achieve a goal. Characteristics of tasks which may influence usability should be described, e.g. the frequency and duration of the task. Tasks should not be described solely in terms of the functions or features provided by a product or system. Descriptions of the activities and steps involved in performing the task should be related to the goals that are to be achieved. For the purpose of specifying user requirements or evaluating usability, a key subset of contextual tasks will typically be selected to represent the significant aspects of the total set of tasks (54).

2.4.4. 2. 3. Technical Environment

The technical environment is the software and hardware which is used in conjunction with the product. The characteristics of the technical environment (such as the speed of the processor or the layout of keys on the keyboard), may have an affect on the usability of the product (58).

2.4.4. 2.4. Physical Environment

The physical environment can have a profound effect on the usability of a product. Bad lighting or loud noise in the workplace may actually prevent the users from receiving vital feedback from the product. Likewise, even the location of the product in relation to the user's workplace can magnify the effect of minor usability problems, such as having to reinsert cassettes frequently when the tape backup machine is located down the corridor (58).

2.4.4. 2. 5. Social or Organizational Environment

The organizational environment will also affect the usability of a product. At a higher level, the attitudes of the organization and its employees towards the introduction of an IT system, and the way work is monitored, can affect whether a system is accepted and used to carry out the work. At a lower level the structure of the organization, the way people work (individually and in groups), the availability of assistance and the frequency of interruptions, are also likely to affect the usability of a product (58).

Context of use can be derived from Background Interviews and questionnaires. If users cannot be contacted directly; marketing, sales, and customer support should be able to answer most questions (48). The typical outcome is a better understanding of the users;

- What the users want to accomplish with the product.
- Procedures needed to accomplish goals.
- How users exchange information with others while performing the task or preparing to do so (59).

2.4.4. 3. Specify the User and Organizational Requirements

The next step in designing for usability is to identify the goals of the software in the context of the requirements of the organization and intended users of the system. Identifying the goals helps to determine the success criteria of usability for the product in terms of user tasks, e.g. how quickly a typical user should be able to complete a task with the product. By comparing goals with measurable objectives, this step provides a method for accessing if an acceptable level of usability for the user's performance with a product and documentation is achieved, and areas of improvement. Examples of measurable goals include:

- Ability to find the installation process understandable and easy to follow.
- Ability to connect a desktop computer to the Internet (59).

2.4.4. 4. Produce Design Solutions

The fourth step in designing for usability is to produce design solutions. Once the stakeholders have been identified and a thorough investigation of their needs has been conducted by performing tasks and needs analyses, designers can develop alternative design solutions to be evaluated by the users. These design solutions can be simple paper and pencil drawings in the beginning phase of the process.

Listening to users and discussing the alternative designs can amplify designers understanding of the intended purpose(s) of the artifact and may provide information that does not come out of initial interviews, observations, and needs analysis (48).

2.4.4.5. Evaluate Design against Requirements

This is the last step in the usability design process outlined by ISO 13407 standard, where, the designs are evaluated against user tasks. At this point, designers should pay close attention to the evaluations by the users, as they will help identify measurable usability criteria. Measurable usability criteria address issues related to the effectiveness, efficiency, safety, utility, learnability and memorability (how long it takes to remember to perform the most common tasks) of the product/artifact and users' subjective satisfaction with it. It would be difficult for designers to know or imagine all the usability criteria that are important to the users. It is only through feedback collected in an interactive iterative process involving users that products can be refined (48).

There are three potential ways in which the usability of a software product could be measured, according to:

- By analysis of the features of the product,
- By analysis of the process of interaction.
- By analyzing the effectiveness and efficiency

And to measure usability in the above context, there are a wide variety of evaluation techniques that have been shown to lead to more usable software applications (60):

2.4.4.5. 1. Inspection methods

Usability inspection methods are evaluation methods involving usability experts examining the software user interface. The main methods of this category are:

- Heuristic evaluation involves usability specialists who judge whether each dialogue element follows established usability principles (the "heuristics"),
- Cognitive walkthrough uses a detailed procedure to simulate task execution at each step through the dialogue, determining if the simulated user's goals and memory content can be assumed to lead to the next correct action.
- Pluralistic walkthrough uses group meetings where students, developers, and usability experts step through a learning scenario, discussing each dialogue element.

2.4.4.5. 2. Testing methods

These are tests, measuring system performance against pre-defined criteria. These criteria are defined according to the usability attributes, suggested by the ISO usability standards.

The most widely accepted usability testing techniques are:

Thinking Aloud Protocol is a technique widely used during usability testing. During the course of a test, the participant is asked to vocalize his /her thoughts, feelings, and opinions while interacting with the software, performing a task - part of a user scenario.

- Co-discovery is a type of usability testing where a group of users attempt to perform tasks together while being observed, simulating typical work process, where most people have someone else available for help.
- Performance measurement. Some usability tests are targeted at determining hard, quantitative data. Most of the time this data is in the form of performance metrics. E.g. required time to execute specific tasks.

2.4.4.5. 3. Inquiry methods

These techniques prompt the users by asking direct questions about the system. While inquiry methods can be used to measure various usability attributes, their most common use relates to measurement of user satisfaction. A known technique for measuring user satisfaction is though SUMI, the Software Usability Measurement Inventory, developed by a research group of the University College Cork, to measure user satisfaction, and hence assess user perceived software quality. SUMI is an internationally standardized 50-item questionnaire, available in several languages.

2.4.5. User Centred Design for Hypermedia Development

2.4.5.1. Introduction

Hypermedia development is a new and still evolving discipline. The process of learning how to develop large hypermedia applications has just begun. Hypermedia applications for the Web or CD-ROM are mostly the result of an implementation ad hoc, growing usually from small to large applications and becoming very soon difficult to maintain. Some guidelines and

tools are beginning to appear assisting developers of hypermedia applications. But these current practices often fail due to inappropriate techniques, processes and methodologies (36).

In recent years a number of researchers have already recognized the lack of design methods for hypermedia applications, and have proposed methods including the following:

- HDM: Hypermedia Design Method (61)
- RMM: Relationship Management Methodology (62)
- EORM: Enhanced Object Relationship Methodology (39)
- OOHDM: Object-Oriented Hypermedia Design Method (63,64,65,66,67)
- SOHDM: Scenario-based Object-oriented Hypermedia Design Methodology (39)
- WSDM: Web Site Design Method (68)
- RNA: Relationship-Navigational Analysis (39)
- MacWeb Approach (39)
- HFPM: Hypermedia Flexible Process Modeling (39)
- OO/Pattern Approach (39)
- Lowe-Hall's Engineering Approach (39)

The development of hypermedia systems differs from the developing process of traditional software in several dimensions. Hypermedia development projects involve people from various departments with different skills. They include not only programmers but also authors, designers, artists, musicians, video editors, etc. However, traditional software applications do not necessarily require various people from various departments. When designing traditional software, developers have to deal only with specific tasks where hypermedia application developer may be required to deal with a variety of tasks including the design of the foundation of whole organizational structure. Designers of hypermedia systems have to breakdown large and complex application domains into clear, small and accessible related domains that can be presented to end users. For example, to create a large WWW site for the university, designers have to breakdown the university into various departments and again into smaller departmental modules and courses. The development of traditional software applications often requires information only for a specific domain. During the development of hypermedia applications, developers require varieties of tools to manipulate various objects, navigational links and multimedia aspects such as authoring tools, audio tools, video editing tools, etc. However, traditional software applications can be

developed using specific tools. Hypermedia applications often require well-structured design and intensive testing because the systems will be used by various classes of users with very low user tolerance to failure of the system or system complexity. This means that end users must be completely guided by the system (40, 42).

The design of hypermedia software is centered around three main aspects of hypermedia systems: the conceptual, navigational and presentational model. The conceptual model is the starting point for the design task. This is one aspect where the method for the development of hypermedia applications differs from the development of other software systems. Based on the conceptual model the navigational structure of hypermedia applications is defined which consists of the navigational class model and the navigational structure model. The navigational class model specifies which classes and associations from the conceptual class diagram are available for navigation and the navigational structure diagram specifies how the navigation is performed. The last step in the design task is the presentational design, where a rough version of the user interface is produced. This is done by first defining the user interface objects which are composed of primitive user interface objects, like text, anchor and image as well as other composite user interface objects, giving hints to the final appearance of the user interface objects on the screen. The final decisions about the layout are made in the implementation task (42, 69).

Each of the above mentioned methods uses existent object-oriented models for the conceptual design but introduces an own notation and diagrammatic techniques for navigational and/or user interface design (70). That is, different modeling languages can be used, but the importance of using a standard is clear: it provides a common language which facilitates the communication among project partners as well as to the external world and future readers of the system documentation. Further, tools based on this standard can be used to develop, test and validate the models. In this regard, the acceptance of UML as a de facto standard for the design of object-oriented systems, together with the explosive growth of the World Wide Web has raised the need for UML extensions to model hypermedia applications running on the Internet (42).

Apart from lack of standards, some of the methods are very implementation oriented. Some have their origin in database design methods and are heavily data driven. These data-driven methods may be able to solve some maintenance problems but they do not meet the usability problems (68).

Bearing the above points in mind, the model used for this study is based on the standard Unified Modeling Language (UML), which is built with well-known UML model elements and UML extensions. These extensions are defined following the UML extending mechanisms (71, 72). The method uses the largely adopted use-case-driven development. This way of development is a user-centered technique that forces to define who are the users (actors) of the application and offers an intuitive way to represent the functionality an application has to fulfill for each actor. Use cases provide a mechanism for determining system boundaries, as well as a user-oriented requirement model. Use cases can be considered as a starting point toward a method for specifying end-user needs and in general for integrating human factors in the development process (47, 68).

The Unified Process adapted for hypermedia applications which is used for this study is 'user centered' rather than 'data driven'. In a data driven method the available data is the starting point of the modeling approach. But, in this approach, the starting point is the set of potential users of the software. To create effective communication it is not only important to plan 'what' to communicate but also to `whom'. Therefore, the method starts by identifying the different types of users. Next, describe their characteristics and their information requirements. This results in so-called perspectives. Only after this is done, the conceptual design of the hypermedia starts, taking as input the perspectives and the (possibly already available) business object model of the organization. This results in hypermedia applications which are better tailored to their users and will therefore have a higher usability and give greater satisfaction (73).

Apart from being user centered, the UML compliant method has two important advantages: First, documentation about syntax and semantics of the UML modeling elements is already available. Second and the most important one, case tools supporting UML can be used in the hypermedia development process (74).

The design methodology which is based on a UML extension for hypermedia consists of three steps similar to other methods. The steps are the conceptual, navigational and presentational design. They produce the following artifacts:

- Conceptual model
- Navigation space model and navigational structure model
- Presentation model (40, 42, 70, 73, 74, 75, 76).

2.4. 5.2. Conceptual Design

The conceptual design is the result of an analysis step in the conceptual model of the problem design (74). It is built taking into account the functional requirements captured with use cases. This model produces a conceptual model of the problem domain defined through classes and associations between classes relevant to the domain. Traditional object oriented techniques are used to construct the conceptual model: finding classes, specifying the most relevant attributes and operations, determining associations between classes, defining inheritance hierarchies, finding dependencies, identifying interfaces, and defining constraints.

Classes and associations defined are used during navigational design to derive nodes of the hypermedia structure. Classes and associations can be organized in groups. Classes are described through attributes and operations are represented graphically with UML notation (71). As discussed above, conceptual model is the base for navigational design and as a result the navigational model is constructed.

2.4. 5.3. Navigational Design

The navigational design presents guidelines to construct a navigation space model from a conceptual model. This model is defined in a two step process. In the first step it is specified, which objects can be potentially reached through navigation and in the second one how these objects are reached (74). Therefore two models are built: the navigational space model and the navigational structure model.

As discussed in (40, 42, 70, 73, 74, 75, 76) the navigational space/class model defines a view on the conceptual model showing which classes of the conceptual model can be visited through navigation in the application. This model is built with a set of navigational classes and associations, which are obtained from the conceptual model. A navigational class is defined as a stereotyped class «navigational class» with same name as the corresponding class of the conceptual model. Navigational objects are instances of these navigational classes connected by links (in UML terms) that are instances of the associations of the navigational model.

In the same literatures it is indicated that, the navigational structure model is based on the navigational class model. It defines the navigation structure of the application, that is, how

navigational objects are visited. Additional model elements are required to perform the navigation between navigational objects: menus, queries, guided tours, indexes, external nodes and navigational contexts (70, 73, 74, 75, 76).

A navigational context (context for short) consists of a sequence of navigational nodes. Navigation is performed within a navigational context. An external node is a navigational node belonging to another hypermedia application, that is, this node is not part of the application that is being modeled. An index allows direct access to each element within a navigational context. A guided tour gives access to the first object of a navigational context. Objects are navigated then sequentially. A query is an input form; when evaluated it produces a filtered context. A menu is an index on a navigational context of a set of navigational nodes. Every hypermedia application has at least one entry point or initial node, so called main menu (homepage). For all of the above, stereotyped classes are defined by their name (like «index», «guidedTour», «query», etc)

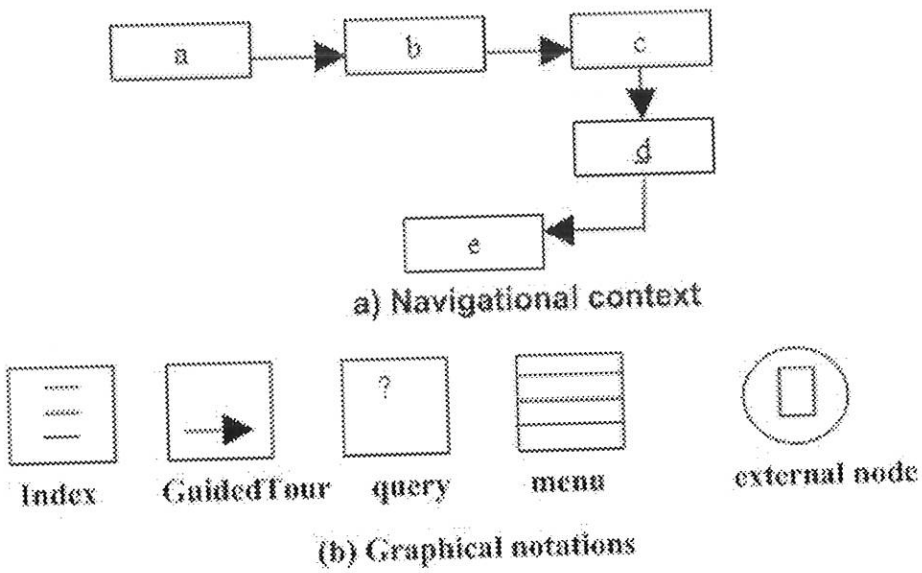


Figure 2.7. Access elements

The activities that are performed to pass from the navigational class model to the navigational structure model are the following (70, 73, 74, 75, 76):

- **Defining navigational contexts.** For each navigational class at least one navigational context has to be defined. A simple navigational context is required to access to the context from a menu through an index. A filtered context is appropriate when a query is used to reach the context. For each association with

navigability and multiplicity "zero or more" or "one or more" a context "by the source class" has to be included. These navigational contexts are grouped into a UML package for graphical representation's purposes only (see Figure. 2.7 (a)).

- **Ddetermining context changes.** At the first glance all navigational context changes are allowed. Context changes are added to the model in function of the typical navigation activities of the user that were determined with a use case or a scenario based analysis.
- **Adding access primitives.** One type of access to navigational contexts has to be chosen in each case. Context changes usually require the definition of additional indexes.

2.4. 5.4. Presentational Design

The presentation of the navigational objects is defined by the presentational design, which is critical step in the design of hypermedia application (42).

The presentational model is a rough design of the user interface; decisions about details such as size color or font of user interface elements are taken when developing the prototype or in the implementation phase.

The navigational structure model shows how to navigate through the navigation space by using the access elements defined in the previous section.

There are many possibilities to construct a presentation model for a given navigational structure model. In any case it is essential to define a presentation for each navigational class and one has also to support the navigation structure. One of the methods is based on the use of framesets, which allow visualizing a navigation structure. Framesets are top level element for presentation. Thereby the idea is to divide a presentation always into two basic parts: One part provides a presentation of the navigation tree (showing the user's actual navigation path and hence the context of navigation) and the other part shows the corresponding content (40).

On this basis the following procedures are defined for deriving a presentation model from a navigational structure model in an entirely systematic way.

- Construct a presentation for each navigational class and for each index class occurring in the navigational structure model. The presentation of a navigational

class has to provide a template for presenting the instances of the class, which takes into account the given attributes.

- Choose one navigational class as a root for navigation.
- For each navigational class and for each index class consider all possible paths (in the navigational structure model) from the root class to the actual class. For each path construct a presentation of the corresponding navigation tree.

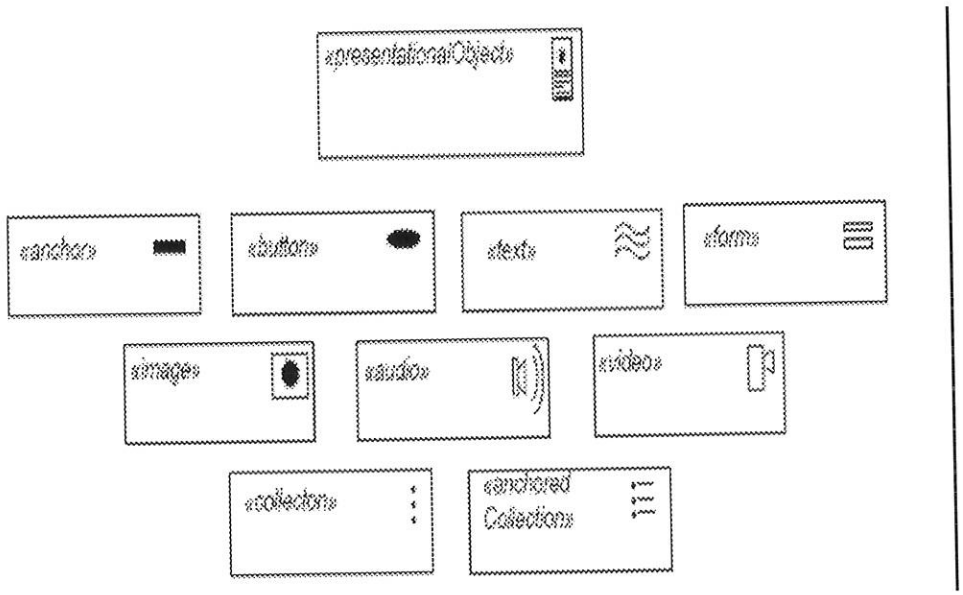


Figure 2.8: Often used user interface objects.

- Combine the results of step 1 and step 3 accordingly to framesets. Any frameset has two parts where the right frame contains the presentation of the navigational class or index class (constructed in step 1) and the left frame represents the navigation tree (constructed in step 3) corresponding to one possible navigation to this class.

Presentational objects contained in a frameset are instances of a presentational class, which is stereotyped by «presentational Class» with a corresponding icon. Such objects are containers, which comprise basic presentational elements like texts, collections (i.e. lists of texts), images, anchors, anchored collections (i.e. lists of anchors) etc. The basic elements and their stereotypes are defined in figure 2.8.

3. Research Design and Methodology

3.1 Research Methodology

Though the degree varies, deaf people in different parts of the world are facing challenges to communicate with hearing people. The situation in Ethiopia is similar except there has been no remedy tried to bridge the gap. As per the investigation of this research, it has been observed that the deaf people are denied so many advantages because of the communication gap they have with the hearing people. The problem was more serious in public service areas like hospitals, police stations, etc.

The main aim of this study was intended to solve /minimize the existing communication gap between deaf patients and health professionals, by creating hypermedia software that can be used to teach ESL for the hearing health professionals. To achieve this purpose the study has used different researching methodologies.

First of all, reviews of relevant literature have been conducted to assess hypermedia technology for learning in general and sign language learning in particular. In doing so, the basic idea behind sign language, computer aided instruction and hypermedia were discussed. Some of sign language learning tools were also reviewed. As to the designing method, UCD was described in brief. The specific hypermedia methodology to develop the MESL^{2}T, UML based methodology for hypermedia design, was also thoroughly discussed. Medical histories of patients have also been reviewed for the sake of gathering specific communication concepts that a health professional use while treating deaf patients.

To create a usable system it needs conducting a user research. It is argued with Software designers that, it would be more effective if such systems are designed taking into account existing problems and the relevant requirements of the user group for whom they are designed. In this study the users are health professionals in different health centers. These professionals and/or health centers do have different experiences, skills, behavior, infrastructure, etc. that must be investigated in order to create appropriate and user centered software. Moreover, it has been a must to include deaf clients of the health centers as part of the research considering them as one of the main sources of information on the nature of existing communication gap.

Bearing this in mined a user research was conducted before designing the MESL^{2}T. Consequently, data was gathered by using questionnaire containing closed-ended items accruing quantitative data and open-ended items accruing qualitative data among the deaf patients and hearing medical staff in the different health centers of Addis Ababa. This approach enabled the researcher to conduct the user research appropriately and sufficiently. The design, development and evaluation of the software have been conducted following the ISO-13407 standard for usability software design process.

3.2. Participants of the User Research and Way of Choosing Them

3.2.1. Participants of the User Research

The number of participants to this research was 119 out of which 89 were health professionals and 30 were deaf patients. The hearing participants selected to fill the questionnaires were used from three health centers located in Addis Ababa. The deaf participants were selected from the members' list of the ENAD.

3.2.2. Way of Choosing Participants for the User Research

3.2.2.1. Hearing Group

Normally, all the health centers in Ethiopia do have similar departments. The difference is the qualification of the professionals or/and facilities. This implies that though the quality of the treatments varies from one center to the other, we can find all kind of professionals in any health center. Based on this homogeneity characteristic of the population (medical professionals in the health centers of the country), it was decided to focus on a particular center for this study. The first action took to select this center was consulting ENAD to know if there exists a particular place where deaf people used to get treatment. Accordingly, the association gives financial supports to its members when they get sick. "Shiromeda" Clinic (located in Addis Ababa) is the health center where most deaf patients were sent from the association. So this center was chosen purposefully for place of investigating the study. More over, Eye and ENT departments of "Yekatit-12" Hosspital and "Minilik-II" Hospital (both hospitals are found at Addis Ababa), were considered. This is because the "Shiromeda" clinic does not have specialized professionals in these areas and it refers the patients to these two hospitals for the Eye and ENT cases. As to the composition out of the total health professional

participants 30 were from "Shiromeda" clinic, 13 were from "Minilik-II" hospital and 46 were from "Yekatit-12" hospital. All members in the mentioned health centers and departments were used to fill the questionnaire.

3.2.2.2. Deaf Group

For this research, 30 deaf people who have been patients at least once before were purposefully considered. In doing so the researcher consulted ENADs' members' record through the chairperson of the association. The record does have attributes indicating the services the members got from the association. Financial assistance to members when they get sick was one of those attributes. Hence the information from the record helped in identifying consistent members who were reporting to the association at least once in a week and had got medical treatments at the aforementioned health centers. The number of such members was 30. Thus it was justifiable to use all the 30 members as participants for this research. The ENAD has played great role in identifying these people and helping the data collector to reach them. In general, all the participants here were members of ENAD and who ENAD financed them at the time when they were sick.

3.4. Procedures of Data Collection and Instruments

3.4.1. Procedures of Data Collection

In collecting data for the study, four steps were adopted. First, relevant literature was collected so as to get adequate information. Second, basic questions were formulated and this helped to indicate the direction of the study. Third, data gathering tools were developed. Fourth, before fully using the tools, especially for the deaf respondents, a pilot test was conducted. The material for hearing respondents were an already tested and used items from various research sources. Off course, some modification has been done before implementing the items for this research.

Three data collector have been hired for the three health centers, to distribute and collect the questionnaire. How ever, the researcher has made contact to the managers of each center to ask for cooperation before the distribution of the questionnaire. Accordingly, each health center assigns one person to help the data distributor and collector. Due to this fact, there has been no serious challenge in the data collection.

Regarding the way of collecting data from deaf participants, as per the question of cooperation of the researcher, the ENAD had assigned a staff from the associations' office. The assigned person used the list of the selected 30 deaf members to distribute the questionnaire when they come to report. During the times where some problems arose the assigned person was contacting the researcher through the translator of the association both in face-to-face and telephone call.

3.4.2. Research Instruments

Questionnaire was used mainly as a method of data collection. Besides, documents and sources pertinent to the topic under review were consulted.

Two types of questionnaires (written in Amharic) were prepared and distributed to the target groups. Type-I was for deaf people who have been treated at health centers before, while type-II was for medical professionals in the health centers where deaf people were referred to treatment. Both questionnaires were more or less similar in format and content. Both were aimed at determining degree of communication gap between deaf patients and hearing medical staff and areas and impacts of the communication gap. The questionnaires were also used to identify element (s) of ESL to be learned and way of learning it. Moreover the questionnaire for hearing group had an aim of identifying the necessary information technology skills and infrastructures to implement the solution.

The questionnaires used to gather data include certain questions requiring fixed responses. These closed-ended items encouraged participation because the questions were quick and easy to answer, allow the results to be revealed immediately, and stimulate respondents' thinking with regard to subsequent participation on the qualitative level. Some of the quantitative questionnaire incorporated qualitative feedback.

Gathering qualitative data through open-ended questions was also used to allow the respondents to reveal their insights once they have completed the quantitative component of the questionnaire. These responses were analyzed to ascertain further essential personal attitudes.

Microsoft Visio was used for drawing the figures in the paper work. The photographs indicated in section 2.1 were put in place using digital photo camera. Video clips for the

prototype were recorded by digital video camera. Microsoft moviemaker was the tool used to capture and edit video clips for the prototype initially. But, it was found that using adobe premier software was better and used finally.

3.5. Tabulation

The questionnaires were composed of items used to pinpointly indicate the degree of communication gap, areas of the gap, impacts of the gap, solutions to bridge the gap and necessary skills and infrastructures (to be filled by hearing only) to implement the solution. Introduction and concluding ideas were also included. Generally, the questionnaires were designed in a way to incorporate issues in development process of the prototype.

Each part of the questionnaire has been tabulated differently. Accordingly, the responses of the questionnaires for both groups have been divided into five parts. Different scoring mechanisms, including the Likert's rating scale have been employed. Accordingly, in all the following tabulations, the increase in numbering (starting from 1) implies the decrease in rank of the response.

Part -I: degree of communication gap

This part contains four questions for the deaf and four questions for the hearings. For the deaf group, the first question was tabulated as 1, 2, 3 which represented "always", "some times", and "never" respectively. The second question for the same group was qualitative in nature. While the third question was tabulated as 1, 2, 3, representing "yes"," some how" and "never" respectively, the fourth question was qualitative type.

For the hearing group, the first question was tabulated as 1, 2, which represented "yes", and "no". The second and third questions were qualitative in nature. The fourth question was tabulated as 1,2,3 which represented "yes"," some times" and "no" respectively.

Part -II: areas of communication Gap

This part contains one question for the deaf and one question for the hearing. All the questions in both groups were qualitative in nature.

Part –III: impacts of the communication gap

This part contains two questions for the deaf and one question for the hearing. The first question for the deaf patients was tabulated as 1, 2, which represented "yes", and "no" respectively. All other questions under this part were qualitative in nature

Part -IV: solutions to the problem

This part contains one question for the deaf and three questions for the hearings. All the questions under this part were qualitative.

Part -V: necessary skills and infrastructure

This part contains six questions which all are for the hearings. The first and second questions were tabulated as 1, 2, which represented "yes", and "no" respectively. The third question was tabulated as 1,2,3 which represented "yes"," some times" and "no" respectively. The fourth question was qualitative. The fifth question was tabulated as 1, 2, which represented "yes", and "no" respectively. The final question was tabulated as 1,2,3,4, representing "higher", "medium", "low" and "lower" respectively.

3.6. Methods of Data Analysis

First of all, the responses of the questionnaires were translated to English. I used merging technique of combining quantitative and qualitative methods of data collection to analyze the responses. To analyze the data gathered and tabulated on the study, the statistical techniques employed were: Numerical counts or frequencies, Percentages, Mode, ranking and ratio. Some responses of both groups were analyzed by merging together. This is because those responses were not specific to any of the group and brought no problem on the result.

3.7. Method of Designing the Software

A UML Based Methodology for Hypermedia Design was used to design the hypermedia-learning tool. This method was chosen because it uses the largely adopted use-case-driven development, which is a user-centered technique that forces to define who the users (actors) of the application are and offers an intuitive way to represent the functionality an application has to fulfill for each actor (see chapter 2).

To create effective communication, planning 'what' to communicate is not enough. Planning to 'whom' to communicate should also get due consideration. Therefore, the researcher started by identifying the types of users. Next, described their characteristics, their information requirements and necessary infrastructure for implementation by using a questionnaire-based user research. After this is done, the conceptual design of the software was done, taking as input the results of the user research and revision of relevant documents. The full design of the prototype was done using the UML methodology for hypermedia design.

3.8. Methods of Evaluation

As discussed in the literature review part, there are three potential ways in which the usability of a software product could be measured, according to ISO 9241:

- Thorough analysis of the features of the product,
- By analyzing of the process of interaction and
- Analysis of the effectiveness and efficiency.

And to measure usability in the above context, there are a wide variety of evaluation techniques that have been shown to lead to more usable software applications. For this research, I have been developing the interface by continuously consulting colleagues, health professionals and teachers of ESL at ENAD for its simplicity and understandability. Co-discovery usability testing method was used to evaluate the final user interface performance. Two groups, having 7 health professionals at "Shiromeda" Clinic, 6 health professionals at "Minilik-II" hospital, were formed. I gave them the software to use on my laptop at the same time observing how they are using it, what difficulties they face, and the like. I noted all their ideas and asked suggestions at the end. Finally all possible changes were made on the interface design of the prototype.

4. Presentation, Analysis of Data and Discussion of Results

4.1. Presentation and Analysis of Data

4.1.1. Characteristics of Respondents

In this study, two categories of respondents- deaf patients and hearing medical professionals were involved. Most of the respondents were direct stakeholders and, as a result, they were considered to be relevant and main source of dependable information for the study.

One hundred and nineteen copies of questionnaire were distributed to the respondents. Of these, eighty-nine of the copies of the questionnaire were administered to hearing health professionals and thirty were distributed among deaf people who have been patients and served by health professional at least once before.

Out of these, 106 (89.08%) copies of the questionnaire were returned. Of the returned copies 78 (87.64%) were from the health professionals and 28 copies were from the deaf patients, which is 93.33% of the deaf participants. As a result, the response was found to be sufficient to draw inferences for the study. The numbers of respondents are summarized in table 4.1.

Table 4.1: Respondents summary

	Deaf patients	Medical Professionals	Total
Returned	28	78	106
Not Returned	2	11	13
Distributed Total	30	89	119
%	25.21	74.79	100

The results from the health professionals' questionnaire and document analysis to the professionals' characteristics of "Shiromeda" Clinic, "Yekatit-12" Hospital, and "Minilik-II" Hospital are presented in table 4.2.

Table 4.2: characteristics of respondents at health centers

Medical staff	%
Specialist Physician	11.54
Medical Doctor	16.67
Nurse	64.10
Pharm.tech	2.56
Lab. Tech.	3.85
Health assist.	1.28
Total	100

As indicated above, a total of 89 health professionals were involved in the study and 78 questionnaires were returned. Out of the participants, 30(33.71%) of the professionals were from "Shiromeda" clinic. From all the participants, 86.67% have returned the questionnaire. Of the participants in the study, 13(14.61%) were from "Minilik-II" Hospital out of which 10(76.92%) returned the questionnaire. The remaining 46 participants were from "Yekatit-12" Hospital out of which 42(91.3%) of these participants have returned the questionnaire.

As to their specific job, 11.54% of the participants were specialists in different departments and 16.67% were general medical doctors. The Nurses working in different departments of the health centers were very large in number, which was 64.10 % of the participants. However, pharmacy technicians, lab technicians and health assistants each took below 5% of the participants.

4.1.2. Communication Gap between Deaf Patients and Hearing Medical Staff

According to the investigations done, there existed communication gap between the deaf patients and hearing medical staff of health centers. Most of responses showed that communication is very time taking, unsuccessful and boring.

4.1.2.1. Degree of the gap

According to this research, above 70% of deaf respondents and above 50% of hearing health professionals said that there was great challenge to communicate with each other. Some 25%

of deaf and 25% of hearing people said that they can communicate moderately by lip reading, writing and reading and other means, but not, using ESL. The remaining respondents had no experience to such a communication.

The study showed that, the challenge of communication starts from the time when the deaf patient reaches a health center. As per the responses from both the medical staff and deaf participants, there existed neither medical hearing staff that knows ESL, nor an ESL interpreter hired for helping deaf patients. More over, 100% of respondents have assured that there is no use of "I speak" cards, which are laminated cards that say in some languages like Amharic "I need a sign language interpreter". So when a patient went to the centers without an interpreter of ESL, the medical professionals used lip reading and/or writing and reading to communicate, which in the words of most respondents was " boring, time taking and totally uncomfortable".

Table 4.3 indicates the data of responses of deaf and hearing participants regarding the ways that one group was experiencing to communicate with the other. Here, the responses of both groups were combined since the question to gather the information was similar to both groups.

Table 4.3: ways of communication of deaf patients and hearing health professionals

Way of communication	**%**
ESL or some undefined signs	4.88
Lip reading or/and writing, family interpreters and talking loudly for hard of hearings	81.71
Professional ESL interpreters	13.41
Total	100

As indicated in the table, most of the time communication was carried on by lip reading or/and writing or not ESL professional family members, which was 81.71% of the respondents. About 13.41% used interpreters and the remaining 4.88% used commonly understood expressive signs for communication, which might not have been enough to have the necessary understanding.

Table 4.4 indicates the level of concepts that the communication gap exists. This data has been gathered from the questionnaire presented for deaf participants.

Table 4.4: level of communication gap existing concepts

Concept level	%
Phrases and/or sentence	10.71
Words	14.29
Both	75
Total	100

As shown in the above table, majority of communication gap (75%) happened during communications incorporating all the cases; words, phrases and sentences. This indicates that in whatever way of communication (with out using interpreters), there was a great challenge for deaf people to understand and convince their treatment givers.

4.1.2.2. Areas of the Gap

The results from deafs' and health professionals' questionnaire detailing the area of concepts or ideas where communication gap between deaf patients and health professionals lied are presented table 4.5.

Table4.5: communication gap areas between deaf patients and health professionals

Areas of gap	%
General communication concepts	11.22
Medical related concepts	39.8
both	48.98
Total	100

As the above table showed, there existed higher communication gap between deaf patients and health professionals (39.8%) regarding medical related concepts. This means, it is difficult for a patient to express his/her feelings about these concepts and a health professional can not easily tell ideas or treatments involving those medical related concepts to his/her deaf patient .

The following medical environment-specific categories of communication concepts were created based on the medical history analysis of deaf patients in the three health centers.

- Diseases
- Injuries
- Nutrition
- Surgery
- Drugs
- Symptoms
- Tests
- Prescriptions
- Health Centers' Infrastructures

Those respondents who expressed communication gap in connection with general communication were also not small in number. As indicated in the table above 11.22% of the respondents had faced with such challenges.

In the context of this study, general communication concepts include concepts that any one uses for his/her day-to-day communication in everywhere. Different dictionaries showed different categories of such concepts. I have summarized and created the following categories of concepts which can be used for general communication purposes based on responses, medical history analysis and different sign language learning software (12,13,14,15,43,44,45,46):

- Finger spellings
- Numbers and Times
- Directions
- Address
- Questions
- Works/Professions
- Clothes
- Instructions
- Bath Room
- Holidays
- Sports
- Relationships
- Days and Months
- Feelings and Emotions
- Nature and Weather
- Nouns and Pronouns
- Household equipments
- Transportation
- Body parts
- Quantity
- Types and Conditions
- Dialogue
- Animals
- Greetings

The above statistics also showed that 48.98% of the respondents have pointed out that, there was a gap in understanding both the general communication concepts and medical related concepts. Therefore the data were good indicatives as there was a huge understanding gap

between deaf patients and health professionals due to language barrier regarding general and medical specific issues.

4.1.2.3. Consequences/Impacts of the Gap

The results from the deafs' questionnaire that showed impact of communication gap in getting appropriate treatment when there was no ESL interpreter are presented in table 4.6.

Table 4.6: Impacts of communication gap in getting right treatment for the deaf visiting health centers with out an interpreter

Have you got the right treatment?	**%**
No	67.86
yes	32.14
Total	100

As indicated in table 4.6, the majority of deaf patients (67.86%) didn't get the appropriate treatment from the health centers they visited due to the communication gap they faced there. Apart from being not treated in good manner, language barrier have made the deaf to face so many serious problems. Table 4.7 shows the summary of the problems that deaf patients have encountered due to the unfair treatments generated by language based communication gaps.

Table 4.7: responses from both groups showing consequences of the unfair treatments to the deaf patients due to language barrier

Problem	**%**
Misuse of medicines out of their prescriptions	2.2
Unsatisfactory and unneeded treatment	6.7
Waste of time	8.9
Worrying	4.4
No experience	77.8
Total	100

As reported in the table above, 2.2% of the respondents showed that deaf patients used medicines out of their prescription. This misuse has three forms and can create some problems on the patients.

- **Using medicines out of dose.** When a patient take a medicine above/below the recommended dose, the patient may lose resistance, face complication of the disease, fails to recover from the disease and finally death may happen.
- **Using medicine out of time (poor adherence).** Poor adherence may result in giving a chance to the disease become accustomed to the medicine so that the patient will not cure from the disease.
- **Using medicine out of prescribed amount.** Using medicine out of the prescribed amount also may bring one or more of the consequences mentioned above.

About 6.7% of the responses indicated that, some deaf patients were not satisfied with the treatments they got and some others got treatments that were not of the right type. Since the degree of understanding was very low, both the patient and the health professional were not comfortable during their contact. In some situations, treatments were based on guesses. In such cases, no one knew whether the patient has got the right treatment or not. Due to this fact, some health professionals had responded that, they really were worrying since they have always been in doubt whether their patient has got the right treatment or not. The deaf patients were also worrying in the same way since they did not know whether they have got the right treatment or not until they were cured from their disease. They knew that they have got the wrong treatment when they felt extra problems due to the medicines or other treatments prescribed for them. Here are two cases I chose from the responses of deaf patients to show how much serious the gap was:

- It was in the 19 70's. This deaf person has been at hospital because of his serious pain in his stomach. His physician did not know ESL. The patient on the other hand could not read and write. He tried to tell to his doctor using lip reading. Finally the physician, as per his understanding, started to treat the patient's ear. Even though the patient did not write what extra problem he had faced on his ear, he has written that he didn't get cured from his stomach disease.
- This deaf person is a young female. She had been eating dates for so many times. Due to this fact she had got a bad feeling in her stomach. She went to a hospital and tried to tell what has happened to her to the doctor. She had the same communication problem mentioned in the first case above. After some time the physician treated her and gave her a medicine. It was after she finished the medicine she understood as she had been treated in wrong way. Due to that wrong treatment, she didn't get cured from her

disease. Moreover she got extra problems, one of which was disordering of menstrual period. In the end, she used another option that she didn't mention and got cured from her original and extra diseases.

As shown in that table 4.7 above 8.9 % of respondents showed that deaf patients were wasting their time by returning now and then to the health centers due to lack of information. Regarding this issue the respondents from the two groups had different ideas. From the responses of the deaf it has been observed that they feel as if the health professionals were cruel to them and wanted to waste their time deliberately. But the health professionals responded that, the deaf patients were wasting their time due to some other reasons. Some of reasons were:

- Since they did not hear when the nurse calls their name at the waiting room, they could not get the treatment within the appropriate time they had to get.
- Since they didn't hear the time when they have to return back for checking or second time treatment, they waste their time by coming always. For example, the physician may appoint them after a month. But as per the responses, they check by coming all the 30 days since they didn't understand when the appointment was.

Though some problems had been outlined as indicated in table 4.7., 77.8% of respondents (majority had been from hearing group) did not have information about the consequences of their treatments on the deaf patients and some of these did not experience communication with deaf patients.

The discussion above showed that deaf patients faced serious problem. On the one hand, they were not having the right treatment and on the other hand they were becoming victims of extra problems due to the wrong treatment they were getting. The only reason for these all problems was lack of common language, which they can communicate with the hearing people.

4.1.2.4. Recommended Solutions to Bridge the Communication Gap between Deaf Patients and Hearing Medical Staff

The respondents have suggested some solutions to the aforementioned communication gap related problems. The ways and situations to implement the suggested solutions were also indicated by the respondents.

Table 4.8 presents the suggested solutions to bridge the communication gap from the deafs' and health professionals' questionnaires.

Table 4.8: suggested solutions to bridge communication gap between deaf patients and hearing health professionals

Suggested solutions	**%**
Teaching ESL to the health professionals	67.62
Hiring enough ESL interpreters to each health center	19.05
Encouraging communication by using lip reading	8.6
Encouraging communication by using writing and /or reading.	2.86
Other means	1.9
Total	100

As indicated in the table above, 67.8% of respondents needed if health professionals learn ESL. This idea has risen from two perspectives.

- There are deaf patients who use ESL but cannot read and write or lip-read Amharic.
- As per the economy of the country it is difficult to hire enough ESL translators to each health center. Moreover it is difficult to get a good translator who can speak Amharic at the same time sign ESL.

From the responses, 19.05% said there must be at least a single interpreter in a health center, 8.6% said lip reading should be used and 2.86 % of the respondents said that using reading and writing Amharic language may be better solution.

About 1.9% of the respondents' suggested different solutions. According to these respondents, the best solution to bridge the gap is either teaching the deaf people to read and

write Amharic or teach them to become health professionals. They pointed out that the Ministry of Education of the country must do its best in this regard.

The majority of the respondents agreed that health professionals learn ESL. All the health professional respondents, except a single nurse at "Yekatit 12" hospital, eagerly wanted to learn ESL. Regarding the way /approach of learning ESL the respondents have given the following suggestions (table 4.9).

Table 4.9: Approaches suggested by health professionals to learn ESL to easily communicate with deaf patients

Approach	%
Signed Amharic	55.3
The whole ESL	43.4
Non of the above	1.3
Total	100

As shown in the table, majority of the respondents (55.3) need to learn ESL in a way they are using Amharic. That is they need to learn the signs of ESL and use in Amharic order (Signed Amharic). About 43.4% of respondents said that they need to know the whole thing about ESL. This implies they need to learn the syntax, grammar, phonology, etc, of ESL. Regarding the appropriate situation and time to learn ESL either in Amharic or ESL order, health professionals' responses is summarized in table 4.10.

Table 4.10: conditions of learning ESL (by health professionals)

Condition	%
Using formal traditional way of learning in a class by ESL instructors	40.8
Using a computer aided learning tool	57.9
Other means	1.3
Total	100

The responses showed that, most respondents (57.9%) need to learn by themselves using computer software. about 40.8% of the respondents need to learn ESL using the traditional way of learning by ESL instructors. 1.35 of the respondents need to learn ESL by using seminars. They need the seminars to be using instructors assisted by computer programs.

4.1.2.6. Availability of Skills and Infrastructures to Implement the MESL^{2}T

4.1.2.6.1. Computer skills

Table 4.11: computer skills of health professionals

Basic computer skills?	%
yes	47.44
no	52.56
Total	100

As shown in table 4.11, 47.44% of the respondents had the basic computer skills by which they can use computer software that uses user-friendly interfaces. However, 52.56% did not have such a skill. From those respondents who chose computer aided self-learning method to learn the Sign Language, 86.7% had the said basic computer skill. The remaining respondents were ready and had plans to upgrade their basic computer skills.

4.1.2.6.2. Computer access

Out of the respondents, only 33.3 % do have computer access either in their home or office, while 66.7% of the respondents do not have any computer access.

Table 4.12: computer access of health professionals

Computer access	%
yes	33.3
No	66.7
Total	100

4.1.2.6.3. Computer use

Among those health professionals who have access to computers, 23.3% use computers always, while 26.9% of them use some times. Surprisingly, 50 % of those people did not use computers (table 4.13).

Table 4.13: computer usage

Computer usage	%
Always	23.1
Sometimes	26.9
Never	50
Total	100

4.1.2.6.4. Type of computers

From the health professionals who had access and were using computers, 66.75% use IBM/PC with windows 98-XP. Others use Power PC (Mac) (Table 4.14).

Table 4.14: type of computer users are using

Computer type	%
Power PC (Mac)	33.3
Apple Macintosh	0
IBM/PC with windows 98-XP	66.7
IBM/PC with windows 3.1	0
Other	0
Total	100

4.1.2.6.5. Connectivity of computers

Among those who have chances to use computers, 33.3% had Internet access and the remaining 66.7 do not (Table 4.15).

Table 4.15: Internet connectivity of users

Internet connectivity	%
Yes	33.3
No	66.7
Total	100

4.1.2.6.6. Users' experience of computer use

As indicated in table 4.16, more than 60% of health professionals had experience to watch video on computers ranging from lower to higher.

Table 4.16: users' experience of watching video on computers

Experience	%
Higher	5
Medium	40
Lower	16.7
No experience	38.3
Total	100

Thus though, the users-computer ratio showed the appropriate information technology tools were in limited supply, the majority of the health professionals had necessary skills and experiences and most importantly interest to use computer aided software that teaches ESL so that the communication gap between deaf patients and hearing health professionals will be bridged.

4.2. Discussion of Results

The focus of this study was to design and develop prototype of hypermedia learning tool for ESL taking health centers as a case. The main aim was to bridge the communication gap between deaf and hearing people. To do this the research was conducted using questionnaires to assess the existing situation (degree or seriousness) of the gap, where and when the gap existed, impacts of the gap, availability of necessary information technology in health centers

to implement the software, professionals' qualification, competence and need in using the technology that were necessary criteria to be assed for a UCD.

According to the study, the researcher has observed the communication gap more than expected. The deaf people were living totally with different culture and style. Almost all of the deaf have great challenges in communicating with the hearing people.

As per the study there was no specific area of communication that deaf people can easily communicate with the hearing people. But the problem was more serious in situations that can not be shown by touching and pointing. For example, in medical specific concepts, deaf patients do have more difficulty in expressing their feeling and pain than showing as they have problem on their eye or other part of the body that can be easily pointed out.

In all the cases it was observed that communication was not effective. Both deaf patients and the health professionals were not successful by their relationship as a patient and health professional. From the findings, it is shown that most health professionals were always worrying since they treat the deaf patients by guessing. The deaf patients on the other hand went to health centers in uncomfortable manner since they may not get the right treatment due to the communication gap. After they went to hospitals, they faced with problems resulted from wrong treatment, misunderstanding of prescriptions, waste of time and the like.

In cases when an interpreter was available, the communication gap some how became lower. But even in these cases, there happened unfair situations for some situations. For example, if a patient needed to have surgical service, the interpreter would be at the surgical class in order to help the doctor, which as per the response of the professionals, was "very much uncomfortable and out of the norm". The responses also indicated that the use of interpreters created not only discomfort, but also social problems in some cases. This was mostly common in places where people went to take HIV blood test.

As per the respondents, since there was no professional who knew ESL and since they feared the social problem to use interpreters during the HIV blood test, most of them were not using the service. They also had no counselor who was using ESL to teach the deaf regarding the ways to protect themselves from the harm of AIDS. This indicated that the deaf group might be seriously affected by HIV related problems. Some of the respondents, in addition to their response to the questionnaire, have indicated that they were really sad since they had no

chances to use the services provided for hearing people especially in HIV AIDS regard because of the communication gap.

Regarding the solution to solve this problem the research showed that almost all of the health professionals had very high need to learn ESL so that they can easily communicate with their deaf patients. The research also indicated that most of the health professionals need to learn ESL by their own way and pace using computer program (software) that can teach ESL. And most of them have the necessary skill to communicate with user-friendly computer interfaces. But according to the study's result, computing infrastructures in the health centers were not sufficient. Regarding this problem, the health professionals who will be the intended users of the software had suggested for the concerned body to create at least a laboratory class for each health center so that staff can use the software easily. The specific areas at which the communication gaps exist are analyzed and created as shown in see appendix-D. The prototype is depending on this basis.

Regarding way of learning ESL, the study has showed that most people need to learn ESL in Amharic order. As experiences show it is possible to communicate with deaf people using Signed Amharic. Even most of the deaf by themselves use signed Amharic for communication.

To achieve this, a user-centered hypermedia-learning tool is most appropriate way. To implement such a tool in every organization may be difficult for the country at the moment. But it is possible to use the already available infrastructures for this purpose. For example the current health professionals have been students at campus some time ago and some of them still may upgrade themselves at those universities and colleges.

Most universities and colleges in the country now are well equipped with enough computers and connectivity. Therefore it is possible to teach students the necessary ESL before they go to work place. Also, there are plenty of Internet cafes in the country that the hearing people are using. This means one can use the tool if made online.

5. Prototype: Design and Evaluation of a Web-Based Medical Ethiopian Sign Language Learning Tool (MESL^{2}T)

The prototype is designed using a UML-Based Methodology for Hypermedia Design (see chapter 2).

5.1. Conceptual Design

The conceptual design is the result of the analysis task in the previous chapter. The objective of this web-based Ethiopian Sign Language Learning Tool (MESL^{2}T) was to help health professionals in learning ESL by their own at their own pace. Others, for example those who need to be ESL instructors may also use this tool. The tool incorporates general communication and medical specific concepts that have terms and/or signed Amharic phrases and sentences under each concept. When users of the tool click on the concepts, term and/ or phrase equivalent of the concepts will be displayed. Clicking on the buttons of terms, phrases, or sentences ESL equivalent of the terms, phrases or sentences will be displayed in video form so that users can learn and practice easily. Moreover instructions of how to use the tool and how to communicate with a deaf person are incorporated. Figure 5.1 shows the use case model for the MESL^{2}T.

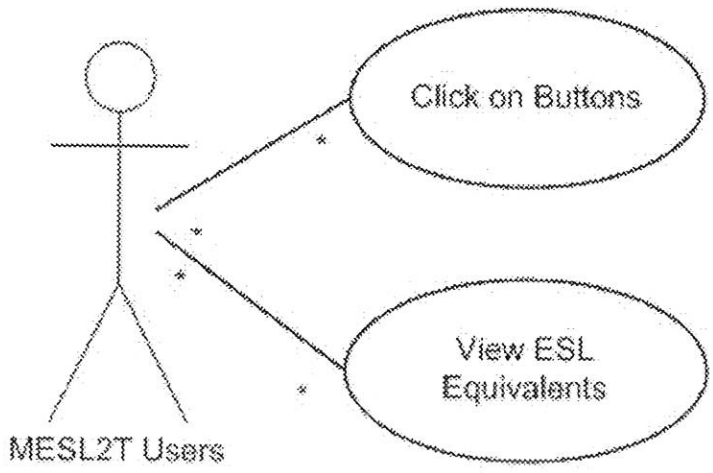
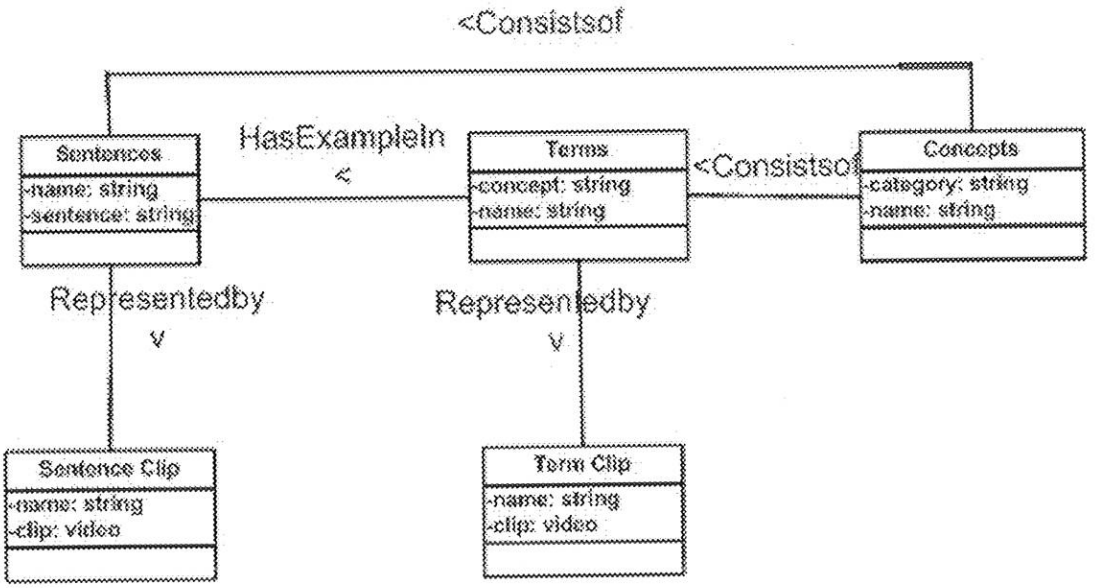


Figure.5.1. Use cases for MESL^{2}T

As discussed in the literature review part, the result of the conceptual design is summarised in a conceptual model represented by UML class diagram that consists of classes and associations between classes modelling the problem domain. Accordingly, the following classes have been identified to model the domain: Concepts, Terms, Sentences, and term and sentence clips. Concepts are a class that groups both general (like, greetings, finger spelling, and animals) and medical specific (like, diseases, drugs, and prescriptions) communication concepts. These concepts are identified in the analysis part of the study (see chapter 4).

Terms are those terms/phrases under the above communication concepts. For example: Cow and Cat are two terms under the concept Animal. Sentences are a class incorporating ESL sentences in Amharic order to the said terms in a sentence context. Specific terms included under each concept of both general and medical specific communication concepts are numerous. But for designing the prototype appendix-D indicates the Amharic version of few of them under each category. Terms and sentences clips are classes showing ESL video equivalents for the above terms/phrases and sentences.

Different types of relationships between classes are identified. That is, the class Concepts related through an association "consistsof" to both terms and Sentences classes. The class Terms related through an association "HasExampleIn" to the Sentences class. Classes Sentences and Terms related through an association "Representedby" to the sentence clip and term clip classes respectively. The conceptual model for the MESL^{2}T is depicted in figure.



5.2.

Figure 5.2. Conceptual Model of the MESL^{2}T

5.2. Navigational Design

As discussed in the literature review part of the study, the navigational design defines the structure of the hypermedia application by building two models: the navigational space model and the navigational structure model.

5.2.1. Navigational space model

The navigational space model specifies which objects can be visited through navigation in the hypermedia application. This model uses two modelling elements for its construction: navigational class and navigational association, which express direct navigability. The first step for the construction of this model is determining which classes of the domain model are relevant as nodes for the hypermedia application MESL^{2}T. All classes of the conceptual model are included in the navigational model. For their representation this research used the UML stereotype "navigational class" as shown in figure 5.3.

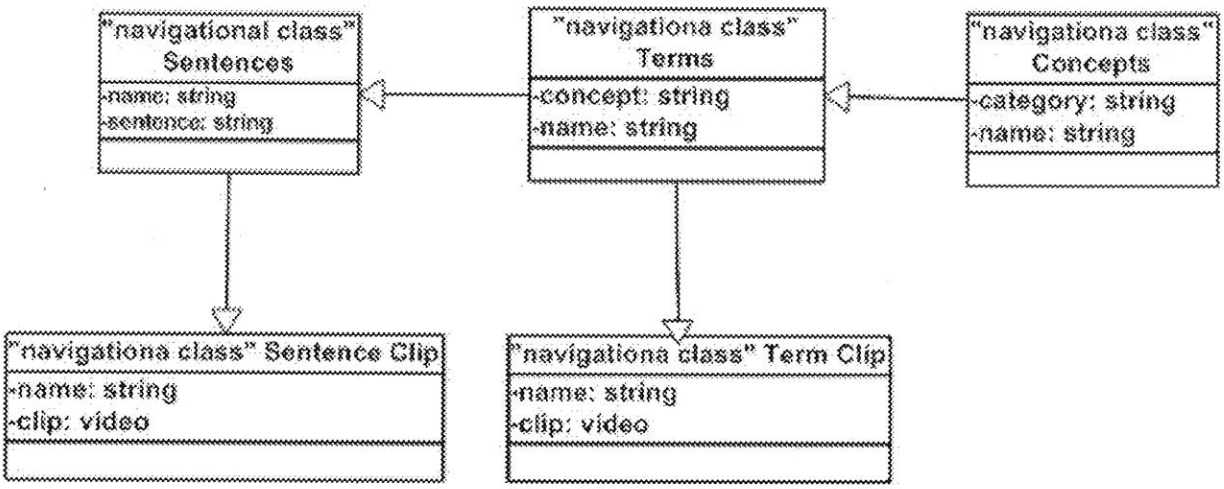


Figure 5.3: Navigation space model of MESL^{2}T built with the navigational class and navigability association

5.2.2. Navigational structure model

The navigation space model tells which objects can be visited by direct navigations from other objects. Access elements used for this research purpose are indexes. I have included external nodes, abstract of the thesis, manual of the MESL^{2}T and my biography, in the navigational structure.

As discussed in the literature review part of the study, the activities that are performed to pass from the navigational space model to the navigational structure model are:

- Defining navigational contexts
- Determining context changes
- Adding access primitives

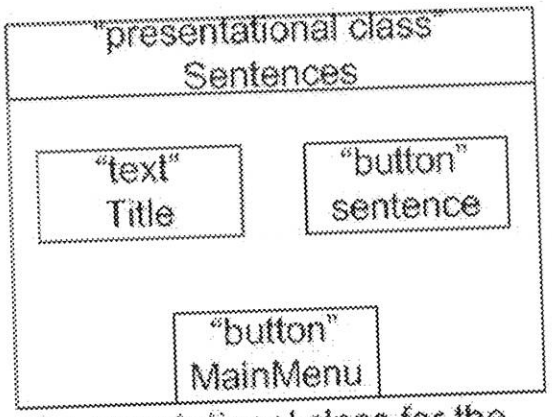
Hence, according to the first activity, the following are the navigational contexts needed: concepts by category, terms by concepts, terms by alphabets, signed Amharic sentences by terms, and manual (instruction) and my biography by their names.

Each navigational context consisting of more than one navigational node requires at least one access primitive. A main menu is the starting point to access different navigational contexts related to the defined navigational classes. Indexes are added to permit direct access to the objects of navigational a context. That is the case of index of Concepts, index of Terms, index of Sentences and index of Alphabets. Query, to reach terms either through concepts or alphabets, is also provided. Figure.5.4. Shows the UML object diagram for the navigational structure model of the MESL2T.

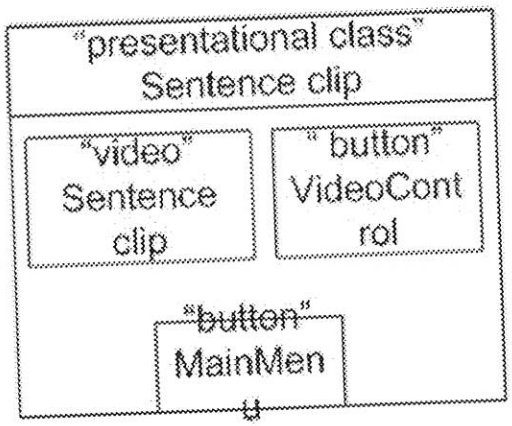
5.3. Presentational Model

While the navigational design defines what the navigational structure of an application is, the task of the presentational design is to define how this navigational structure is presented to the user. This is done by constructing a presentational model, which focuses on the structural organisation of the presentation. As indicated in the literature review part, for constructing a presentation model one has to decide which presentational elements will be used for the presentation of the instances of navigational classes and, on the other hand, for the presentation of the access elements. For this purpose, there are several presentational modelling elements (with corresponding stereotypes). Among those elements framesets are top-level elements for presentation. Hence, Framesets were used in this research to partition the presentation into frames, whereby the left frame shows the actual navigation tree and the final model was designed. For example at the draft design, "category" of the navigational class "concepts" was made as "anchored collection". But the users argued that it would be easy to use if both categories could be put in a single place. Based on this comment it has made to be "text".

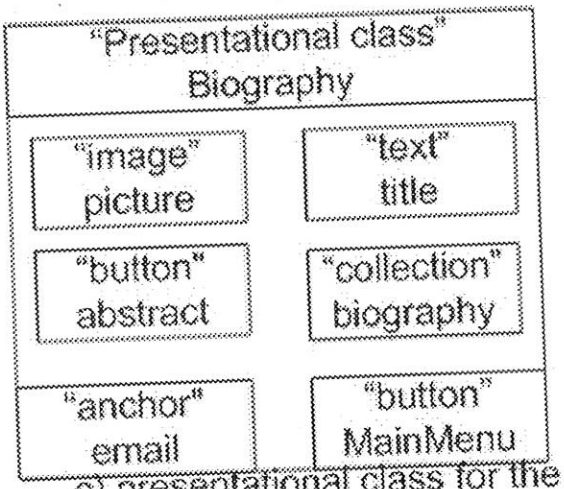
The anchors "Concepts" and "Alphabets" are starting points to reach the clips via terms and/or sentences buttons. The button MainMenu allows going back to the main page. The anchor email permits to send email to the designer of the MESL^{2}T.



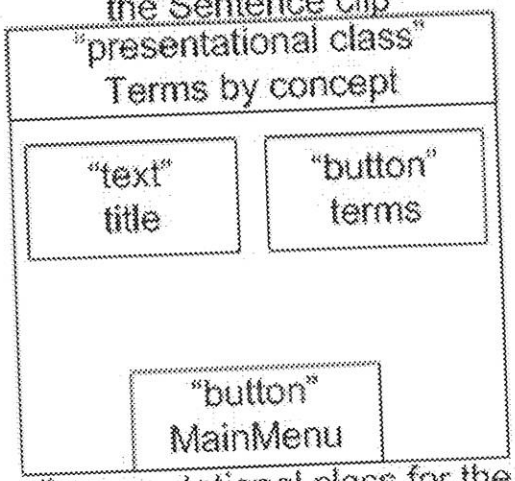
g) presentational class for the Sentences



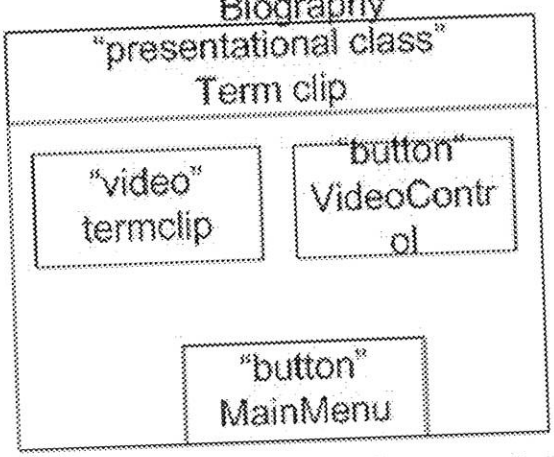
h) presentational class for the Sentence clip



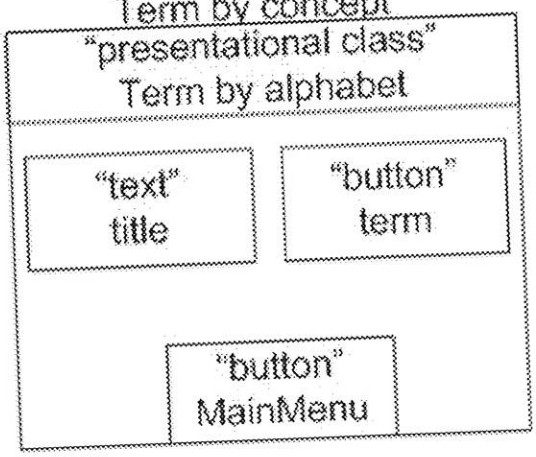
c) presentational class for the Biography



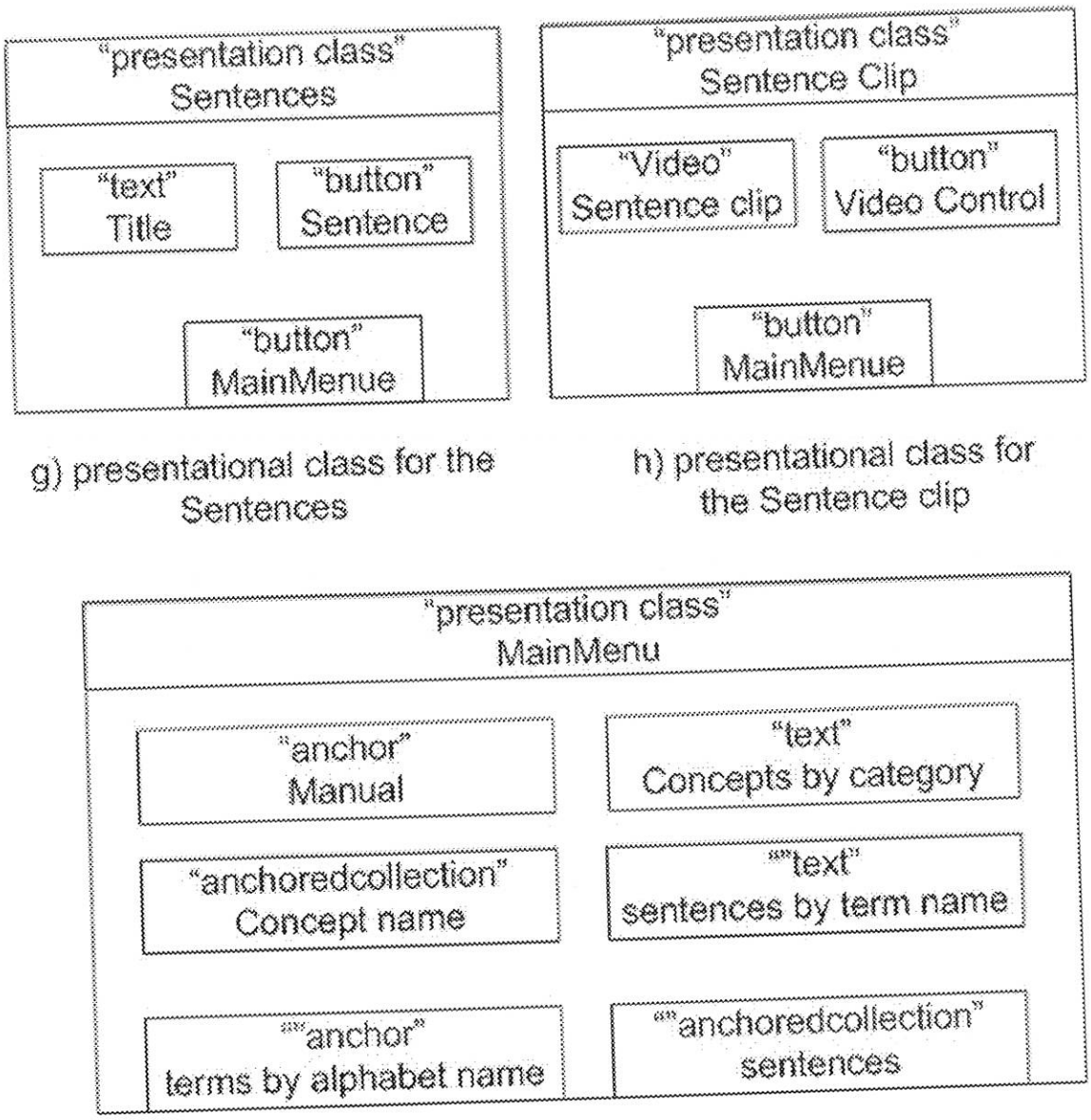
d) presentational class for the Term by concept



e) presentational class for theTerm clip



f)presentational class for the Term by alphabet



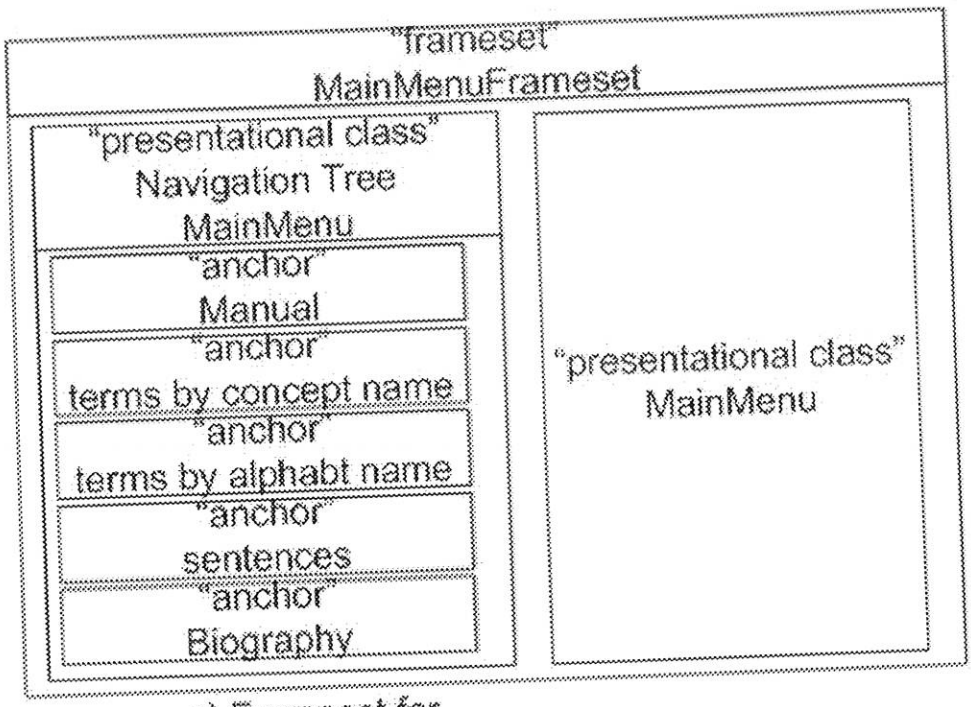
g) presentational class for the Sentences

h) presentational class for the Sentence clip

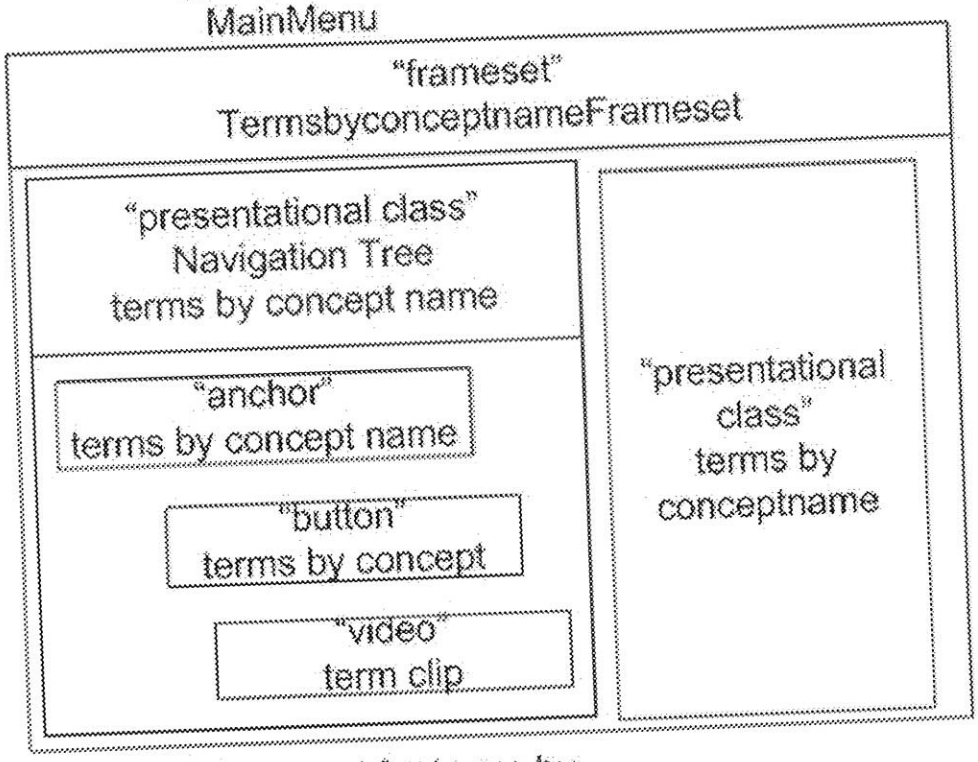
i) presentational class for the MainMenu

Figure.5.5. Presentational models for the MESL^{2}T

Figure 5.6. Shows the frameset for the presentational models of the navigational and index classes of the MESL^{2}T. These framesets show all the possible paths in the navigational structure model from the root class to the actual class for each navigational and index class. Framesets are not shown for some of the classes because their path already is indicated in the framesets of the classes in the figure.



a) Frameset for MainMenu



b) Frameset for terms by concept name

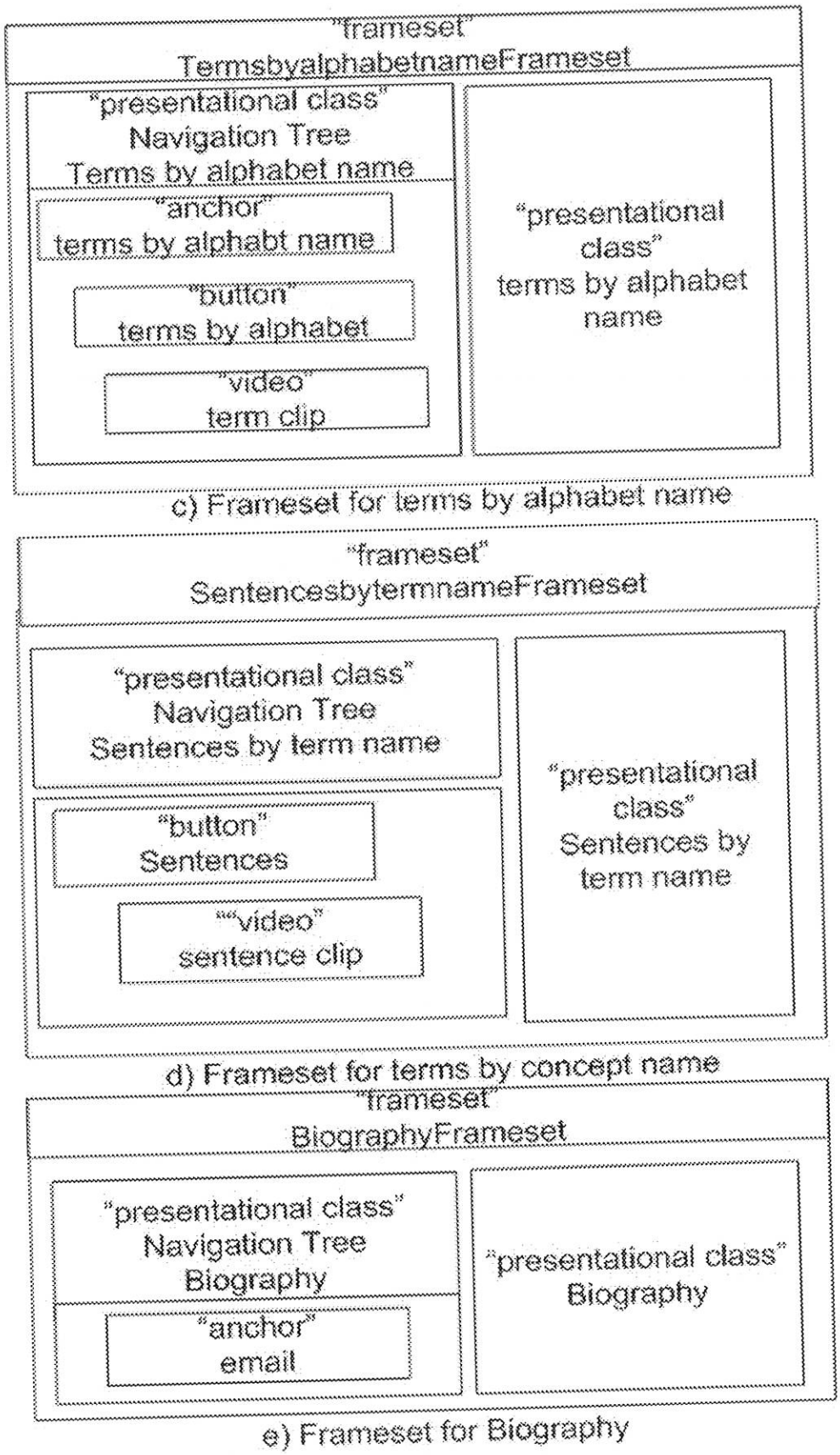


Figure 5.6: Frameset for the presentational models of MESL^{2}T

In the above figures, terms by concept indicate the terms, which were identified under the two categories of communication concepts: general and medical specific (see chapter 4). Terms by alphabet indicate the same terms but categorised under the Amharic alphabets by which their spelling starts. Sentences by term name imply the Amharic sentences which show the use of the identified terms in sentence context. Term clip and sentence clip are the ESL equivalents of the terms and sentences respectively.

Since, the mission of this research was to implement the MESL^{2}T in Amharic language, information that have been necessary for the implementation and specific to the user were translated to Amharic. Some of the screens of the implemented user interface are shown in appendix-c. The information that has been translated to Amharic for the implementation is indicated in Appendix D.

5.4. Evaluation of the MESL^{2}T

As discussed before the interface has been developed by continuously consulting colleagues, health professionals and teachers of ESL at ENAD for its simplicity and understandability. The intended users though made to comment at navigational design stage, they had played important role at the presentational design phase. Modifications made based on the users input are discussed in section 5.3.

Co-discovery usability testing method was used as a summative evaluation for the interface of the prototype. This evaluation was done at two of the three health centers where data were collected. The evaluation was done by forming groups, having 7 health professionals at Shiromeda Clinic, 6 health professionals at Minilik-ii hospital. (See chapter 3). The evaluation result showed that the users can easily understand and use the tool for the intended purpose.

6. Summary, Conclusions and Recommendations

6.1. Summary

Sign language is a visual language where Communication is done by means of hands, face, head and upper torso. Sign language is not international. Hence, different sign languages have been developed in different countries where deaf communities exist. Examples of such sign languages include American Sign Language (ASL), British Sign Language (BSL), and South African Sign Language (SASL).

In Ethiopia, even though there is little variation among sign languages used in different parts of the country, there is what is known as Ethiopian Sign Language (ESL). ESL is used as an effective mode of communication for deaf people in the country.

In perusing their day-to-day activities with their hearing acquaintances deaf people face communication problems of various kinds. This communication gap has made the deaf people to have a very much-restricted knowledge about the basic information of their day-to-day lives and surroundings and have inadequate knowledge, unfavorable attitude and undesirable behavior towards social aspects like sexual and health issues.

As per the investigation of this research, it has been observed that deaf people in Ethiopia are denied so many advantages because of the communication gap they have with the hearing people. The problem was more serious in public service areas like hospitals, police stations, etc

If we see the case of health environments, which was the focus of this study as an example, when a hospital fails to provide a qualified interpreter, or other means of effective communication, a deaf person who has no Sign Language translator may have to make critical health decisions without being able to adequately communicate with his or her doctor. This communication gap could place some deaf patients at risk.

In different countries, different options have been suggested and used to resolve communication gap between the deaf and hearing people. Among those some of the most effective, acceptable, and ethical solutions are:

- Using sign language translators
- Creating the chance for and training the deaf to use Minicoms or Typetalk
- Using software tools, which are capable of converting spoken language to sign language and vice versa
- Training the hearing people to be aware of and learn sign languages

Deaf people in Ethiopia have no direct access to the flow of information as hearing people do. There is no use of specialized or adapted Telecommunication devices freeing them from dependence on face-to-face communication or the intervention of a third party. Moreover, it is very challenging for most deaf people in terms of economy to hire a private sign language translator. Even for those who have capacity to hire translator, Good Sign Language translators are in high demand and are not always available. That means, communication among hearing and deaf people is almost impaired or nonexistent, to the detriment of both groups.

Implementation of any solution to any problem depends on the place where it is going to be implemented, condition and time. Accordingly, teaching sign language to hearing people may be the appropriate and timely solution in Ethiopia, bearing in mind the economic, awareness and other related factors. It will be possible to bridge the gap between hearing and deaf people of the country if those people who have close relationships to the deaf citizens learn the appropriate element(s) of ESL, which is the communication means for the deaf in the country.

One can learn ESL using either the formal way of teacher and class room based process or using a self learning computer aided software. However, the formal process of learning ESL has some drawbacks. For example, the numbers of schools specifically for the deaf are only restricted in towns. Therefore, those who need to learn sign language, including the deaf children, in rural areas have no chance to do so. Even in the towns the situations of most people especially parents and other care givers of the deaf, are not convenient to attend the formal ESL classes. Moreover, since sign language writing system is not in use in Ethiopia, learning ESL has been a great challenge.

Self-learning computer aided hypermedia systems can overcome the problems with formal sign language learning methods. Such learning tools also can help formal sign language students for revision and supplementary home study. Also, we know that people learn language best by watching and doing. Therefore self learning hypermedia learning tools

would make it possible for students to see ESL in action in their own homes – something which an ordinary textbook can never hope to do. In addition to being computer aided, if the process of learning ESL is made online, caregivers of deaf children and other people who communicate visually can benefit from it. This is because with a web based program, there is an opportunity to connect to the Internet so that one can learn at his/her own pace.

This thesis was therefore to contribute in this area by designing and developing a user centred and web based hypermedia-learning tool for ESL, considering health environments as a case, so that those health professionals who can write and read Amharic (the national language of Ethiopia) can learn ESL which enable them communicate with their deaf patients.

In order to achieve its aim, the research has followed a user centered design methodology for developing software. User research was done in order to have a good input to the design of appropriate tool. Based on the analysis of this user research, a prototype of the hypermedia-learning tool was developed.

The tool was designed using a UML based hypermedia designing methodology. . The whole process of developing the tool, including the design, was based on the ISO-13407 standard for user-centered design. The processes of doing the software using this way fulfills the DDD-E (Decide, Design, Develop and Evaluate) way of designing an Instructional Software. The program was created in HTML, to be read by an internet browser, ideally Internet Explorer on a Windows platform. HTML was chosen for its versatility: it can eventually be uploaded to the web if and when bandwidth improves; it can be accessed through a local area network (LAN); or it can be burned on CD-Rom and used as a stand-alone system. Also, a browser-window provides a very navigable interface with which most users are familiar and comfortable.

Evaluation of the tool was done in two phases. Primarily, the researcher was working in close to the intended users. During this time the users gave feed back and the researcher has considered all their needs. This was taken as the first phase. With the second phase, co-discovery method of usability testing was done. User requirements at the second phase also were considered before finalizing the interface. Accordingly, the final product has been found appropriate in the context of the intended users.

6.2. Conclusions

Based on this thesis research, the following conclusions are drawn:

- The research revealed that there exists communication gap between deaf patients and hearing health professionals.
- The degree of the gap is to the extent that deaf patients consider the very kind health professionals cruel over them.
- There exists no health professional who know ESL, no use of I speak cards or no ESL translator hired for any health centre. These facts have great role in increasing the aforementioned gap.
- Deaf patients were getting unfair treatments because most of the health professionals are treating them by guessing because of the communication gap.
- The communication gap also was creating social interaction problems among the deaf. This especially was observed in situations where deaf patients were trying to take HIV blood test by the help of ESL translators. This is because they feel that their result will no more kept secrete.
- Among the various means of solving/minimizing such communication gaps teaching sign language to the hearing members of the society, in particular to health professionals, was considered in this research. Accordingly, the research has indicted that people are very much interested in learning ESL, especially if it could be a computer assisted self learning methodology. Therefore, more efforts must be taken in order to satisfy the society in this regard. These efforts may include creating necessary facilities like computer infrastructure and efficiently implement learning tools like the one developed in this thesis.
- Regarding the software developed in this study, evaluation result indicated that, the intended users can easily use and learn ESL with it. This implies that the design and development process was successful and in the context of the users. Hence UCD based software creation is essential for the usability of the product.

All in all, I had to adopt a very pragmatic approach to this research – things had to work, not just look nice. Because of the time constraints and the fact that I am only one person working on this, I had to decide which was more important to me: it would be pointless and foolish to fret about intricate technical design at the cost of content. I feel very satisfied with the product

as it turned out – I have spent a lot of time and energy working on it. I sincerely hope that I will be able to continue making a contribution to the researches of Sign Language in Ethiopia.

6.3. Recommendations

Web-based ESL instruction is not available (as far as I know). Yet because people enjoy, the convenience of being able to study anytime, anywhere, and in the comfort of their own homes, this learning modality is certain to grow in scope and application. Hence I suggest if other studies on communication areas, apart from health environments, will also be conducted and ESL learning made online, so that other researchers also may use it as a base to conduct more researches on ESL.

As per the findings of the user research of the thesis, it has found that even if health professionals were interested and ready to learn ESL through a self-learning CAI mechanism, the necessary infrastructure is still not satisfactory in the health centers. Therefore the responsible bodies should facilitate things and create conducive atmosphere (a computer laboratory, for example) so that staff members can easily have an access to learn ESL.

As indicated in chapter 1, there exist different ways to bridge the communication gap between hearing and deaf people using IT. The focus of this thesis was on one of those options, teaching ESL to the hearing ones. It may be more efficient if further researches on other approaches could be conducted. Therefore I recommend if ENAD or any other researcher focus on those options so that it may play a great role in bridging/minimizing the communication gap.

The most important recommendation that I would like to suggest is the inclusion of ESL as a course in the curriculum at all levels of Ethiopian education including, Colleges and Universities. As indicated in chapter 1, students are very much interested to learn ESL to enhance communication with deaf acquaintances. This research also has showed that medical professionals need Ministry of Education to include an ESL curriculum in medical schools so that they can get knowledge of basic ESL to communicate with their deaf patients. Therefore the Ministry of Education must permit schools and other academic institutions to include ESL courses in their curriculum. Considering the shortage of ESL instructors in the country, a hypermedia-learning tool, like developed in this thesis research, can be used in the teaching/learning process.

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APPENDICES

Appendix -A: Questionnaire for Deaf Patients

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በኢንፎርማቲክስ ፋኩልቲ የኢንፎርሜሽን ሳይንስ ትምህርት ክፍል

<u>መስማት ለተሳናቸው የተዘጋጀ መጠይቅ</u>

የዚህ መጠይቅ አላማ በጤና ተቀማት አካባቢ በማተኮር መስማት የተሳናቸው ሰዎች መስማት ከሚችሉ ሰዎች ጋር የሚገጥማቸውን የመግባባት ችግር ለመዳሰስ እና አማራጭ መፍትሄም ለማበጀት ነው፡፡ ስለሆነም ይህንን መጠይቅ የሚሞሉት ከዚህ በፊት ወደ ጤና ተቀማት ለህክምና ቢያንስ አንድ ጊዜ ሄደው የሚያውቁ መሆን አለባቸው፡፡ ለዚህ መጠይቅ የሚሰጡት መልስ ሙሉበሙሉ ለጥናት እና ምርምር ስራ የሚውል እንደሆነ እና እያንዳንዱ መልስም በምስጢር የሚጠበቅ መሆኑን እያረጋገጥኩ ለትብብሮ በቅድሚያ አመሰግናለሁ፡፡

<u>ማሳሰቢያ</u>

በተሰጠው ባዶ ቦታ (ዎች) ላይ የ "X" ምልክት በማስቀመጥ ወይንም ተገቢውን መልስ በመጻፍ ይመልሱ፡፡ ለሚሰጡት መልስ በቂ ቦታ ካልበቃዎት እባክዎ ተጨማሪ ወረቀት ይጠቀሙ፡፡

I. Questions to Asses Degree of Communication Gap

1 ቀደም ሲል ወደ ጤና ተቀማት ለህክምና በሄዱበት ወቅት የኢትዮጲያ ምልክት ቋንቋን

የሚችል የጤና ባለሙያ ምን ያህል ጊዜ አጋጥሞት ያውቃል?

----ሁልጊዜ ----አልፎአልፎ -----አላጋጠመኝም

2 ከሚከተሉት የመግባቢያ ዘዴዎች ከጤና ባለሙያዎች ጋር ለመግባባት የሚጠቀሙበትን

በተሰጠው ባዶ ቦታ 1፣2፣3፣ ወዘተ በማለት በቅደም ተከተል ያስቀምጡ፡፡

--- በኢትዮጲያ የምልክት ቋንቋ -----በከንፈር እንቅስቃሴ ---በጽሁፍ ----በኢትዮጲያ

የምልክት ቋንቋ አስተርጓሚ ---ሌላ (ይጥቀሱት) ----------

3 የኢትዮጲያ ምልክት ቋንቋ አስተርጓሚ በሌለበት ወቅት ከጤና ባለሙያዎች ጋር በቋንቋ

ምክንያት ያለመግባባት ችግር አለብዎ?

---አዎ ----በመጠኑ ---የለብኝም

4 አዎ ካሉ ለመግባባት የሚቸገሩት በየትኛው ደረጃ ለሚገለጹ ሃሳቦች ነው?

----በሀረግና /ወይም አረፍተ ነገር ደረጃ ለሚገለጹ ሃሳቦች

----በቃላት ደረጃ ለሚገለጹ ሃሳቦች

---በሁለቱም ደረጃ መግባባት ያስቸግረኛል

------ሌላ (ይጥቀሱት)----------

II. Questions to Assess Areas of the Communication Gap

5 ለ3ኛው ጥያቄ መልስዎ አዎ ከሆነ በምን ጉዳዮች ላይ መግባባት እንደሚያስቸግርዎ ያሳዩ::

----አጠቃላይ የመግባቢያ ሃሳቦችን (ለምሳሌ፣ሰላምታ፣ቁጥርና ጊዜ፣አድራሻ፣ ወዘተ) ለመግለጽና ለመረዳት

----ከህክምና ጋር የተያያዙ ሀሳቦችን (ለምሳሌ፣የበሽታ አይነቶችና ምልክቶች፣የመድሃኒት ትእዛዝ፣ ወዘተ) ለመግለጽና ለመረዳት

----ሌላ(ይጥቀሱት)----------

III. Questions to Asses Impacts of the Communication Gap

6 የኢትዮጲያ ምልክት ቋንቋ አስተርጓሚ በሌለበት ወቅት በቋንቋ ያለመግባባት ምክንያት ተገቢውን ህክምና አላገኘሁም የሚሉበት ጊዜ አለ?

-----አዎ ----የለም

7 አዎ ካሉ ከጤና በለሙያዎች ጋር በአግባቡ መግባባት ባለመቻልዎም የደረሰብዎት ችግር

ካለ ቢያብራሩት?

IV. Questions to Asses Solutions of the Communication Gap

8 የኢትዮጲያ ምልክት ቋንቋን ከማይችሉ የጤና ባለሙያዎች ጋር ያለብዎትን የመግባባት ችግር በቀላሉ ለመፍታት ምን ቢደረግ ጥሩ ነው ይላሉ?

--- የጤና ባለሙያዎች የኢትዮጲያ ምልክት ቋንቋን ቢማሩ

--ለየጤና ተቋማቱ በቂ በዛት ያላቸው የኢትዮጲያ ምልክት ቋንቋ አሰተርጓሚዎች ቢመደቡ

----በከንፈር እንቅስቃሴ መግባባት ቢለመድ

---በጽሁፍ መግባባት ቢለመድ

---ሌላ(ይጥቀሱ)----------

V. Questions to Assess Deaf Awareness Issues and Additional Comments/Ideas

9 የጤና ባለሙያዎች ስለ መስማት የተሳናቸው ሰዎች እና የኢትዮጲያ ምልክት ቋንቋ ያላቸውን ግንዘቤ እና አመለካከት (Deaf awareness) እንዴት ይገልጹታል?

10 ከዚህ መጠይቅ ጋር በተያያዘ ተጨማሪ አሰተያየት፤ጥቆማ ወይንም ሊገለጽ ይገባዋል የሚሉት ጉዳይ ካለ ቢያብራሩት?----------

Appendix -B: Questionnaire for Health Professionals

አዲስ አበባ ዩኒቨርሲቲ

በኢንፎርማቲክስ ፋኩልቲ የኢንፎርሜሽን ሳይንስ ትምህርት ክፍል

<u>ለጤና በለሙያዎች የተዘጋጀ መጠይቅ</u>

የዚህ መጠይቅ አላማ በጤና ተቋማት አካባቢ በማተኮር መስማት የተሳናቸው ሰዎች መስማት ከሚችሉ ሰዎች ጋር የሚገጥማቸውን የመግባባት ችግር ለመዳሰስ እና አማራጭ መፍትሄም ለማበጀት ነው፡፡

ለዚህ መጠይቅ የሚሰጡት መልስ ሙሉበሙሉ ለጥናት ና ምርምር ስራ የሚውል እንደሆነ እና እያንዳንዱ መልስምበምስጢር የሚጠበቅ መሆኑን እያረጋገጥኩ ለትብብርዎ በቅድሚያ አመሰግናለሁ፡፡

<u>መግቢያ</u>: የሚሰጡትን መልስ በአግባቡ ለመገምገም ይረዳኝ ዘንድ የሚከተሉትን የመነሻ ሀሳቦች በመሙላት ይጀምሩ፡፡

የሚሰሩበት የጤና ተቋም ስም ----------

የስራ ድርሻዎ/ክፍልዎ----------

የሙያ ዘርፍዎ----------

የስራ ልምድዎ ----------የትምህርት ደረጃዎ----------

<u>ማሳሰቢያ</u>

በተሰጠው ባዶ ቦታ (ዎች) ላይ የ "X" ምልክት በማስቀመጥ ወይንም ተገቢውን መልስ በመጻፍ ይመልሱ፡፡ ለሚሰጡት መልስ በቂ ቦታ ካልበቃዎት እባክዎ ተጨማሪ ወረቀት ይጠቀሙ፡፡

I. Introductory Questions

1 በወር ምን ያህል ታካሚዎች በርስዎ የስራ ክፍል ይስተናገዳሉ? ----------

2 በወር በርስዎ የስራ ክፍል ከሚስተናገዱ ታካሚዎች ውስጥ ምን ያህሉ መስማት የተሳናቸው ናቸው? ----------

II. Questions to Assess Degree of Communication Gap

3 በጤና ተቋማችሁ /የሰራ ክፍልዎ ያለ የኢትዮጲያ ምልክት ቋንቋ አስተርጓሚ የሚመጡ መስማት የተሳናቸው ታካሚዎችን ለመለየት እና በአግባቡ ለመርዳት "እኔ መስማት የተሳነኝ ነኝ" ወይንም "እኔ አስተርጓሚ እፈልጋለሁ" የሚሉ ካርዶችን (I speak cards) ትጠቀማላችሁ? ------አዎ ------አንጠቀምም

4 አንጠቀምም ካሉ ያለኢትዮጲያ ምልክት ቋንቋ አስተርጓሚ የሚመጡ መስማት የተሳናቸው ታካሚዎችን ለመለየት እና በአግባቡ ለመርዳት ምን ዘዴ ትጠቀማላችሁ?

5 በርስዎ የስራ ክፍል መስማት የተሳናቸው ታካሚዎችን ለማስተናገድ የመግባቢያ መንገዳችሁ ምንድነው? መልስዎ ከአንድ በላይ ከሆነ 1፣2፣3፣ ወዘተ በማለት በተሰጡት ባዶ ቦታዎች ላይ በመሙላት ቅደም ተከተላቸውን ያሳዩ፡፡

---የኢትዮጲያ ምልክት ቋንቋን የሚችሉ የስራ በልደረቦች አሉን

---የኢትዮጲያ ምልክት ቋንቋ አስተርጓሚዎች

---የታካሚዎች ቤተሰብ እና/ወይንም የቅርብ ሰው

---በጽሁፍ

---በከንፈር እንቅስቃሴ

---ሌላ(ይጥቀሱ)---------- ----------

6 በርስዎ የስራ ክፍል ያለኢትዮጲያ ምልክት ቋንቋ አስተርጓሚ የሚመጡ መስማት የተሳናቸው ታካሚዎችን በምታስተናግዱበት ወቅት በ ቋንቋ ምክንያት የመግባባት ችግር አለ? ------አዎ ----አልፎአልፎ አለ -----የለም

III. Questions to Assess Areas of the Communication Gap

9 በርስዎ የስራ ክፍል ከሚስተናገዱ መስማት የተሳናቸው ታካሚዎች ጋር የኢትዮጲያ ምልክት ቋንቋ አስተርጓሚ በማይኖርበት ጊዜ መግባባት የሚቸገሩት በየትኞቹ ሀሳቦች ላይ ነው?

----አጠቃላይ የመግባቢያ ሃሳቦችን (ለምሳሌ፣ሰላምታ፣ቁጥርና ጊዜ፣አድራሻ፣ ወዘተ) ለመግለጽና ለመረዳት

----ከህክምና ጋር የተያያዙ ሀሳቦችን (ለምሳሌ፣የበሽታ አይነቶችና ምልክቶች፣የመድሃኒት ትእዛዝ፣ ወዘተ) ለመግለጽና ለመረዳት

----ሌላ(ይጥቀሱት)----------

IV. Questions to Assess Impacts of the Communication Gap

7. □6ኛው ጥያቄ አዎ ወይንም አልፎአልፎ አለ ካሉ መስማት የተሳናቸው ታካሚዎች በ ቋንቋ ያለመግባባት ምክንያት የተዛባ አገልግሎት በማግኘታቸው እርስዎ የሚያውቁት የደረሰባቸው ችግር እና ጉዳት ካለ እያነዳንዱን በጥልቀት ቢያብራሩት?

V. Questions to Asses Solutions of the Communication Gap

8 በርስዎ የስራ ክፍል ያለኢትዮጲያ ምልክት ቋንቋ አስተርጓሚ የሚመጡ መስማት የተሳናቸው ታካሚዎችን በምታስተናግዱበት ወቅት በ ቋንቋ ምክንያት የሚፈጠሩ ያለመግባባቶቸን ለመቀነስና በታካሚዎቹም ላይ የሚደርሰውን ችግር ለመቅረፍ ምን

ቢደረግ ጥሩ ነው ይላሉ?

--- የጤና ባለሙያዎች የኢትዮጲያ ምልክት ቋንቋን ቢማሩ

----ለየጤና ተቋማቱ በቂ በዛት ያላቸው የኢትዮጲያ ምልክት ቋንቋ አሰተርገሚዎች ቢመደቡ

----በከንፈር እንቅስቃሴ መግባባት ቢለመድ

---በጽሁፍ መግባባት ቢለመድ

---ሌላ(ይጥቀሱ)----------

10 መስማት ከተሳናቸው ታካሚዎች ጋር በቀላሉ ለመግባባት የሚያስችል የኢትዮጲያ ምልክት ቋንቋን ለመማር እድሉ ቢገጥምዎት በምን መልኩ ቢሆን በቀላል ጊዜ እና ሁኔታ መከታተል ይችላሉ?

---ምልክቶቹን በመማር በአማርኛ የአገባብ ስልት መግባባት በሚያስችል መልክ

----የኢትዮጲያ ምልክት ቋንቋን ሙሉ በሙሉ በመማር መግባባት በሚያስችል መልክ

---- መማር አልፈልግም

11 የኢትዮጲያ ምልክት ቋንቋን መማር የሚፈልጉ ከሆነ መስማት የተሳናቸው ታካሚዎችን በቀላሉ ለመግባባት የሚያስችል የኢትዮጲያ ምልክት ቋንቋን ከላይ

በመረጡትመልክ ለመማር የሚመርጡት ሁኔታ የትኛው ነው?

---- በትርፍ ጊዜያት በክፍል ውስጥ ባስተማሪዎች

-----በአመቺ ቦታ ለመማር በኮምፒውተር የሚታገዝ "ራስን በራስ ማስተማሪያ ዘዴ"

ቢዘጋጅ

----ሌላ(ይጥቀሱት)----------

VI. Questions to Assess Necessary Skills and Infrastructures for Implementation of the Software

12 መሰረታዊ የኮምፒውተር አጠቃቀም እውቀት አለዎት? ---አዎ ---የለኝም

13 በስራ ክፍልዎ ወይም በቤትዎ ኮምፒውተር አለ? ---አዎ ---የለም

14 አዎ ካሉ እርስዎ የኮምፒውተር ተጠቃሚ ነዎት?

----አዎ -----አልፎአልፎ -----አይደለሁም

15 አዎ ካሉ የሚጠቀሙበት የኮምፒውተር አይነት ምንድነው?

___Power PC (Mac) _Apple Macintosh

__IBM/PC with Windows 98 – XP __IBM/PC with Windows 3.1

__Other(specify) ----------

16 የሚጠቀሙበት ኮምፒውተር የኢንተርኔት ግንኙነት አለው? ---አዎ ----የለውም

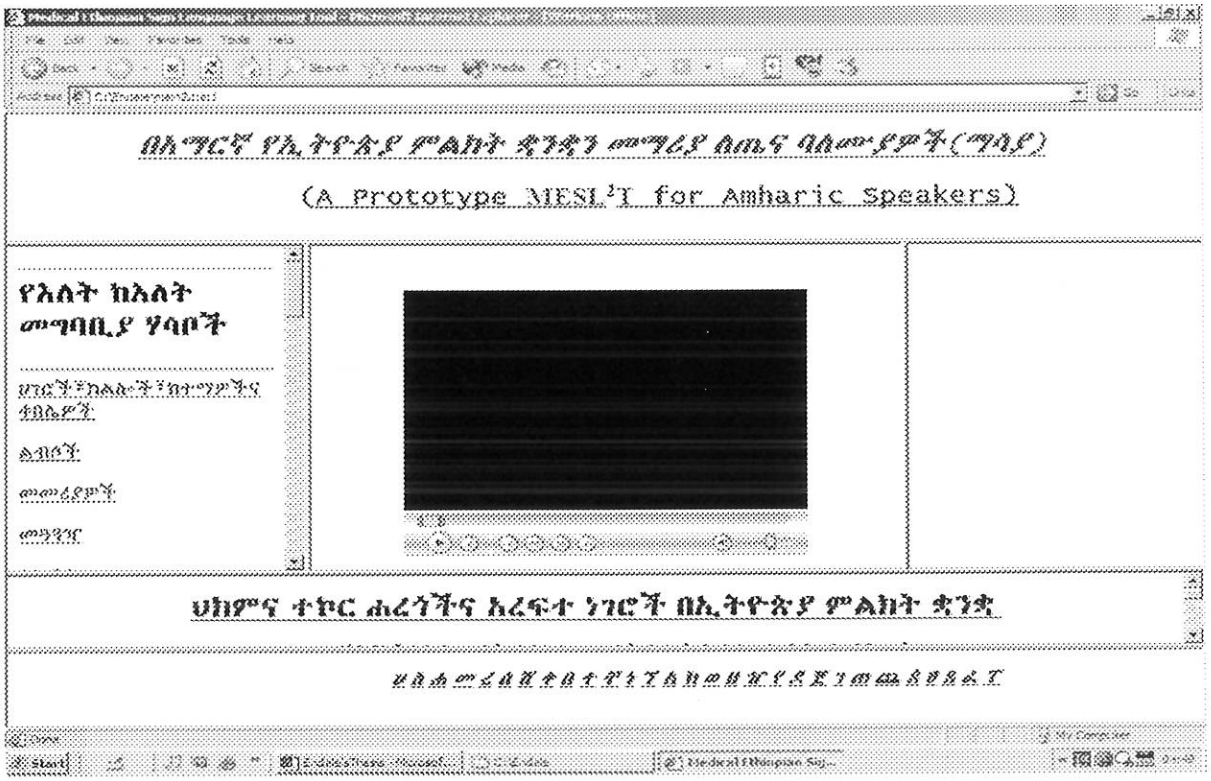
17 ቀደም ሲል ምስል (ቪዲዮ) ነክ ስራዎችን በኮምፒውተር የመመልከት ልምድዎ

እንዴት ይገለጻል? ---ከፍተኛ ---መጠነኛ --ዝቅተኛ ----ልምድ የለኝም

VII. Questions for Comments and Additional Ideas

18 ከላይ ከተነሱት ሃሳቦች ጋር በተያያዘ ሊጠቀስ ወይም ሊብራራ ይገባል የሚሉት ጉዳይ ካለ ቢገልጹት?

Appendix-C: Sample Prototype Program Screens



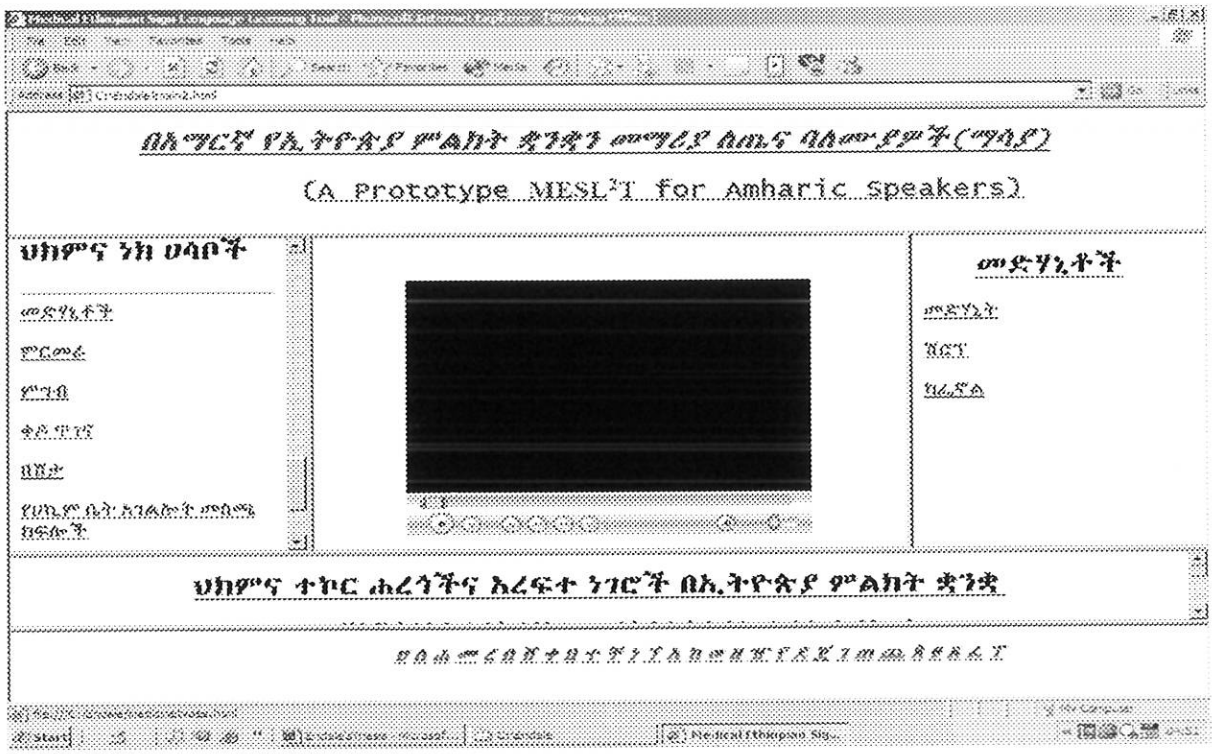


Figure A.1: Sample Prototype Program Screens

Appendix –D: Terms/Phrases and Sentences Used

Table D-1: communication concepts categories and their related terms/phrases

የመግባቢያ ሃሳብ ክፍል	ምሳሌዎች
የአማርኛ የጣት ፊደሎች	ሀ ፣ ለ፣ሐ ፣መ፣ረ ፣ሰ ፣ሸ፣ቀ፣በ፣ተ፣ቸ፣ነ፣ኘ፣አ፣ከ፣ወ፣ዘ፣ዠ፣የ፣ደ፣ጀ፣ገ፣ጠ፣ጨ፣ጰ፣ፀ፣ጸ፣ፈ፣ ፐ፣
ቁጥሮችና ጊዜያት	ቁጥር፣፩፣፪፣፫፣፬፣፭፣፮፣፯፣፰፣፱፣፲፣ጊዜ፣ጠዋት፣ትናንት
እንስሳት	ድመት፣ላም፣ዋልያ፣ቀበሮ
ምግብ	ምግብ፣የናት ጡት ወተት፣እንጀራ፣ገንፎ፣አልኮል
ጉዳት	ጉዳት(አደጋ)፣መሰበር፣መመረዝ፣ትንፋሽ ማጠር
የአእምሮ ተግባር ገላጭ ቃላት	ማወቅ፣ማመን፣የማይገባው፣ሐሳብ
ንግግር	የምልክት ቋንቋ፣ሀሜት፣ተረት፣ማወጅ፣መሃላ
አይነትና ሁኔታዎች	ጥሩ፣ሀብታም፣ቀላል፣ስህተት
ብዛት መጠንና ተዋረድ	ብዙ፣ምንም፣ሙሉ፣ረጅም፣ቀጭን
የሰውነት ክፍሎች	ጥርስ፣አስኪት፣ከረቤሳ፣ኩላሊት፣ልብ
መገዋገዣ	መኪና፣ጢያራ፣ግመል፣ጋሪ
የአራቱ ዋልታዎች አቅጣጫዎች	ሰሜን ፣ደቡብ፣ምእራብ፣ምስራቅ
ሀገሮች፣ክልሎች፣ከተማዎችና ቀበሌዎች	ኢትዮጵያ ፣አሮምያ፣አዲስ አበባ፣ቀበሌ
ዝምድናና ቀረቤታን ገላጭ ቃላት	እናት፣ወንድም፣ባል፣እጮኛ፣አክስት
ቀናትና ወሮች	ሰኞ፣ማክሰኞ፣ረቡእ፣ሐሙስ፣አርብ፣ቅዳሜ፣እሁድ፣መስከረም፣ ጥቅምት፣ህዳር፣ታህሳስ፣ጥር፣የካቲት፣መጋቢት፣ሚያዝያ፣ግንቦ ት፣ሰኔ፣ሐምሌ፣ነሐሴ፣ጳጉሜን
ስሜት ገላጭ ቃላት	መከፋት፣መናደድ፣መፍራት፣መሳቅ
ተፈጥሮና የአየር ሁኔታ	ፀሐይ፣ባህር፣ቀዝቃዛ፣በረሃ
ስሞችና ተውላጠ ስሞች	ስም፣ወንድ፣ሴት፣ህዝብ፣ብሄር፣የምርጫ ቦርድ፣የኢትዮጵያ መስማት የተሳናቸው ብሄራዊ ማህበር፣እናንተ፣የእናንተ
ንፅህና ነክ ቃላት	ሻወር፣ፀጉር መታጠብ፣ጥርስ መቦረሽ

አመት በአላት	አዲስ አመት፣ገና፣ጥምቀት፣አረፋ፣ፋሲካ
ስፖርት	ስፖርት፣ሩጫ፣የጠረቤዛ ቴኒስ
የቤት እቃዎች	ቤት፣አልጋ፣ቴሌቪዥን
ጠያቂ ቃሎች	ጥያቄ ፣እንዴት፣ለምን
የመተዳደሪያ ስራዎች	ሀኪም/ ዶክተር፣ነርስ፣ጥበቃ፣መምህር
ልብሶች	ብርድ ልብስ፣ቀሚስ፣ሹራብ፣ሱሪ
መመሪያዎች	ዋጥ፣ቁጭ በል፣ተረጋጋ፣ተንፍስ
ሰላምታ	እንደምን ነዎት?፣እግዚአብሄር ይመስገን፣ደህና ይሁኑ!
በሽታ	መታመም(በሽታ)፣አች አይ ቪ ኤይድስ፣የሆድ ቁርጠት፣አስም፣የልብ ድካም
የሀኪም ቤት አገልሎት መስጫ ክፍሎች	ክፍል፣ህክምና፣ካርድ ፣መኝታ፣ምርመራ፣ማዋለጃ
የመድሀኒት ማዘዣ	ከምግብ በፊት፣በቀን ሶስት ጊዜ ፣ከቆዳ በታች፣በአፍ ብቻ
የበሽታ ምልክቶች	ማዞር ፣ማቃጠል፣ረሀብ
ምርመራ	ምርመራ፣ሽንት ፣ርግዝና ፣የልብ ምት
መድሃኒቶች	አምፒሲሊን፣ሽሮፕ ፣ዲፕሮን ፣ክኒን
ቀዶ ጥገና	ቀዶ ጥገና፣ፅንስ ማቋረጥ፣የጡት ቀዶ ጥገና፣ የአጥንት ቀዶ ጥገና

Table D-2: communication terms/phrases in signed Amharic context

የመግባቢያ ሃሳብ	የአረፍተ ነገር አጠቃቀም ምሳሌ
የማዋለጃ ክፍል:	ይቅርታ! የማዋለጃ ክፍሉን: ያሳዩኛል?
ነርስ	የኔ ነርስ እርስዎ ነዎት ? አይደለሁም! የርስዎ ነርስ ሂዋን ናት::
ነገ	ነገ ደምህን ተመርመር
ክኒን	ራሴን አሞኛል እባክዎ ክኒን ይኖራል? ይህንን ክኒን መጠቀም አለብዎት::
ብርድልብስ:	ብርድ እየተሰማኝ ነው ተጨማሪ ብርድ ልብስ ይኖራል?
ልብ:	ልቤን ይከብደኛል በዛላይ ትንፋሽ ያጥረኛል::
ባል:	እባክዎትን ባሌን ጠርተው አንድ ነገር ይነግሩልኛል?

Appendix-E: Minimum Computer Hardware Specifications to the MESL2T

I recommend that the MESL^{2}T software be used on a high-end notebook or desktop computer that meets the minimum computer hardware specifications listed below. For enhanced performance it is recommended to use Windows XP or 2000 as the operating system, a 1 GHz (or higher) processor, and 512 MB RAM. Amharic font reader should be in place before using the software.

Table E-1: Minimum Computer Hardware Specifications to the MESL^{2}T

Processor	Pentium III, 800 MHz
Hard Drive	130 MB available space on Drive C
Memory	256 MB RAM
Parallel Port	Required to attach hardware security key
Video	2 MB
Display Resolution	345X 265 Screen Area Capability, High Quality
CD-ROM	24X (or DVD-ROM)
Software	Word Processing Program
Operating System	Microsoft Windows XP, 2000, or 98SE

DECLARATION

I declare that the work presented in this thesis is, to the best of my knowledge and belief, original, except as acknowledged in the text, and that the material has not been submitted, either in whole or in part, for a degree at this or any other university.

Endale Asefa

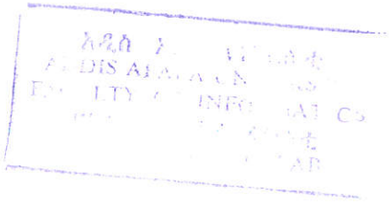
JUNE 2005

This thesis has been submitted for examination with our approval as University Advisors.

Dr. Gashaw Kebede

Dr. Lynette Van Zijl

JUNE 2005



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