DEVELOPMENT OF SIGNS FOR SCIENTIFIC TERMS IN SCHOOLS FOR THE HEARING-IMPAIRED

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Declaration

This thesis is my original work and has not been presented for a degree in any other university.

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Acronyms

K.I.E---------- Kenya Institute of Education

K.I.S.E ---------- Kenya Institute of Special Education

UNESCO ---------- United Nations Educational, Scientific and Cultural Organization.

NGOs ---------- Non-governmental organizations

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All the hearing-impaired children and those genuinely concerned with their education.

And to

My late mother, Assenath I. Wanjau, through whose quiet influence I joined education of the deaf.

Abstract

This study was designed to specifically develop signs for scientific terms commonly used in the teaching and learning of science in primary and secondary schools for the hearing-impaired in Kenya. The greatest problems faced by the deaf individuals continue to be related to matters of communication with the predominant society. Hearing impairment interferes with both reception and production of language. Because language influences practically every dimension of development, inability to hear and speak is a critical deficit that may have an unfavorable social and academic adjustment. In order to alleviate the communication handicap amongst the deaf learners, the Kenya Institute of Education (K.I.E) has so far developed a sign language textbook with a vocabulary covering various fields of knowledge. However, signs to represent scientific terms important to the subject matter in primary and secondary schools have not been included in this book. Consequently, communicative interchange between teachers and the learners has been difficult during science lessons. The purpose of this study, therefore, was to develop signs to represent scientific terms that will make communication during science lessons easy, fluent and accurate.

The design that was used is descriptive survey to find out the scientific terms, important to the subject matter, for which signs would be developed. The population of study was drawn from two schools for the hearing-impaired in Nyeri District. A purposive sample was selected from the two schools for the hearing-impaired in the district. Study subjects were randomly selected from forms two, three, and four and standards six, seven and eight. A total of thirty-three participants were involved in the study. Twenty-eight out of the 33 participants were pupils and five science teachers. A checklist of scientific terms and a videotape were used to collect data. Two hundred terms were nominated from the chosen terms and signs developed for each of them. The collected data was later analyzed linguistically. Each new sign was judged as appropriate on the basis of clarity, appearance and cultural acceptability, and then presented in simple descriptions and illustrations by a fine artist.

CHAPTER ONE

INTRODUCTION

1.0 Background of the study

Children with hearing impairment present some of the most difficult and challenging problems in special education. Hearing impairment interferes with both the reception and the production of language. Because language influences practically every dimension of development, inability to hear and speak is a critical deficit that may have an unfavorable social and academic adjustment. The greatest problems faced by deaf individuals continue to be related to matters of communication with the predominant society and the insensitivity of most hearing individuals (Moores, 1982). Consequently, the deaf have encountered difficulty in all aspects of their lives that is socially, educationally, psychologically and cognitively. The difficulty in communication is more pronounced in the area of their education (Alade&Abosi, 1991). According to Gbegbin, (1991) "...it is a generally accepted fact that a person's intellectual and personal attainment is largely determined by his mastery of language; and that language stimulates the self development of every individual" (p.88) .This assertion also applies to the hearing impaired persons. Studies have established the fact that hearing impairment imposes in the area of ability to acquire language by natural means on those who have marked hearing loss. There is no doubt that hearing-impaired persons experience language difficulties which also strike at the core of successful living, as language difficulties or deficiencies interfere with their communication competence. This is so because the avenue to discoveries and growth easily become blocked by the hearing impairment. Language is a prerequisite for effective

learning. Since language is a process requiring the receiving and interpreting of information, and the school situation demands that a child be able to express his/her learning by the spoken and/or written word, it follows that any deficit of language must receive remediation. This fact was realized very early in the education of the hearing impaired people. Thus, various individuals, organizations and governments of various nations have been actively involved in seeking ways of alleviating this communication handicap.

There is no evidence in all recorded history of any systematic attempts to educate deaf individuals before the work of Ponce de Leon in Spain in the sixteenth century. The honor of being the first teacher of the deaf is accorded to Pedro Ponce de Leon (1520-1584), a Benedictine monk who established a school at a monastery in Valladolid and tutored deaf children of Spanish nobility. Deafness was common in Spanish aristocracy, including even the royal family. Ponce de Leon was motivated to begin his work by the presence in the monastery of two deaf brothers Francisco and Pedro de Velasco, members of a wealthy and influential Velasco family. Ponce de Leon undertook the task of teaching Francisco to read, write and speak. Because it was a requirement that children should acquire speech to claim their inheritances, the prime emphasis was placed upon teaching of speech (Evans, 1982). Francisco, the legitimate heir to the marquisate of Berlenga and the eldest son of the house of Tudor, learned to speak and write and thus gained inheritance. However, in regard to the methods that Ponce de Leon used, Moores (1982) notes "...Unfortunately, very little is known of the techniques employed by Ponce de Leon. Although he produced a written account of his work, it was either lost or destroyed, and no record of it survives"(p. 39). Soon, the formal education of the hearing impaired spread to Europe and later to United States of America (U.S.A.). Different countries adopted different methods

of teaching the hearing impaired. For example oral method was predominantly used in Germany while manual method was predominant in France and became popular in U.S.A., mainly because of French influence. Thomas Hopkins Gallaudet, to whom the honor of establishing the first permanent school for the deaf in 1817 in U.S.A belongs, studied manual method in France (Moores, 1984).

Throughout the history of education of the hearing impaired, the two methods of teaching namely, manual method and oral method have generated heated controversies among the educators in this area the proponents of each method claiming their method to be the best for teaching the hearing-impaired. However, in 1880 during the famous Milan International Congress, it was resolved that the method to be used in teaching the hearing-impaired was the oral method (Moores, 1984). These controversies clearly indicate that communication of the hearing impaired has been a serious and thorny issue amongst the educators of the deaf. In 1960s, an increasing concern and dissatisfaction on aural-oral method of teaching the hearing impaired was expressed in the industrialized countries especially U.S.A. This was due to the mainstreaming of the partially hearing children into regular schools or units, which left the special schools with severe to profound children, who responded even poorer to this method. Evans, (1982) cited a number of studies such as that by Trybus and Karchmer (1977) who found that in the twenty-year old population (who had passed through education in 1960), the average student had a reading ability below fifth grade level.

At around the same time, studies were carried out by researchers such as Stevenson (1964), Stuckless and Birch (1966), and Meadow (1968) who tried to compare deaf children of deaf parents with deaf children of hearing parents. Deaf children of deaf parents used

manual communication while deaf children of hearing parents used oral communication. They concluded that early use of manual communication had positive influence on various aspects of development such as general education attainment, lip-reading abilities, written language and social maturity.

Since the early 1980s, there has been a growing worldwide awareness of the need to help the hearing impaired persons to realize their potential as human beings. Efforts have thus been channeled towards breaking the communication barrier that impacts negatively on the deaf persons. For instance, teachers and other people involved in education of the deaf persons have tried their best to ensure that the lots of the hearing impaired are improved by adopting approaches that enhance communication in the education of the deaf. In fact, other alternative ways of educating the hearing impaired besides oral methods have been sought (Yego, 1991). For instance, the Total Communication Philosophy has been surfacing as a more liberal approach of teaching the hearing impaired. UNESCO Consultation on Alternative Approaches for The Education of the Deaf (1984) observes that "... the communication philosophy presents an attitude of openness to all methods of training so as to make optimal use of all known approaches to communication... and takes into account the social, psychological and educational adaptation difficulties experienced by the deaf"(p.12). It can therefore be seen that the value for a hearing impaired individual to acquire the best possible oral and manual skills as well as good competence in written language is recognized. The awareness of the significance of sign language in education of the deaf has been growing in recent years. The old idea that the use of sign language will be a hindrance to the development of spoken and written language is no longer valid. Bench, (1992) has cited a number of researchers such as Lane and Grosjen (1980), Kyle and Woll (1985), Brenna, Colville and Lawson (1984) who have concluded that the

various sign languages have grammatical structures that are different from that of spoken languages.

Sign language is considered an important component of total communication. The question often asked is whether sign language is universal. Concerning this, Riekehof, (1987) has pointed out "although signs are used in many countries, each has developed its own system, which has been standardized to some extent within that country" (p. 8). Kenya, too, has developed a national sign language for the deaf.

According to Mwangiri (1988), the hearing-impaired in Kenya have also historically been taught using oral method of communication. However, the wave of change that was experienced in the industrialized countries towards manual communication was also experienced in Kenya, although much later. This occurred in the 1970's due to similar reasons as those in the industrialized countries. At this time, the educators and other stakeholders in the education of the hearing impaired realized that the academic performance of the hearing impaired children was not encouraging. For instance, formal education of most hearing impaired children is terminal at standard eight level. Makumi (1987) in an attempt to establish the output of special education programs in Kenya found out that "There is 'nothing tangible' in the area of hearing impaired" p.64. Makumi has observed with a lot of concern that only a few girls had managed to achieve secondary school education and these barely passing in the national examinations at that level.

Yego (1991) notes that in the past the emphasis on the curriculum of the hearing impaired in Kenya has been on the specialist subjects, that is speech and language development, speech training and auditory training. Perhaps the assumption was that the specialist

subjects would assist the hearing impaired to follow the regular curriculum. Unfortunately many people involved in this area such as the curriculum developers, inspectors, teachers of the hearing-impaired children and parents, as earlier indicated, have had great concern over the general low standard of education of the hearing impaired. The following statements made by different people on the same issue express such concern and dissatisfaction.

a) In 1980, the Kenya Society for Deaf children stated that one of the problems that strike one when dealing with deaf school leavers is the poor communication skills that they acquire, not to mention their low level of education. The society indicated further that the type of education provided or rather the method of teaching used, the oral method, was not very effective as the majority of the deaf came out of school not able to lip-read, talk or write.

b) In 1981, Nkinyangi and Mbindyo interviewed a number of headmasters who observed that hearing impaired children went to the schools for the deaf with great enthusiasm, only to leave the schools "more deaf or more mute" than when they had first entered them.

c) In November 1984, the subject panel for the hearing impaired of the Kenya Institute of Education observed that most of the young people who graduated from schools for the deaf were semi-literate. The panel further noted that the fact that the young deaf boys and girls were semi-literate after spending eight or nine years in school was embarrassing and a matter of serious concern.

From the foregoing, it appears that the low standard of education of the hearing impaired was due to two factors: communication skills and the method of teaching.

At around 1985, another controversy on which mode of communication to be used particularly with the deaf children also arose. There are those who believed that contrived systematic sign system such as Signing Exact English (SEE 2) would be the best for use in the schools for the hearing-impaired. On the other hand were those who believed that indigenous sign language, that is Kenya sign language, was the best because it is a true language and it is rooted in the culture of the people (Yego, 1991).

The controversies in the foregoing discussion called for immediate intervention as they were having a negative impact on the education for the hearing-impaired children. Thus, the hearing impaired subject panel at the Kenya Institute of Education (K.I.E) saw the need for flexibility in the method of teaching the hearing-impaired. The panel therefore made a decision to consider alternative methods of teaching the deaf because the oral method had failed to give the desired outcome. Actually, in 1982, the panel had recommended an effective method of teaching the hearing-impaired children using a combination of speech, speech reading and sign language be explored. However, certain factors made it difficult to implement this recommendation. The major one was lack of uniform sign language for the deaf children in Kenya. To solve this problem the K.I.E. Subject panel, in adopting the recommendation of Kamunge Commission, resolved that a uniform sign language be developed by the K.I.E., bearing in mind the varied Kenyan cultures. In this regard, the K.I.E developed a sign language textbook covering various fields of knowledge for example, nature and environment, politics and government, English grammar, health and animals. The K.I.E. Academic Board approved the book in 1983 (Koech, 1999). A sign

language panel of 15 persons who are leaders in the deaf community revised the book in 1998. It was necessary to use a panel in order to ensure that the language reflected signs used by deaf persons in Kenya (Yego, 1991).

The K.I.E. Hearing Impaired Subject panel has done a lot to reduce the communication handicap experienced in the instructions of hearing-impaired children as indicated in the discussion above. The sign language textbook that the panel has developed incorporates a good number of signs that greatly improve communication interchange in most of the subjects taught to the hearing impaired learners. Nevertheless, the panel has not included signs to represent scientific terms. This is a serious omission in my opinion, the reason being that the hearing-impaired children also learn science and sit the same national examinations with their hearing counterparts. Bearing in mind that these examinations determine an individual's future prospects, and that good performance in sciences in particular is a requirement for entering into prestigious careers such as law, medicine and engineering, then there is an urgent need to bridge this gap. Actually, Ndurumo, (1986) decrying the dismal performance of the hearing impaired children pointed out that in academic realm, hearing impaired perform woefully below hearing children. In spite of the specialized strategies and methods of teaching, "something remains amiss". He asserts that head teachers should be held responsible for the performance of the children in national examination. Finally, Ndurumo (1986) suggests that the teachers graduating from teacher training colleges should be proficient in the use of different sign languages systems such as bilingualism, signed English and natural sign languages. He points out that merely awarding graduation certificates without ensuring that teachers are proficient in the method they will use to teach the deaf children only perpetuates academic and learning deficits in the hearing impaired. Although I share these concerns with Ndurumo, I tend to differ with

him in some of the issues. In the first place, the head teachers should not be held fully responsible for the performance of the children. This is because some of the factors that contribute to the poor performance of these children are beyond the control of the head teachers. For instance, their poor achievement in science subjects could be partly blamed on the communication difficulties experienced by the teachers and the deaf learners due to lack of signs for scientific terms. Furthermore, lack of proficiency amongst the teachers in the method they will use to teach the deaf children is not something of their own making. As earlier indicated, there are no signs to represent scientific terms in the Sign Language for Schools. This is the sign language book recommended for instructing the teachers for the hearing-impaired. How then are those teachers expected to be proficient in the said methods? Actually, the original impetus for this research came from a sense of frustration over my inability to pass biological science concepts to the hearing impaired learners in Rev. Muhoro Secondary School for the Deaf as a science teacher from 1993-1997. Due to lack of signs to represent such ideas and concepts, I often had to rely on chalkboard. This practice proved very laborious, often resulting to fatigue and waste of time. Moreover, communication between my learners and I incorporated a lot of fingerspelling. Frequently, the learners experienced a lot of strain in their attempt to read fingerspelled words. The other difficulty arose in instances where I slowed down the rate of fingerspelling considerably. Although this would enable the learners to follow the fingers, it resulted in interruption of the normal flow of speech and intonation.

The other driving force behind this research was the recommendation made by the Koech Commission of inquiry into the education system of Kenya (Koech, 1999). Concerning the method of teaching the hearing impaired the commission made a number of recommendations. One is that research in sign language and how it could be used in

teaching the hearing impaired using the appropriate modes of instructions be encouraged and information be shared with the K.I.E. for possible use in schools. The other recommendation is that local and international organizations interested in developing sign language should aim at enriching the sign language textbook by the K.I.E. in order to maintain uniformity of sign language to be used in schools, colleges and universities (Koech, 1999). These two recommendations indicate a need for further development of Kenyan sign language, and specifically the need to increase sign coverage of the Kenya Sign Language for Schools. Thus, invention of signs for scientific terms will go a long way in enriching it.

1.1 Statement of the problem

From the discussion above, it is clear that the greatest problems faced by the deaf individuals continue to be related to matters of communication. The difficulty in communication, as earlier indicated, is more pronounced in their education. In particular, the communication difficulty experienced in the teaching and learning of sciences is of such a magnitude that it precludes any meaningful interaction between the teachers and the learners. Earlier Ndurumo, (1986) pointed out that something remains amiss in regard to the academic performance of the hearing impaired children. "What is amiss?" in the researcher's opinion, is that the sign language vocabulary provided by the K.I.E. is not yet adequate for instructing the hearing impaired in all fields of knowledge.

Johnson (1995) citing Cadzen (1986) has described classroom communication as a "problematic" medium (Cadzen, 1986); since differences in how things are communicated can not only create slight misunderstandings, but also can seriously impair effective teaching and learning. This is exactly what happens in teaching science to the hearing

impaired. Cadzen (1986) has cited Barnes, (1979), who believes that classroom learning is negotiable between teachers' meanings and students' understandings, a sort of give-and-take between teachers and students as they conduct shared understandings through face-to-face communication. Barnes argues that classroom learning is based primarily on the relationship between what the students know and what teachers offer them in classroom. Ultimately, he recognizes the patterns of communication in classrooms as representing a crucial aspect in that the constraint to a greater degree, affects students' participation in learning and in construction of knowledge. The researcher therefore feels patterns of communication ought to be improved in the case of the hearing impaired. One way through which this could be done is by developing a sign language system that will be understood both by the teachers and the learners. Towards this end, therefore there is a need to develop common signs for use by the teachers and the learners. This is not a new practice amongst the hearing impaired. Actually, when deaf children learning sign language as a native language want to express something for which they do not know the sign they freely invent the sign (Klima, 1979).

Koech seems to echo the sentiments of Riekehof (1987) who observes that:

> The consensus among the deaf adults is that conceptually based new signs have a place particularly for the deaf children who should have as much language stimulation as possible, in as precise a form as possible, and as many modes as possible in order to provide them with tools that they will need for their educational development (p.8).

Signs for scientific terms are, undoubtedly one of such necessary tools.

1. 2 Purpose of the study

The purpose of this study was to develop signs for scientific terms for possible use in teaching of science in schools for the hearing impaired.

1.3 Objectives of the study

This research had two main objectives:

i. To find out the important scientific terms that did not have existing signs.

ii. To develop at least two hundred signs, each representing a given scientific term, idea or concept encountered during the teaching and learning of sciences in the schools for the hearing impaired.

1.4 Research questions

i. Which important scientific terms did not have existing signs?

ii. What signs could be suitable to represent scientific terms, ideas or concepts encountered during the teaching and learning of sciences in the schools for the hearing impaired?

1.5 Significance of the study

The study aimed at developing signs for scientific terms, ideas and concepts commonly encountered in teaching and learning of sciences. Such signs would be useful to the teachers and pupils who are hearing impaired in various ways. First, they will enhance communication, hence classroom interaction between the teachers and the pupils. This will ultimately enhance learning of sciences and therefore improve the performance of the hearing impaired in science subjects. Use of these signs in classroom interaction will save

time and effort that teachers spend in writing or fingerspelling words or inventing new signs on the spot.

This information will also be useful to the K.I.E which has been charged with the responsibility of developing Kenya Sign Language for Schools. The developed signs may be incorporated into the Kenya sign language for use in instructing the hearing impaired children in the science subjects. Thus, the K.I.E. will therefore avoid importing sign language, as has been previously the case. The signs will also be useful to the interpreters who get involved in interpreting scientific information to the hearing impaired individuals. To the parents, relatives and friends of the hearing impaired the signs will enable them to give the hearing impaired children the assistance that they may need in learning sciences.

Lastly, the study will stimulate further research and address the inadequacy of sign language in the teaching and learning of other subjects.

1.6 Scope of the study

The researcher drew the population and sample of study from Nyeri District. All the schools for the deaf in the district were included in the study.

1.7 Limitations of the study

Financial constraints and insufficient time compelled the researcher to draw the population and sample of the study from Nyeri District only because of its easier access. Because the respondents were drawn from the schools in Nyeri District, the signs developed mainly reflect the opinions of the learners and their teachers in the district. The findings may therefore not be representative of all the deaf learners in Kenyan schools for the hearing

impaired. For the same reasons the study has developed signs to represent a limited number of scientific ideas and concepts.

1.8 Assumptions of the study

The basic assumption in this study was that sign language is universally accepted as a natural language for the deaf. Thus, there is a case for using it in the education of the hearing impaired. The researcher therefore, assumed that fluency in sign language is advantageous in learning of science. This is an assumption that has held an important place in the argument for total communication for schools (Conrad, 1981). The other assumption was that the participants would be able to communicate in sign language. The third assumption was that the participants would have a basic knowledge in science

1.9 Definition of terms

The following terms were used in the study and should be understood as defined below:

Deafness- refers to the condition of individuals whose hearing is disabled and is expressed in terms of speech or other sounds calibrated for frequency and intensity.

Deaf-refers to an individual whose hearing disability precludes successful processing of linguistic information through auditory channel, with or without hearing aid.

Finger spelling-use of manual alphabet to form words and sentences.

Hard-of-hearing-person- a person who has partial hearing.

Hearing impairment- an incapacity due to a defect of hearing.

Hearing impaired- is a general term that is preferred when one has a hearing loss that may be mild, moderate, severe or profound. It is a term that is especially used in educational setting.

Kenyan Sign Language-A visual-gestural language used by the deaf persons in Kenya.

Lipreading, speechreading-The ability to understand the oral language or speech of a person through observation of his lip movement and facial expression.

Manual Alphabet- The twenty-six different single-hand positions representing the twenty-six letters of the English alphabet.

Method of communication- method of communication is one of the modes used exclusively or in combination with others to communicate with, or instruct, the hearing impaired. Examples of these methods are: oralism, manualism and total communication.

Manual method/manual communication-communication by use of signs and finger spelling.

Oral method-teaching and training of deaf children without the use of sign language or fingerspelling. Apart from reading and writing, oral communication alone is used.

Oral-aural method- refers to the use of speech and speech reading. It stresses auditory training (learning to listen), oral training, (learning to speak) and speech reading (learning to read the lips and facial expression). In this method, emphasis is also placed in the use of hearing aid for amplification.

Post-lingual deafness- refers to the condition of persons whose deafness occurred at an age following the spontaneous acquisition of speech and language.

Pre-lingual deafness- refers to the condition of persons whose deafness was present at birth or occurred at an age prior to the development of speech and language.

Profoundly deaf- hearing loss greater than 90dB HL

Signs-these are manual symbols. They are the primary units of a sign language. Signs usually represent ideas and not words.

Sign language-It is a non-oral method of communication. It is a language that uses manual symbols to represent ideas and concepts. The term is generally used to describe the language used by the deaf people in which both manual signs and finger spelling are employed.

Signing Exact English (SEE 2) – modification of American Sign Language to resemble English words, with sign markers to denote English grammar.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

This chapter is divided into two sections. The first is comprised of the theoretical framework upon which this study was based. The second section is a review of related literature on sign language.

2.1 Theoretical Framework

The sign

Earlier, the term "sign" was defined as a unit of sign language, which represents a concept. Signs perform a function in sign language similar to the function of words in a spoken language. Just as words are comprised of units, which work together in various ways to make each word unique from other words, so are the four units, which comprise each sign to make each one unique. Wilbur (1979) has cited the work of Stokoe (1960), who investigated sign formation "Cherology" treating it as analogous to phonological system of oral languages. Stokoe defined three parameters that were realized simultaneously in the formation of a particular sign. These are: DEZ (Designator, handshape); TAB (tabulation, location); and SIG (signation, motion). Wilbur also has pointed out that a fourth parameter, orientation, which refers to the orientation of the palm, was added later by Battison. Constraints on the structure of signs are an important aspect in sign formation. These constraints separate signs from mime. They include visual constraints and linguistic constraints, which will be discussed later in the section.

Handshape

Wilbur (1979) has cited the works of Stokoe, Casterline and Cronberg (1965) who have defined handshape symbols (see Appendix C). According to them, the DEZ parameter has 19 values, that is,A,B,5,C,E,F,G,H,I,K,L,3,O,R,V,W,X,Y,and 8. It is important to note at this juncture that, although some of the hand shapes are named with letter names like A, B, G, these hand shapes are not necessarily identical in formation of the letters of the alphabet of the same name, for instance G in the hand shape and G in the manual alphabet (see Appendix B). Wilbur (1979) also emphasizes that the use of letter names for handshape configurations does not imply a connection between the formation of the sign and the letters of the English word that is used to translate that sign. There are some signs whose formation has been modified so that the handshape does correspond to the first letter of the English word (initialized signs).

Location

Wilbur, (1979) has also cited the works of Stokoe (1965) in which Stokoe has also developed symbols for the location of a sign. Wilbur has pointed out that:

> A basic distinction is made between those signs made on the body (including so-called "body anchor verbs") and those made in neutral space. All signs must be made within the "signing space" (Battison, 1973; Bellugi and Fischer (1972); Frieshberg, 1975), described by Lacy (1974) as extending from the top of the head to just below the waist (or hip area) on the vertical axis while horizontally and laterally forming a "bubble" in front of the speaker, extending from the signer extreme right to the signers extreme left (an arc of 180^0). The signing space may be proportionately

> enlarged for signing to larger audiences ("louder") or confined for purpose of more rapid signing or to be secretive ("quieter") so as not to be "overseen". Few signs are made over the head, behind the ear, or below the waist (p.19).

Akatch, (1991) has noted that hand configuration; positions and movements can be used when new word-sign is to be developed. Hence these parameters as well as the orientation, were given due consideration in developing new signs for scientific terms.

Constraints of sign formation

In oral languages, distinctive features are simultaneously combined to produce consonantal and vocalic segments. Analogously, Stokoe parameters are produced simultaneously to form a signs. In oral languages, physical constraints make certain combinations of divisions impossible. For example, a vowel cannot at the same time be both high and low. Other combinations are possible on purely linguistic grounds. Many similar redundancy conditions have been described for combination of sign parameters. Adherence to these conditions defines a possible sign, whereas violations are considered impossible or improper signs. Just as English has actual words like "brick", possible but non-occurring words like "bnick", American Sign language also has "blick-type" signs, which are used creatively, as well as "bnick"-type signs which are not used at all. Some of the conditions on allowable signs may be attributable to constraints placed on the visual mode by perpetual mechanisms whereas others may be linguistically arbitrary.

Visual constraints

There is an optimal visual acuity for sign reception. This occurs in an area that encompasses two fixation points, one between the eyes and the other slightly lower, assuming a downward cast of the eyes, at about neck or chain (Siple, 1978). Within this high acuity area, it is easier to detect small differences in hand shape, in location and in motion .In the areas of lesser acuity, discrimination becomes more difficult, and it is not surprising to find that signs made in this area do not utilize finer details of handshape or small distinctions of location or motion. Instead, they maximize discriminability in a number of ways. This includes grosser distinctions in hand shapes or small distinctions of location or motion (for example, open B or 5 and closed S, but not G and H, which differ only in the number of fingers extended,), larger motions, and increased redundancy of sign formation (tendency to be two-handed symmetrical sign; utilization of reduplication.)

Linguistic constraints

In his view of the works of Battison, Markowicz and Woodward (1975), Wilbur gives several examples of linguistic constraints on sign formation. Some signs involve two sequential contacts with the body. If the body is divided into four major parts that is head and neck, trunk, arm and hand, then only the combinations summarized in table 1 are permissible for the first and second contacts. In addition, the second contact is constrained to a centralized position in the major contact area, so that a sign may go from head to center of chest, but not from head to either shoulder or to a corner or side of the trunk. A constraint such as this, which is not required by physical limitations although it is possibly an aid to perception, distinguishes signs from pantomimes (Wilbur 1979). Table. 1 below shows the permissible contacts with the body for double-contact signs.

Table. 1. Permissible contacts with the body for double-contact signs

	Second contact			
First contact	Head	Trunk	Arm	Hand
Head	+[a]	+	+	+
Trunk	-	+	-	+
Arm	-	-	+	-
Hand	+	-	-	+

Source: Wilbur, R. (1979)

Key:

+[a] indicates an acceptable sequence

_: indicates an unacceptable sequence.

Wilbur has also cited the works of Battison (1974) that give two further constraints related specifically to signs formed with both hands. Basically, there are three types of two-handed signs: 1) both hands move independently; 2) only one hand moves but both hand shapes are identical; and 3) only one hand moves (the dominant one) and the handshape of the non-dominant, non-moving hand is restricted to one of a limited set of possible

handshapes. For the signs in which both hands move, a symmetry condition exists, specifying that the handshapes and movement for both hands must be identical and that the orientation and movements of both hands must be opposites, that is, mirror images. For two-handed signs in which the hand shapes are not identical (3 above), a dominance condition exists, specifying that the nondominant hand must remain static while the moving dominant hand produces the sign. (The dominant hand is most often considered to be the hand that is used by the signer to make one-handed signs and the moving hand in two-handed signs where only one moves. Wilbur (1979) cites the divergence from this practice by Kegl and Wilbur (1976). They consider the moving hand to be the dominant; thus if both hands are moving, they are both dominant. If a signer first makes a one-handed sign with his right hand and then a different one–handed sign with his left hand, he has switched dominance. They also assert that the non-dominant hand can assume only one of the six most unmarked handshapes, which include:

S hand: a closed fist

B hand: the flat palm

5 hand: the B hand with fingers spread out

G hand: fist with index finger extended

C hand: hand formed in a semi-circle

O hand: fingertips meet with thumb, forming a circle

(See Appendix C; Handshapes).

It is important to emphasize what Wilbur (1979) says, that these conditions hold for the citation forms of signs. The citation form is the isolated answer to the question, "what is the sign for X?" In actual signing, grammatical modifications or creative use of signs may result in forms that appear to violate the conditions.

2.2 Historical perspective of the education of the deaf

Introduction

The following is a brief review of various communication systems used with the deaf in their education. Its purpose is to provide perspective to approaches in vogue today by relating them to their historical predecessors. As Quigley (1982) puts it: "What's past is prologue. A better sense of what is being done today, and what perhaps needs to be done in the future, can be gained by knowledge of what has gone before" (p.13).

Europe -Up to 1700

Up to the mid-1700 schools did not generally exist for the education of deaf children, but many deaf children were taught individually or in very small groups by private tutors. Usually, these were children of wealthy and noble families. The first formal instruction seems to have taken place in Spain as earlier mentioned in chapter one. This was under the tutelage of Ponce de Leone. Ponce de Leon apparently used oral communication to instruct the deaf children. He taught speech through articulation of written words and the curriculum proceeded from language and communication to academic subjects.

Pablo Bonet followed Ponce de Leon in Spain. The communication approach that Ponce used was fingerspelling and speech (manual and oral). According to Quigley (1982) the combination of fingerspelling and speech that Bonet used is a direct precursor of the Rochester method in the United States in the late 1800s and what was called neo-oralism in Soviet Union in the 1950's. The one-handed manual alphabet that was used by Bonet and described in his book, The Simplification of Sounds and the Art of Teaching the dumb to Speak, is directly related to one-handed manual alphabet used in the United States today. In contrast, a two-handed alphabet was developed in England and is still used there and in

many England's former colonies (Quigley, 1984). John Wallis and George Dalgarno were major seventeenth century figures in England in the education of the deaf. Both used writing and manual approach to communicate.

Europe-1700 and 1800

General widespread deaf education of deaf children began in the eighteenth century with the establishment of the first public schools in Paris in 1775 by the Abbe' Charles de l'Epee. This century also saw the beginning of the controversy between "French method" manualism as exemplified by de l 'Epee in France and the German Method oralists as exemplified by Samuel Heinicke in Germany.

The dominant figure of the nineteenth century was Abbe de l 'Epee in France. The Abbe used signs of deaf people as a language of instruction. He later developed this language into a sign system to approximate the vocabulary and syntax of the French language. This involved creating signs for the words and signs and other devices to function for inflections, articles and other grammatical parts of French. Thus, creation of new signs is not a recent practice, but was initiated early in the education of the deaf with main purpose of improving communication for and with the deaf. The system initiated by Abbe was continued and elaborated by the Abbe Sicard, de l 'Epee's successor, who also compiled an elaborate dictionary of signs. The greater similarities between this approach and the modern day approaches in the United States of conforming sign language to the structure of English (LOVE, SEE I, SEE II) are obvious (Quigley, 1984). De l 'Epee's language of instruction used very little emphasis on original composition and conversation. Sicard followed de l' Epee's methods but put more emphasis on original language. A climatic change in the nineteenth century in the communication approaches used with the deaf

children was the historical International Congress at Milan in 1880, presided over by Guilio Tarra. The members of the congress strongly endorsed the use of the oral approaches in communication with the deaf students. Concerning this, Quigley and Paul (1984) have cited Schmitt (1966) who concluded that, "most countries were swift to adopt oral method".

The United States: The 1900s

The formal education of deaf children in United States of America is considered to have begun with the establishment of a residential school in Hartford, Connecticut in 1817 by Thomas Hopkins Gallaudet. Gallaudet had visited the Braidwoods in England to acquire knowledge of their methods. He did not succeed in this due to the secrecy maintained by the Braidwood and their opposition to Gallaudet's intent to learn manual as well as oral methods of educating deaf children. Gallaudet then met with Sicard, who was traveling in England with one of his star pupils, Jean Massieu, and accepted an invitation to study at the school in Paris. Having learned the methods constituted there by de l' Epee and Sicard, Gallaudet returned to the United States bringing with him a deaf teacher and former student at Paris school, Laurent Clerc. Thus began two traditions that have distinguished American education of the deaf children from European systems, that is, manual communication and deaf teachers (Quigley, 1984). Manual communication approach reigned supreme in United States until the establishment of the Clarke School for the Deaf in Northampton in 1867 and the establishment of what is known as Lexington School for the deaf in New York City.

Although this brief history of the 1880s indicates that considerable interest and activity in language development and teaching approaches took place in that century, American

educators were also preoccupied with debates on communication methods. Not all educators in the early part of the century agreed with Thomas Hopkins Gallaudet and Laurent Clerc on the merits of signs to be used. But the sign-based methods of the school at Hartford, dominated public and private residential schools throughout most of the century. The oral methods introduced at the Clarke School for the Deaf in 1867 and shortly thereafter at what is now called Lexington School for the Deaf exerted their major influence on the deaf children.

During the 1960s and 1970s, there occurred new developments in the communication methods in the education of the deaf children. These and other developments of recent times are presented here. Until the 1960s and early 1970s, day schools and day classes were almost exclusively oral as were a number of private residential schools. The oral approach of the nineteenth century became the oral/aural approach of twentieth century with the advent of, and rapid improvements in electronic amplification. In addition to using speech and speechreading of the oral method and developing devices for amplification, the oral/aural method used the auditory training method. The great increase in financial support and public and governmental interest in general education during the 1960s spilled over into special education, including the education of the deaf. Dissatisfaction was expressed with the low literacy levels that prevailed among deaf children and, in the spirit of the times; there was a renewed interest in research in trying new methods (Quigley, 1984).

Quigley (1984) has pointed out that, "In spite of 200 years of effort in the United States and more than 300 years in Europe, only limited success has been achieved in developing language in deaf to the extent where it serves as an adequate vehicle for educational

development" (p.21). This is typified by performance in reading achievement measures and written language samples. These two variables are identified as criteria against which the success of educational programs for the deaf children could be measured. The impact of deafness on literacy development has been documented. Studies have consistently indicated that the adult deaf reader enters adulthood with a third-to-fourth grade reading level. There are however many deaf individuals who are competent readers (Weaver-trumble-Babara.1996).

2.2.1. History of education of the deaf in Kenya

The development of the education of the hearing-impaired in Kenya has followed a similar trend as in the industrialized countries. The NGO, s and missionaries started the education of the hearing-impaired, just like the regular education. Education of the hearing-impaired started when the Kenya Society for the deaf children was formed in 1958. The initial purpose of forming the society was to assist hospitals in starting ear, nose and throat (ENT) clinics. In these clinics assessment of degree of hearing loss could be done. In addition, other problems could be diagnosed here and treated medically. For some of these problems, remedial education would be provided. Soon church organizations and other services clubs such as Round Tables, Rotary, Lions, and Agha Khan Education Board developed an interest in the education of the hearing-impaired. In 1958, two units were started in the Agha Khan schools in Nairobi and Mombassa (Mwangiri, 1988). In 1961, catholic missionaries established fully pledged schools in Nyang'oma and Mumias. Since this was early 1960's the oralists were on the scene to steal the limelight. The development has been rapid and to-date there are about thirty-seven schools and thirty-two units for the hearing-impaired in the country. A notable development is the establishment of the first secondary school for the hearing-impaired in 1987, the Rev. Muhoro Secondary School for

the Deaf, in Nyeri District. Later a secondary unit for the deaf was started in Mumias School for the deaf. The 8-4-4 curriculum of education is followed in educating the hearing-impaired in these schools as well as in the primary level of education. Hence, just as is the case in regular education the hearing-impaired learners are expected to learn and perform well in science subjects.

At the same time, a special education training program was started in order to meet the manpower needs for the established schools for special needs. The first local course for teachers of the hearing-impaired was started in 1964 at Central Teachers' College (the present K.I.E) as a unit attached to the regular teachers' college. The unit was later moved to different colleges between 1972 and 1985 that is, Siriba, Maseno and Highridge Teachers' training colleges. In 1986, Kenya Institute of Special Education was established to cater for teachers' training programs in all areas of special education (Mwangiri, 1988).Later, in 1996, Kenyatta University started a special education unit under the department of educational psychology. The aim was to train teachers in various areas of special education who could teach the handicapped children at the secondary school level. This has now grown to a fully pledged department. Soon after, Maseno University also started a department of special education to prepare secondary school teachers for the handicapped children.

Kenya has also undergone similar developments and changes as those of industrialized countries in matters relating to the education of the deaf. As earlier indicated, some of the factors that may have influenced the education of the hearing-impaired in Kenya are as a result of what was inherited from some developed countries. For instance, the oral method of teaching, which has been in use since the initiation of education of the deaf in Kenya up

to around 1988, was predominant in Britain for many years and it may have found its way in Kenya through past historical events. As mentioned earlier in chapter one, many people involved in the education of the deaf became dissatisfied with the oral method. In Kenya, such dissatisfaction occurred in the 1970s. This was precipitated by the observation by the educators of the deaf that deaf individuals, even after completing the years of literacy in school, they came out completely illiterate. Consequently, in 1978 the hearing-impaired subject panel of the K.I.E. found flexibility in the method of teaching the deaf necessary. Therefore there was need to consider other methods. For instance, in 1982, the same panel agreed that sign language should be developed to be used to facilitate teaching of the hearing-impaired children, especially the profoundly deaf children. Consequently, a few signs used by the deaf people in Kenya and those that are used in U.S.A. were collected and compiled in 1984 (Yego, 1991).

In 1985, the Ministry of Education decided that there was a need to start alternative method of teaching the hearing-impaired children. In an effort to implement this decision, the Ministry of Education considered it more logical to establish a pilot scheme in Machakos to experiment with total communication approach, with special emphasis on simultaneous method. The signs to be used were those collected in 1984. The hearing-impaired pupils who joined the pilot scheme (Machakos School for the Deaf) were selected from five residential schools for the hearing-impaired and three units in the country. Six teachers for the hearing-impaired were selected and in-serviced for three months in the new materials. The subsequent in- servicing followed after they had taught for seven months (Yego, 1991).

In June 1987, the Director of Education appointed a committee to evaluate the new approach of teaching the hearing-impaired children in the pilot school and compare it with the oral/aural method. The results of the evaluation would determine the National policy on the method and mode of communication and language to be used in teaching the hearing-impaired children. In short, the findings revealed simultaneous communication method was superior to the oral/aural method when used alone. The evaluation report was submitted to the Ministry of Education in May 1988. Akatch (1988) however pointed out that the only drawback that could be seen in the "wind of change" in Kenya was that the Ndurumo report (1983) suggested introduction of sign language in the schools for the hearing-impaired in Kenya, came with the introduction of American Sign Exact English which includes signs that are not Kenyan culture based. Akatch has observed that some of the borrowed signs are repugnant in Kenyan culture. According to Akatch (1988), if the trial at Machakos School for the Deaf succeeded, the younger generation of the deaf community would be alienated from older generation who are very strongly culture based. These remarks by Akatch are very important as they caution the educators against borrowing very many signs even when it is possible to develop or invent new signs that are based on Kenyan culture. As Akatch (1991) puts it, signs are "culturally based".

Meanwhile other developments have been taking place. As earlier mentioned K.I.S.E., which was established in 1986, trains teachers for most areas of handicap. One of the many obligations of K.I.S.E. besides training teachers for the handicapped children is to conduct research in special education as stated in the Legal Notice No. 17 of 1986. In 1988, two lecturers in the hearing–impaired department at K.I.S.E. documented a basic Kenya sign language dictionary. The main purpose of writing the dictionary was the need for basic material for teaching Kenya sign language. There was the desire to demonstrate the fact

that a national sign language is a living language that is rooted in the culture of the users. While these developments have been taking place, there has also been a heated controversy on different issues, among those involved in the education of the hearing-impaired. The first controversy that emerged in 1970's was on the method of teaching, that is, oral versus manual method. The latest controversy is on which sign language to be used especially with deaf children. There are those who believe that contrived systematic sign system such as Sign Exact English would be the best for use in schools for the hearing-impaired. Others believe that indigenous sign language, that is, Kenya sign language is the best because it is a true language and is rooted in the culture of the people. Concerning this Yego (1991) asserts that unless this issue is resolved, the education of the hearing-impaired may have negative results. Similar sentiments to those of Yego were echoed in the Koech Commission, (Koech, 1999). The commission was informed that some local and international organizations interfere with the development of sign language under the pretext that the sign language developed at the K.I.E. and used in schools for the deaf is not Kenyan sign language. It was pointed out that the controversy, lead to retardation of the deaf education in Kenya.

In regard to the foregoing, Koech (1999) observed that sign language was officially introduced in 1982 in the schools for the deaf barely two decades ago. Thus, being a mixture of Kenyan and borrowed signs, it has evolved in a similar pattern, as Kiswahili. It is therefore impossible at this juncture to have a pure Kenyan sign language. Koech further observed that some countries that have evolved a comprehensive sign language followed this pattern. Koech quips, "Avoidance of borrowing is next to impossible as we live in a global village." In view of this, the commission recommended that:

i. The sign language used by the deaf persons in Kenya and compiled by K.I.E. in consultations with deaf persons and stakeholders be adopted as the Kenya sign language; and that sign language continue to be used in schools for the deaf.

ii. Local and international organizations interested in developing sign language aim at enriching the book by the K.I.E. in order to maintain the uniformity of sign language to be used in schools, colleges and universities.

iii. Research in sign language and how it could be used to teach hearing-impaired children using appropriate modes of instruction is encouraged and information be shared with K.I.E for possible use in schools for the deaf.

From the foregoing, it is clear that the government of Kenya is aware of the need to have a national sign language which will enhance communicative interchange in the education of the hearing-impaired children.

2.3 Communication of the hearing-impaired

Communication involves the transmission and exchange of information related to thoughts, feelings and experiences. It is accomplished through an astounding variety of media, which pervade all aspects of life. Communication is the cohesive, compelling force in biological survival of all human species as well as in our social, cultural and personal lives. The ultimate purpose of communication in human beings is pursuit of knowledge (Skinner, 1985).

From this definition, it is clear that knowledge is a requirement for our survival, and that the only way to acquire it is through communication. For communication to occur, language is necessary. Bloom and Lahey (1974) have defined language as a "code whereby ideas about the world are presented through a conventional system of signals for communication."

The importance of communication in human species cannot be over-emphasized. In agreement with the definition of Skinner above, Bloom and Lahey have also pointed out that universally, it is agreed that communication is a fundamental aspect of all human interaction. They have indicated that it is through language that humanity has been able to record its history and transmit its cultures from one generation to the next. Furthermore, the ability to communicate has enabled humans to build societies, organizations and social groups that make for survival and better living (Bloom and Lahey, 1974).

The need to communicate is clearly indicated by the fact that all human societies have developed signal system for communication based on the spoken word, using the aural oral channel for reception and expression. According to Quigley and Kretschmer (1982), "most members of societies acquire language of their group in an apparently effortless fashion during the first few years of life" (p.9). They have pointed out that a child will effortlessly internalize an auditory-based language system if the infant has a reasonably intact sensory system. The infant must also not have severe intellectual or cognitive deficit, and should be exposed to a reasonably stimulating environment. The parents or parent surrogates of the infant also aught to be reasonably verbal, providing a reasonably warm and loving atmosphere and communicate reasonably fluently with the infant. This

internalized effortless language system will serve as a foundation of the child's receptive and expressive language in early childhood and as a base on which reading and writing and all education factors related to them will later be developed.

In view of the foregoing, Quigley (1982) asserted that:

> Severe and prolonged deprivation in any of these areas will eventually produce communication and language problems, with severity of disorder being at least roughly related to severity of deprivation. The primary problem seems to be interference with the establishment of easy and fluent communication between the child and the immediate figures in his environment. (p. 10)

In the case where an individual has suffered auditory deprivation, the result is deafness. Consequently, deafness (Quigley, 1982) "will certainly produce a massive disruption of the normal development of language and communication". (P.9) Indeed, individuals who are deaf experience a serious communication handicap whose effects impact negatively in all areas of the individual's life.

Ballantyne (1977), quoting the words of Stevenson, puts it succinctly:

> Deafness is worse than blindness…it is the loneliness, the sense of isolation, that makes it so, and the lack of understanding in the minds of ordinary hearing people. The problem of the child born deaf from birth …is quite different from that of the man or woman who has become completely deafened after school age or in adult life. The hard-of-hearing person whose deafness has developed slowly over the years…is different again. But for all of them the handicap is the same, the handicap

of the silent world. The difficulty of communication with the hearing and speaking world. (P.208.)

This is deafness in a nutshell. Whatever its cause, whenever its onset, whatever its degree, the most conspicuous handicap of deafness, at whatever age, is the difficulty experienced by the deaf in communicating with hearing and the hearing with the deaf. The communication handicap of deafness impacts very heavily on all areas of development of the affected individual. In particular, it impacts negatively on their academic achievement. The concern of this proposed research is, actually, the negative impact of the communicative handicap of the hearing-impaired learners particularly, in their dismal performance in science subjects.

Due to their need to communicate, hearing-impaired people have developed a gestural system of communication. This is referred to as sign language. In addition to this language, some systems of manual communication have been developed. These are discussed below.

Sign language

Riekehof (1987) has defined sign language as "a language that uses manual symbols to represent ideas and concepts" (p.9). The term is generally used to describe the language used by the hearing-impaired people in which manual signs and finger-spelling are employed. Since most profoundly deaf people universally communicate with one another by some manual form, the suggestion has been made that "manual communication is the natural language of the deaf" (P.97). According to Bench (1992), Standard English is not the native language of deaf people who acquire a manual form of communication. He

further observes that spoken language is not perceived and acquired naturally by prelingually profoundly deaf children. If they are to learn it, they have to learn it over a long period of instruction. Further, he points out that insistence on oral communication in educating the deaf, as earlier noted, led to 'oral failures', which consequently resulted to its rejection as the only mode of communication in the instruction of the hearing-impaired. The manual form of communication used by the profoundly deaf people amongst themselves is deaf sign language. Until quite recently, this gestural form of communication was not seen as a language in its own right. Thus, Furth (1966a) tended to argue that prelingually profoundly deaf children functioned as a group without language. He thought that since the children had no language, their performance would be weak in cognitive tasks, such as thinking and problem solving. However, it became clear that, provided the tasks are not verbal, profoundly deaf children perform at about the same level as hearing children (Furth, 1971, Furth & Youniss, 1975). It also came to be recognized that verbal language is not essential for the performance of non-verbal cognitive tasks. This realization left the way open for the exploration of deaf sign language as a language in its own right, as a code through which ideas could be communicated, with a vocabulary and semantics of its own, with a generative capacity in the sense developed by Chomsky (1971). Bench (1992) poses the question, "How effective is sign language as a means of communication?"(P.108). In response to his own question, he asserts, "...for the profoundly deaf individuals with no other form of communication, it is 100% effective. Deaf children born to signing deaf parents know no other way of communicating" (P.108). These remarks by Bench imply that sign language is indispensable as far as communication for the deaf children especially the prelingually profoundly deaf individuals are concerned. Consequently, it is important that the individuals be exposed to sign language as much as possible. For instructional purpose,

the lexicon ought to be adequate to ensure easy, efficient and accurate communication with this group of individuals (Kannapel, 1969). Actually, sign language can provide deaf children access to the information flow of the people around them, provided their parents and teachers are competent and consistent signers. Emphasizing the importance of sign language in instruction of the hearing-impaired, Olukesusi, (1991) says thus, "Signing makes communication among teachers and learners fluent without distortions or reverberations. Deaf learners need to be taught sign language and taught in it. It is the most vital of all the components of total communication" (p.134).

Fingerspelling

Bench (1992) indicates that communication by fingerspelling for the hearing-impaired people is one of the oldest known forms. He observes that fingerspelling is sometimes used to connect signs into sentences, or to add stress in sign languages. Fingerspelling is particularly useful for introducing names, neologisms and technical terms. The manual alphabet is a one-to-one cipher for letters of an alphabet on the fingers of the hand. In the United Kingdom, the manual alphabet is two-handed, but elsewhere it is usually displayed on one hand. In Kenya, the one-handed American manual alphabet has been adopted (see Appendix B). For English, there are twenty-six positions, or combination of finger placement and handshapes, corresponding to the twenty-six letters of the English alphabet. These, therefore, are shown without ambiguity and can be used to spell out a word with the fingers, as with the conventional spelling of English letters (Bench, 1993).

Clearly, as earlier noted in chapter one, fingerspelling is a slow form of communication. Bench, (1999) reviewing the works of Bornstein (1979), has reported a maximum transmission rate of about "sixty words per minute, roughly three times slower than

rather fast speech or signed communication". It is for this reason that signs for communicating scientific concepts and ideas in schools for the hearing-impaired ought to be developed. Such signs will enable clear quick and precise communication with the hearing-impaired.

Fingerspelling can be used in other ways. Besides its direct use for names and technical terms, fingerspelling has a role as a lexical tool for learning of such items, and can reinforce the written form of new words (Evans 1981). Evans also observed that signs tend to communicate content words, whereas fingerspelling is useful for function words, such as articles and prepositions. The fingerspelling plays a complementary role to signs, when it may significantly increase understanding of the signed message.

The Rochester Method

This is a combination of oral method plus fingerspelling. Children receive information through speechreading, amplification and fingerspelling (Moores, 1982). According to Bench (1992), "this method allowed the talker to write in the air, as it were, while speaking" (p.100). Bench indicates that fingerspelling is slower than speech; hence, the use of simultaneous fingerspelling can only be used to indicate salient words or emphases, unless the speech is unnaturally slowed. Bench (1992) cited the studies of Moores (1987), who considered a number of programs to find the preferred educational approach for a given child at a given developmental stage. Moores found marked differences amongst the programs, particularly for receptive communication. The results revealed that the programs using Rochester method, as a combination of sounds, speechreading and fingerspelling obtained results superior to those using printed words,

sounds alone and sounds and speechreading, but not sounds, speechreading and signs. The results are a clear indication of the important role that signs play in deaf communication.

Simultaneous method

This is a combination of the oral method plus signs and fingerspelling. The children receive input through speechreading, amplification, signs and fingerspelling. Signs are differentiated from fingerspelling in that they may represent complete ideas or words rather than standing for individual letters of English alphabet (Bench, 1992).

Total communication

Despite the emphasis on oralism following the Milan Congress in 1880, a proportion of the hearing-impaired children, especially those born to deaf parents, continued to acquire sign language as their first language, and used signs in communicating with other deaf individuals. To this day, both deaf children and adults who are competent in sign tend to seek out the deaf individuals in mixed groups of hearing and deaf people, and carry on communication in sign. Sign language began to acquire official and linguistic respectability in the 1960's, notably boosted by the work of Stokoe, which initiated a status for sign language as a language on its own right. According to Bench (1992) this seminal work was followed by a burst of research into sign language, continuing, from which it seems that the more that is known of sign language, the more accepted is its status as a language. Further recognition of the potential of sign language came from the 'oral failures', an unfortunately large proportion of deaf children who had been educated orally but who did not perform well in academic achievement tests and whose speech was intelligible. Those mentors who based academic attainment on the development of

good communication skills argued that deaf child signers, who were expert in their native sign language, could benefit educationally from good-signed communication with their teachers. However, this attitude quickly ran into problems, because few of the teachers, who were mainly hearing, were fluent in sign language. Rather they used some form of signed English. The educational attainment of deaf children as a whole continued to be unacceptably low, whether the children were educated orally or manually. Bench (1992), citing works of various authors has pointed out that in the mid to late 1960's in the United States of America, soon followed in the United Kingdom (Montgomery, 1966), and Australia (Burch Hyde, 1984) proposals were made to combine oral and signing approaches (Schlesinger, 1986) in what came to be known as Total Communication (Newell et al, 1990). In theory, total communication goes beyond oral plus manual approaches to permit other forms of communication. Total communication thus allows aural, manual and oral modes of communication. In practice it may amount to not much more than manual approach, occasionally augmented by other methods, such is the attraction of manual communication to the profoundly deaf (Bench, 1992).

In retrospect, (Bench, 1992,) notes "it is odd that it took so long to consider what seems to be an obvious alternative to oral-only or manual-only forms of communication" (p.124). One reason, observes Bench, was a fear that successful use of one alternative could be hindered by introduction of another. The main reason, however, was probably that the position of oralists on the one hand, and manualists on the other, were so entrenched, and defended with so much vigor and emotions ,that for a long time consideration of compromise was out of the question.

Total communication should help to reduce the dominant position taken in class by the teachers of the deaf, because total communication would help to induce rapport between teachers and children, besides assisting a deaf child to communicate with hearing children and adults. Total communication also offers a prospect of the deaf child participating in an educational curriculum more like that of the hearing children. It also promises insights into spoken language learning by providing continuing opportunities for the deaf child to analyze and compare spoken and manual languages. A large number of studies, which investigated the use of total communication in educational programs, have been summarized by Schlesinger (1986). Her review concluded that, apart perhaps from deaf children whose background suggests that they would have successful oral methods and who could meet the demands a successful oral approach implied, such as well-educated and motivated parents of above average intelligence, total communication could produce quite positive results. Total communication is also valued because it can provide both a means of communicating and a way of assisting oral communication. Total communication could also help by stimulating the child's attention span, motivation and social interaction. Total communication could also decrease behavior problems. Schlesinger concluded her overview with a plea urging a truly bilingual approach, since for a greater majority of deaf children, the situations with which they are faced require bilingual solutions involving both signs and speech. What the foregoing discussion reveals is that no single method of communication is suitable for all hearing-impaired children. Therefore, all the available methods should be used together with the sole aim of communicating effectively with the deaf. Actually, the adherents of total communication argue that total communication promotes communication, and a resulting increase in facility with language will assist academic learning and improve the

production of speech. However, it should be noted that signs are fundamental in communicating with the hearing-impaired.

2.4 Importance of science to the hearing-impaired

The hearing-impaired individuals have a need for science knowledge and skills because they live and interact with the society and the society is ripe with science and technology. They need skills to fit into everyday existence. Although they are handicapped, they need not be alienated from the society of which they form a part. They need science and technology to enhance the efficiency of what they do to improve the quality of their life and in extreme cases of handicap to merely survive. Actually, the importance of science knowledge for any individual is universally acknowledged. Muriithi (1996), citing works of Baez (1986) has enumerated the universally accepted goals of teaching sciences. Among these are:

- To enlarge the learner's interest in order to choose a useful and meaningful career in science, technology and related fields.

- To apply scientific knowledge and methods in daily life and tackle practical problems at individual, local and national levels.

These goals apply to all learners and in order to achieve them, it is important to realize that one of the indispensable tools for the learners, whether impaired or non-impaired, is efficient communication. Consequently, an effective language will be mandatory. Indeed, language is the medium through which teachers teach and students demonstrate what they have learnt (Johnson, 1995).

According to Ndurumo (1986), academic education is important in the education of the hearing-impaired. This is because it assists in preparing these children to compete with hearing children. He asserts that special education cannot be divorced from regular education, and its importance in preparing hearing-impaired children for the competitive world of work and survival. Science subjects are a part of the regular curriculum in Kenya and, in fact, science is compulsory and examinable at primary level of education as well as secondary level. Thus, what Ndurumo (1986) advocates is that the hearing-impaired learners should also learn science, just as their hearing counterparts. The Ministry of education seems to have listened to Ndurumo's sentiments because the hearing-impaired children at the primary and secondary levels now follow the regular curriculum. They therefore sit for the same national examinations with their non-handicapped contemporaries, and thus compete with them for places in the institutions of higher learning for example, Universities. This therefore being the case, the question that comes to mind is, "is the playing ground level for all these competitors?" Considering the communication handicap of deafness, it is obvious that the deaf individuals are less advantaged because communication during science lessons is very difficult. The educators in charge of developing signs for instructional purposes have not developed any such signs to represent scientific terms. Consequently, the hearing-impaired children have been performing poorly in science subjects. This drastically lowers their chances of obtaining well paying jobs, unlike their hearing counterparts. It is important to note that by capitalizing on their visual sense, we can, in a sense, head off some of the problems they face at their source. In order to most effectively learn their lessons in the classroom, they have to see the signs representing the ideas or concepts, since they cannot hear the lessons, and the more they can see signed, the more they are going to learn.

2.5 Sign communication in science

Just as educators should never make assumptions concerning students on the basis of race or gender, neither should educators be quick to jump to conclusions concerning deaf students in their science classrooms.

Each deaf student, whether in residential schools or in public schools, is an individual. If anything, deaf students are more heterogeneous than their hearing peers (Marschark, Lang, & Albertini, 2002). Each deaf student will have:

- different levels of hearing loss;
- different reasons for hearing loss (for example: meningitis versus central auditory disorder) that can impact other neurological functions;
- different backgrounds in experience and previous learning in science dependent upon the language of the family.

Since the background and experience of deaf students will be so diverse, it only makes sense that educators must be prepared to provide diverse modalities of communication in science.

Over the past two decades, a great deal of attention has been paid to diversity in learning abilities and diversity in intelligences (Gardner, 1983; Goldman, 1995). Research has shown that different learners require different methods of access to the information to be learned. One learner may excel in the traditional lecture format science classroom, whereas another learner may do best working on his or her own in front of a computer or

with visual models. Some learners may need access to both lecture and visual self-learning in order to perform at their best.

With deaf students, this concept of diversity of methods will need to be taken a bit farther. Some deaf students will have no previous exposure to science experiences upon arrival in schools. Other deaf students will have similar backgrounds in experience as their hearing peers, but…the means of communicating science may require significantly different methods.

The stereotype of the deaf student, unfortunately, still exists. If you ask educators what a deaf student looks or sounds like, the answers will probably include

1. Uses sign language;
2. Can hear everything with a hearing aid or cochlea implant;
3. Probably has bad or different speaking skills;
4. Most probably will not be able to learn on par with their hearing peers.

Even though in some cases, the above may be true, in most cases only one of them may be true or all of them may be false. Regardless of what educators think on the basis of little or no experience with deaf learners, they must be prepared to recognize that difference of communication skills must be accommodated in order for each individual deaf student to reach their full potential.

Parents and educators of deaf students are almost invariably hearing; and in Kenya, being hearing and educated means using English as your primary mode of communication. Success in any field of endeavor in this country requires adequate English skills.

What has changed over the last forty years is where the emphasis lies within English skills. From the time of Alexander Graham Bell (late 1800's) until the seminal work of William Stokoe, most institutions and methodologies of teaching centered on the teaching and achievement of English speaking skills.

The antiquated assumption that good English speaking skills automatically lead to good reading and writing skills in English has not been proven true beyond all doubt. In all too many cases, people who have hearing have been able to do well even though their level of reading and writing skills are not on par with their speaking skills.

In the past, educators attempted to construct what are considered unnatural signed languages. This was an attempt to help deaf learners to acquire the English language structure. Research has shown that while SEE (Signed Exact English) may help in communicating between the deaf learner and some educators, there seems to be evidence that these learners' literacy skills are no higher than among children using American Sign Language (ASL) (Luetke-Stahlman, 1990; Power & Hyde, 1997; Power & Leigh, 1997).

There has been a decided change in emphasis in teaching deaf learners from oral communication to 'total communication'. Teachers who strive for excellence in the education of the deaf students will recognize the heterogeneity that is often found in the classroom and will be prepared to adjust their instruction accordingly. This is especially true with regard to use of sign language. Currently, there is little research (but many opinions) on the best way to sign in science classes. What works with one group of students may not work with another .We also know little about how deaf students construct knowledge as they learn through signs. We do not know whether using a combination of conceptual signing and fingerspelling may be more effective than

extensive use of "technical" or "field-specific" signs. Nor do we know how well deaf students can use long-term memory to make associations between signs teachers use and the concepts the signs represent. These questions and answers will thus be modified as we learn more from research studies.

Good signing, along with the use of graphics, text, and adjunct questions to promote active involvement of students, appears to have a combined and powerful effect on learning.

Studies of interaction of deaf learners with computerized instructional materials have shown promising results. In a multimedia research study with 144 deaf students, Dowaliby and Lang (1999) examined the influence of four types of adjunct instructional aids on immediate factual recall of science content in a series of 11 lessons about the human eye. Students were grouped by standardized test scores as low, middle, and high ability readers and were assigned to condition which included:

i. text plus viewing "content movies" (animation),

ii. text plus sign language translations of the text,

iii. text plus answering adjunct questions about the text, and

iv. all conditions together (text, sign language translations, animations, and adjunct questions).

Low reading ability students learning through text with adjunct questions performed on a test of immediate factual recall as well as high-reading-ability students learning through text only. Dowaliby and Lang (1999) attributed the improved recall to the engaging nature of the adjunct questions. Moreover, the combined use of signs, graphics, text, and adjunct questions also resulted in statistically significant gains as compared to the control group (text only).

While the sign language movies resulted in increases in factual recall, among low-reading ability students, the increases were not statistically significant in comparison with the control group, which received only text. The conclusion may be that adjunct sign language movies contributed to enhanced recall of science facts, but it was the combined effect of adjunct questions, sign movies, pictorial aids and English text that had a powerful synergistic effect.

Similarly, Donald Steely at the Oregon Center for Applied Science (ORCAS) made extensive use of carefully-sequenced lessons, "considerate text", graphic organizers, animations, and a rigorous quiz and testing schedule to facilitate student mastery of facts and knowledge needed to understand the big ideas in science. To effectively present the material to deaf and hard-of-hearing students, he developed the content of each lesson using a series of "triads". Each triad contained a short text screen, a corresponding animation explicating that passage of text, and an American Sign Language (ASL) version of that text. Students typically first read the text screen, then viewed the ASL movie, and then watched the animations. The results of his three different studies with earth science, physical science, and chemistry, each eight months long, indicated that the interactive multimedia and web-based curriculum materials yielded significantly greater knowledge gains for deaf students as compared to traditional classroom experiences (Lang and Steely, 2003). The results also supported the idea of a synergistic effect and provided strong support for a multimedia instructional approach. Lang and Steely (2003) write that well-designed, proven-efficacious science instructional programs for hearing students can be successfully adapted for use with deaf students by interspersing text and ASL explanations with content animation and by providing additional practice on vocabulary and content graphic organizers.

A question is often asked: "How should we sign in Science?" While the growing body of multimedia research supports the use of sign movies in combination with other instructional components, there is little research on the "best" way to sign in science and mathematics. Until more research is conducted, teachers will need to experiment with various combinations of conceptual signing, fingerspelling, and technical signs, along with the use of text, graphics, and adjunct questions to see what may be most effective with a particular group of students.

From the foregoing, it is clear that deaf learners are heterogeneous. Therefore educators must be prepared to provide diverse modalities of communication in science in order for each individual deaf student to reach their full potential. Signing in a science classroom enhances communication of ideas as has been revealed in the study above. Consequently, signs to represent scientific terms need to be developed for use in teaching and learning of sciences in schools for the hearing impaired.

2.6 Studies done on sign development outside Kenya.

A panel of Gallaudet Faculty College carried out a study (Kannapel, 1969) on signs for scientific terms. The invented signs were meant for instruction in high school and college. Gallaudet faculty nominated the terms for which signs were to be invented. Each sign or phrase represents a word or a phrase important to subject matter, frequently used in class, and usually made up of many letters. The aim of inventing these signs was to enable the signers to communicate with the deaf persons more quickly and more

precisely. The researchers invented four hundred and sixty-five signs. Each new sign was judged for clarity and appearance in classrooms (Kannapel, 1969).

A similar study was initiated in 1975 at National Technical Institute for the Deaf (NTID), in U.S.A. This project, the Technical Signs Project (TSP), which was conducted from 1975 through 1992, resulted in the production of 59 videotapes in 26 areas, including anthropology, computer terminology, engineering, human sexuality, mathematics, and science.

In addition to videotapes, the TSP resulted in the development and publication of 11 books. These books included 9 of the 26 areas for videotapes, with signs in these books being depicted in the same order as presented on the videotapes for each technical area.

Since the end of the Technical Signs Project in 1992, work has continued at NTID on a project-by-project basis to update and expand the materials produced. The first of the new books developed, Signs for Science and Mathematics: A Resource Book for Teachers and Students (Caccamise & Lang, 1996), includes signs from TSP manual 3: mathematics and manual 10: science, with updating as appropriate.

Another study was carried out by Riekehoff (1987). The aim of the study was to collect signs that deaf people used in Connecticut and other parts of United States. The study provided signs for more efficient communication with the deaf people. However, no signs to represent scientific terms were collected.

Recent researches on sign language development have been done. For instance, in 1999 the project "The Deaf community in Flanders: evaluation, sensitization and

standardization of Flemish Sign Language carried out a research on Dutch-Flemish Sign Language (Kristof De Weerdt, Eline Vanhecke& Katrien Van Mulders, 1999). The project set out to develop a tool - being a sign language dictionary in both book and electronic form, to support the education of the lexicon of Flemish Sign Language. On the basis of the lexicographic part of this research project a sign language dictionary; Dutch-Flemish Sign Language was created in book form. The dictionary currently contains over 6000 signs from Flemish Sign Language, but is still being elaborated.

The signs were elicited from voluntary informants, who formed regional working parties. Composing five such regional working parties (one in each Flemish province) was necessary, since currently there exists five regional sign language variants in Flanders. These variants developed in the Flemish deaf schools and the regions in which they are used more or less correspond with the five Flemish provinces: Antwerp, East-Flanders, Flemish-Brabant, Limburg and West-Flanders. Each working party consisted of about six deaf informants, who all met the following demands: between twenty and fifty years of age, having a thorough command of the studied sign language variant and using it as their first language, being an active member of the Flemish Deaf community and having received education in a deaf school. Both men and women were involved in the research.

In each group one native signer was allowed to look at the lists of priority terms and was in charge of eliciting the signs by means of eliciting material and of filming the conversations. The informants themselves did not get to see the Dutch words, in order to avoid possible interference from Dutch.

2.7 Studies on sign development in Kenya

The hearing-impaired subject panel of Kenya Institute of Education (1983) also carried out a study aimed at developing signs for use in instructing the hearing-impaired in Kenya. The subject panel developed signs for various fields of knowledge, for example, nature and environment, politics and government, English grammar, and health.

The Kenya National Association of the Deaf (1991) carried out a research aimed at collecting signs used by the deaf community in Kenya. The core lexicon of Kenya Sign Language vocabulary was made and later compiled as a dictionary. The dictionary contains about 2,314 signs that illustrate the structure of signed words.

It should however be noted that in various countries a number of researches have been done on development of signs for scientific terms, for instance in United States of America and Flanders, as the above review indicates. However, in Kenya such researches have not included development of signs to represent scientific terms. There was, therefore, an urgent need to bridge this gap.

Summary

The literature review has shown that the major handicap of deafness is the communication difficulty experienced by individuals who have a hearing impairment. The language problem, obstacles to interaction and difficulties in the access to information are regarded as the major problems encountered by the deaf people all over the world. From the review, it has also come out clearly that at the inception of the education of the deaf in the Sixteenth Century, different countries adopted different

methods of teaching the deaf. The aim in each of the countries was however to provide a method of communication that would reduce the communicative handicap. However, the oral method resulted to "oral failures" which caused dissatisfaction in industrialized countries in the 1960's, especially in U.S.A. Consequently it was later accepted that manual communication was a more effective method of teaching the deaf than the oral method. Henceforth, there occurred an increasing awareness of significance of sign language in education of the hearing-impaired. Thus, in a continued effort to alleviate the communication handicap of the hearing-impaired, many countries have developed their national sign language based on the culture of the people of that country. The reviewed literature has further indicated that the vocabulary of sign language continues to increase as new signs are invented to represent terms for which no signs exist. In some countries like the U.S.A, researches have been carried out to develop signs to represent scientific terms. In the case of Kenya, it has come out clearly that the Kenya Institute of Education (K.I.E) has not yet developed any signs to represent scientific ideas, terms or concepts. This therefore has made teaching and learning of sciences very difficult in the schools for the hearing impaired. It is in the light of this that the researcher set out to develop signs to represent scientific terms. These signs will hopefully provide enough vocabulary to express a wide range of scientific information when coupled with the linguistic principles of sign language. Consequently, the hearing-impaired learners will be able to acquire the scientific knowledge and skills that are essential for survival of every human being. Since the hearing-impaired learners and their science teachers were involved in developing the signs it is hoped that the signs will be acceptable to them for use in learning science. As Gustason (1983) puts it, "if a modality, a system, or a language is not respected, it will not be effectively used" (p.17). The literature has also indicated that there is no single method of teaching which is suitable for every hearing-impaired child.

Good signing, along with the use of graphics, text, and adjunct questions to promote active involvement of students, appears to have a powerful effect on learning. Thus, total communication has been recommended because it offers a prospect of the deaf child participating in educational curriculum more like that of the hearing child. As earlier noted the language of signs is an important component of total communication. It is for this reason that the researcher set out to develop signs for scientific terms.

CHAPTER THREE

METHODOLOGY

3.0 Introduction

This chapter describes methods that were employed to answer the research questions posed in chapter one. The description is undertaken under six subheadings: These are: Research design, population, sample, instrumentation, data collection and data analysis.

3.1 Research design

The design that was used in this study is descriptive survey to find out scientific terms, important to the subject matter, for which there were no existing signs. Signs were developed for these terms. Surveys involve the gathering of limited data from a relatively large number of cases at a particular time. This method is frequently employed to indicate prevailing conditions or particular trends (Verma 1981). The method seems an effective way of collecting data from a large number of sources, relatively cheaply and perhaps in a short time. Furthermore, the results can be analyzed quickly and action can be taken if this is the objective of the study (Verma 1981). The researcher therefore selected descriptive survey because it would be possible to find out the scientific terms for which to develop new signs.

3.2 Population

The study was conducted in the schools for hearing-impaired in Nyeri District. In Nyeri District there are two schools for hearing-impaired namely, Rev. Muhoro Secondary School for the Deaf and Tumutumu Primary school for the Deaf. Rev. Muhoro Secondary

School for the Deaf was chosen because it is the oldest secondary school for the deaf and the one that has been offering science subjects to the hearing-impaired learners for a long period. I therefore envisaged that the learners and the science teachers had more exposure to science subjects. Thus, they were more qualified to respond to the materials for eliciting signs that is, the checklist. The other reason for choosing this school was that the signs to be developed were meant for secondary level deaf learners. It was therefore logical that the deaf learners in secondary school should be included in developing them. The third reason was that Rev. Muhoro School for the Deaf is a national school. Thus, the subjects of study represented wide cultural backgrounds as is required in this type of study. These signs are also intended for use in classroom instruction of primary school deaf learners. For this reason Tumutumu School for the deaf was included in the study.

3.3 Sample

A purposive sample was selected from the two schools for the hearing-impaired. Study subjects were selected according to classes. Subjects were drawn from standard six, seven and eight in Tumutumu Primary School for the Deaf. All the students chosen were hearing impaired. These students were also following the 8-4-4 curriculum of education. Therefore they were learning science as one of the compulsory and examinable subjects in the Kenya Certificate of Primary Education (K.C.P.E). In Rev. Muhoro Secondary School for the Deaf subjects were drawn from forms two, three, and four. These students were also hearing impaired and undergoing the 8-4-4 curriculum of education. Thus, they were learning science that is, biology, physics and chemistry, which were compulsory and examinable in the Kenya Certificate of Secondary Education (K.C.S.E). A random sample was drawn from each class in both schools. We chose these classes in each of the schools on the basis that they have had some learning experience in science and use of sign

language, just enough to provide the necessary information from the time they joined these institutions. We felt that the science teachers are the experts in their area of specialization, and that they are the curriculum implementers. Therefore, we could not ignore their suggestions. They were also selected for the study. Three science teachers in Rev. Muhoro Secondary School for the deaf were chosen for the study. Three science teachers for standard six, seven and eight in Tumutumu Primary School for the deaf were also included in the sample. Table 3.1 and 3.2 below show the final composition of the study sample.

Table 3.1 Composition of study sample in Rev. Muhoro Secondary School for the Deaf.

Students			**Teachers**	**Total**
Form 2	Form 3	Form 4		
6	6	6	2	20

Table 3.1 above indicates the composition of the study sample in Rev. Muhoro Secondary school for the Deaf. A total of twenty participants were selected from this institution. The sample comprised of eighteen learners in forms two, three, and four, both boys and girls. Two science teachers were also chosen for the study.

Table 3.2. The composition of the study sample in Tumutumu Primary school for the Deaf.

Students			**Teachers**	**Total**
Std. 6	Std. 7	Std. 8		
2	4	4	3	13

Table 3.2 above shows the study sample in Tumutumu Primary School for the Deaf. The sample was made up of ten learners, both boys and girls drawn from standards six, seven and eight. Three science teachers were included to make thirteen participants from this school.

Table 3.3 Summary: Subjects from Rev. Muhoro Secondary School for the Deaf and Tumutumu Primary School for the Deaf.

Students			**Teachers**		**Total**
School	Males	Females	Males	Females	
Rev. Muhoro Secondary School for the Deaf	10	8	2	0	20
Tumutumu Primary School for the Deaf	4	6	0	3	13
Total	14	14	2	3	33

Table 3.3 above is a summary of the subjects from Rev. Muhoro Secondary School for the Deaf and Tumutumu Primary School for the Deaf.

3.4 Instrumentation

A checklist was used to collect the scientific terms for which signs were to be developed. The checklist consisted of three sections, that is, biology chemistry and physics. The meaning of each of the terms as used in science was discussed so that the participants understood them. In each of these sections, the participants were required to tick the scientific terms for which they felt new signs should be developed.

3.5 Data collection Technique

From the ticked terms, the participants nominated two hundred terms. These were then listed down. These were the terms for which signs were developed. I then gave the list of the nominated scientific terms to each of the respondents. Next, I picked one term from the list, at a time, and gave a chance to each of the participants to suggest a sign for it. Once every participant had given his or her suggestion, a discussion followed. In this discussion the participants evaluated the suggested signs then agreed on which one of them would be the most suitable of all to represent the particular scientific term. Only the signs judged as excellent on clarity, simplicity and cultural acceptability were accepted. Finally, a model from amongst the participants was videotaped as she gave the agreed upon signs.

3.6 Data analysis and presentation

Qualitative analysis was used to summarize the data. The data was analyzed linguistically then clear drawings to illustrate the handshapes and movement were made by a qualified artist, skillful in sign language. A step-by-step description of the handshapes and movements was also provided.

CHAPTER FOUR

RESULTS

4.0 Introduction

This chapter focuses on the results of the study to find out the scientific terms for which no signs existed and what possible signs could be used to represent them. Two hundred terms were nominated and appropriate signs developed for them. Some of these signs are iconic, that is, they use a visual image for signing the idea. Signs are also represented by actions, while other signs are arbitrary. For the iconic signs and those represented by actions, their origins have been stated whereas for the arbitrary the origin has not been stated because no reason was given for forming or moving the signs in the suggested ways.

4.1 Illustrations and descriptions

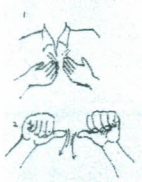
For each term an illustration has been provided beside each of the verbal description of the sign. The signs have been arranged below according to subjects for easier signing since signs belonging to the same family are closely related. Further, closely related signs within a subject have been grouped together for the same reason. However, some terms are common to two or the three subjects, that is, biology, physics and chemistry. These have been grouped accordingly. That is signs for: biology, physics, physics/chemistry, biology/ physics/chemistry, biology/ chemistry and chemistry terms respectively. Signs for biology terms are 95, for physics 24, for physics/chemistry 25, for biology/ physics/chemistry 9 for biology/ chemistry 11 and for chemistry 36. It is important to make note of the explanations

given in Appendix "D" for a clear and precise understanding and interpretation of these signs (Sternberg, 1987).

SIGNS FOR BIOLOGY TERMS

BIOLOGIST
Sign "BIOLOGY": Place both the "B" hands in front of you, palms forward; alternately move the right to the left and down, and move the left to the right and down; + "INDIVIDUAL": Both open hands, palms pointing forward are brought down in front of the body, a short distance apart.
Origin: sign for "BIOLOGY"+ "PERSON".
Usage: The biologist dissected the rat and made a sketch of its digestive system

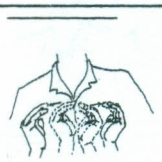
BOTANY
Sign "PLANT": The right fingers, pointing up, emerge from the closed left hand, and they spread open as they do ; + "SCIENCE": Place the "A" hands in front of you, palms forward; alternately move the right to the left and down, and move the left to the right and down.
Origin: sign for "PLANT" + "SCIENCE".
Usage: She studied botany in Kenyatta University.



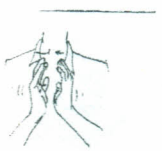
ZOOLOGY
Sign "ANIMAL": Place the fingertips on the chest and rock the hands back and forth with the tips still resting on the chest; + "SCIENCE" : Place the "A" hands in front of you, palms forward; alternately move the right to the left and down, and move the left to the right and down.
Origin: sign for "ANIMAL" and "SCIENCE".
Usage: Zoology is the study of animals.

MICROSCOPE
Place the right "C" (palm facing left) on the left "C" palm facing right and twice make a semi-circular motion with each hand twisting in opposite direction.
Origin: adjusting the lens of a microscope.
Usage: bacteria are clearly viewed under a microscope.

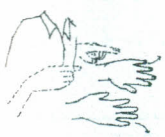
OSMOSIS
Place both "O" hands in front of you, palms down, and direct them forward and towards each side as fingers open.
Origin: fingers spreading represent movement of water molecules.
Usage: the two fluids percolated and mixed through osmosis.



TURGID
Hold both hands in front of you, palm facing palm and slightly curved; fingers pointing up, draw hands apart.
Origin: swelling of cells when immersed in a concentrated solution.
Usage: if a cell is placed in water when it is not fully turgid it will take up water by osmosis.



FLACCID
Hold both slightly curved hands in front of you, palm facing palm, and push hands towards each other, almost touching.
Origin: shape of flaccid cells.
Usage: cells become flaccid when placed in a concentrated salt solution.

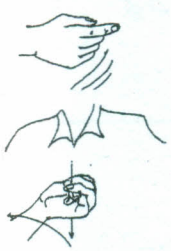


DIFFUSE/DIFFUSION
Place the "D" hands in front of you, palms down, and direct them forward and toward each side as fingers open.
Origin: Fingers spreading represent movement of molecules.
Usage: air molecules move into the atmosphere through diffusion.

RESPIRATION
Sign "SUGAR": Draw the fingertips down across the mouth + "BREAK": Hold the "S" hands side by side, palms down, and give them a sudden outward twist several times.
Origin: breakdown of glucose in cells to release energy.
Usage: There are two types of respiration, aerobic and anaerobic.

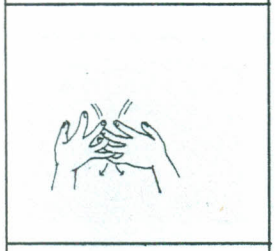
ABSORB\ABSORPTION
The open "AND" hands in front of you, (palms facing down), move the hands towards the body gradually to end in "AND" position.
Origin: sucking up something.
Usage: plants absorb mineral salts through roots.

PHOTOSYNTHESIS
Both 'P' hands, palms facing in, circle over each other in a forward motion.
Origin: sign of "PROCESS" made with "P" hands.
Usage: the raw materials for photosynthesis are carbon dioxide, water and energy from sunlight.

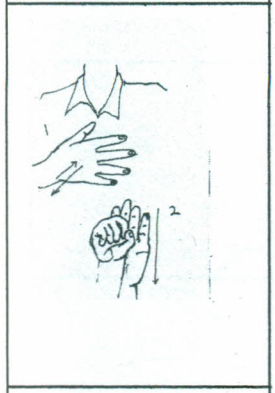


CHLOROPHYLL
Draw the right "G" hand to the right with a shaking motion, then change to "M" hand, palm facing up and drop it slightly.
Origin: sign for "GREEN" and sign for "MATERIAL"/ "MATTER".
Usage: Chlorophyll traps the sun's energy for use in the process of photosynthesis.

PERISTALSIS
Place the right "C" on the left "S". Close the right "C" to "S" hand as the left "S" opens to "C"; do this several times.
Origin: contraction and relaxation of muscles.
Usage: roughage facilitates peristalsis along the gut.

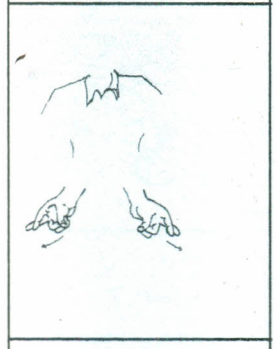


ASSIMILATION/ASSIMILATE
Place both curved "FIVE" hands in front of you, palms facing you, and interlock the fingers beginning with the little finger.
Origin: something becoming a part of the other.
Usage: assimilation takes place in cells.

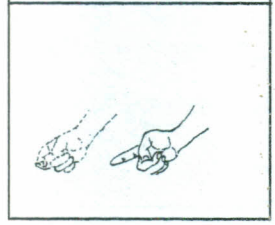


RESPIRATORY SYSTEM/BREATHING SYSTEM
Place the right palm on the chest. Move it a few inches away from the chest then back; then sign, "SYSTEM": Place the index finger-side of the right "S" hand, on the palm of the left hand, palm facing forward and move it downwards.
Origin: indicating the natural breathing motion and sign for "system".
Usage: breathing system in mammals consists of lungs, trachea, chest cavity diaphragm and nostrils.

SYMBIOSIS
Left hand in modified "A" position thumb out, right hand in "S" position; the left hand is positioned with its thumb pointing straight up, and the right hand revolves above the left thumb in a counterclockwise direction.
Origin: Associate; mingling with.
Usage: a symbiotic relationship exists between ruminants and certain bacteria in their stomach.

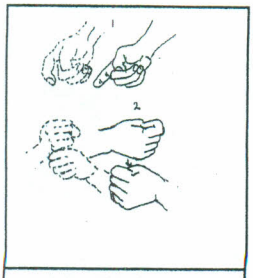


REPRODUCE/REPRODUCTION
Both "R" hands on the sides the hips, elbows bent and slightly raised are moved in a down-out motion simultaneously.
Origin: sign of "birth" made with "R" hands.
Usage: There are two types of reproduction, sexual and asexual.



SPERM

Right "X", palm facing down, snap the index finger once.
Origin: movement of a sperm.
Usage: a zygote is formed after a sperm fertilizes an ovum.



SPERMATOGENESIS

Sign "SPERM": Right "X", palm facing down, snap the index finger once; + "MAKE" :The right "S" hand, palm facing left, is placed on top of its left counterpart, whose palm faces right. The hands are twisted back and forth, striking each other slightly after each twist.

Origin: sign for "sperm"+ "make".

Usage: spermatogenesis is the process by which sperms are manufactured.

SEMEN

Place both "AND" hands in front of the mouth, palms down, and direct them forward and towards each side as fingers open.

Origin: flow of semen following ejaculation.

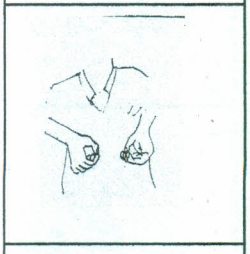
Usage: Sperms swim in semen up the fallopian tubes.

EJACULATE

The index finger is snapped several times out against the inside of the thumb of the right "S" hand, palm facing forward.

Origin: spurts of semen during ejaculation.

Usage: semen is released during ejaculation.

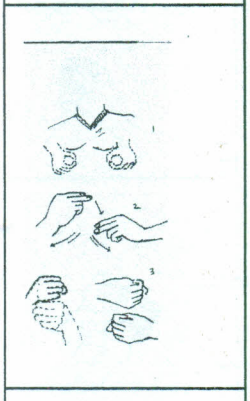


OVARY\OVARIES

Place "O" hands, palms facing the body, on the area of ovaries.

0rigin: position of ovaries in the body.

Usage: a woman has two ovaries.

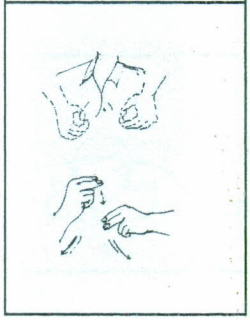


OOGENESIS

Sign "OVUM": Place "O" hands, palms facing the body, on the area of ovaries; then right "H" hand is brought down on the left "H" hand, and then both hands are pivoted down as they move slightly apart; + "MAKE": The right "S" hand, palm facing left, is placed on top of its left counterpart, whose palm faces right. The hands are twisted back and forth, striking each other slightly after each twist.

Origin: sign for "egg" + "make".

Usage: Oogenesis occurs in the ovary.



OVUM

Sign, "OVARY" :Place "O" hands, palms facing the body, on the area of ovaries; + " EGG" :The right "H" hand is brought down on the left "H" hand, and then both hands are pivoted down as they move slightly apart.

Origin: Ova in the ovaries.

OVULATION
Sign "OVUM": Place "O" hands, palms facing the body, on the area of ovaries;then sign, "EGG": the right "H" hand is brought down on the left "H" hand, and then both hands are pivoted down as they move slightly apart + "RELEASE" (The hands in the "JOIN" position are disconnected).
Origin: sign for "ovum" and "release".
Usage: ovulation occurs once a month in mature female mammals.

OVIDUCT/FALLOPIAN TUBE
Place both "F" hands on the position of the ovaries; palms facing down then move them in an outward-forward-upward motion.
Origin: position of oviducts in the body.
Usage: fertilization occurs in the oviduct.

FERTILIZATION
Place the "F" hands in front of you, a few inches apart, palms facing out; bring the right hand towards the left then hook the right index and thumb into the left index and thumb, other three fingers separated .
Origin: sperm and ovum coming into contact.
Usage: the result of fertilization is a zygote.

IMPLANTATION
Place the left "C" hand in front of you, palm facing right, and then place the fingertips of the curved right hand on the palm of the left "C".
Origin: The zygote attaching itself onto the uterine wall.
Usage: a zygote implants itself on the uterine wall.

UTERUS/WOMB
Place left "C" hand in front of you, palm facing right; move the right "U" hand ,palm facing left , forth and back, in the left "C".
Origin: palm indicating the shape of uterus.
Usage: an embryo is connected to its mother's uterus.

FETUS
Cross "S" hands at the wrist (palms in), place them on the chest, and then rest the chin, head slightly bowed, between the two wrists.
Origin: Posture of the fetus in the womb.
Usage: an embryo develops into a Fetus.

BIRTH

Both hand, (palms in) and elbows bent slightly move them simultaneously in a down-forward motion.
Origin: natural act of giving birth.
Usage: giving birth in animals is referred to as parturition.

ORGAN

Place the right "O" hand, palm in, into the left slightly curved palm; draw the right "O" hand towards self and open/straighten it.
Origin: indicating a part of the whole.
Usage: liver is one of the body organs.

CIRCULATORY SYSTEM

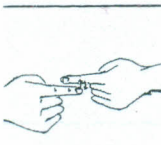
Rotate index fingers several times in front of the body, and then sign "SYSTEM": Place the index finger-side of the right "S" hand, on the palm of the left hand, palm facing forward and move it downwards.
Origin: Sign for "circulate" + "system".
Usage: fish have a closed circulatory system.

AURICLE

Touch the upper part of the heart area with the right "A", palm in.
Origin: position of auricle in the body.
Usage: a human heart has two auricles.

VENTRICLE

Touch the lower part of the heart area with the "V" hand, palm in.
Origin: position of right ventricle.
Usage: a human heart has two ventricles.



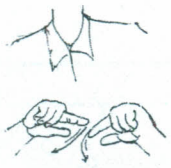
VALVE

Point the right index finger towards the left; and slightly behind the left index finger, palms facing you, shake the right index finger forwards and backwards.
Origin: forward and backward movements indicating closing and opening of the heart valve.
Usage: a human heart has four valves.

ARTERY

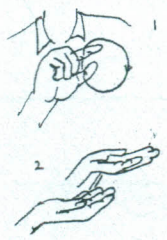
Strike the tip of the thumb, of the modified right "A" hand (palm facing down) on the inside of the left wrist.
Usage: arteries carry oxygenated blood.

AGGLUTINATE
Place the right hand in front of you, fingers slightly spread apart (palm facing left); close the fingertips.
Origin: blood cells coming together.
Usage: agglutination occurs if blood group A and B are mixed.



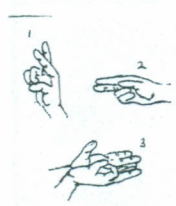
GENETICS
Place both "G" hands in front of you, palms forward; alternately move the right to the left and down, and move the left to the right and down.
Origin: sign for "science" made with "G" hands.
Usage: genetics is a branch of science that studies heredity.

GENES
Make a circle over the heart with the right "G" hand, palm facing left.
Origin: the initial letter over the heart and sign for "character".
Usage: genes determine the character of an individual.



CHROMOSOME
Sign, "GENE": make a circle over the heart with the right "G" hand, palm facing left + "CARRY": both hands, palms up, move from right to left in front of the body.
Origin: chromosomes carry genes.
Usage: a chromosome is made up of many genes.

MUTATION
Place the right "M" so that palm faces forward, with the left "M" facing it. Twist the hands around until they have reversed position.
Origin: chromosomal change.
Usage: some of the human abnormalities are due to chromosomal mutation.



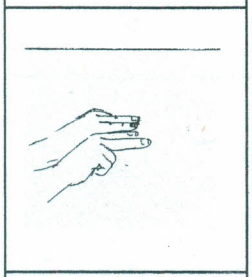
RHESUS FACTOR
Sign, "R" , "H" ;then " FACTOR": strike the palm of the left hand which is facing left , with the little finger edge of the " F" hand ,palm up.
Usage: some people are Rhesus positive while others are Rhesus negative.

HEREDITY/INHERIT

Both 'H' hands, palms facing in, come down from the right shoulder in a rolling motion.

Origin: passed from generation to generation.

Usage: some of human diseases are hereditary.

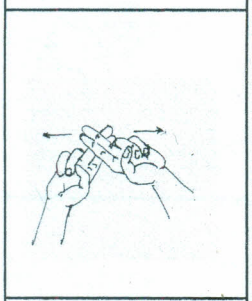


HOMOZYGOUS

Place both extended "H" hands side by side, touching each other with palms down.

Origin: sign for "SAME", "ALIKE", "UNIFORM".

Usage: if allelomorphic genes are of the same quality, the resulting character will be homozygous.

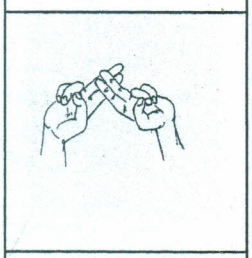


HETEROZYGOUS

Place both "H" hands in front of you, palms facing you, and cross them so that the back of the right "H" passes across the palm of the left.

Origin: based on sign for "different".

Usage: heterozygous characters result from allelomorphic genes carrying different qualities.

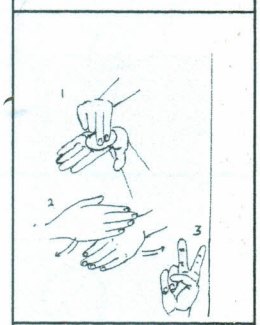


HYBRID/CROSS

Place both "H" hands in front of you, palms facing you, and then rest the back of the right "H" on the left "H".

Origin: crossbreeding.

Usage: various maize hybrids have been developed in Kenya.



MITOSIS

Sign "NUCLEUS" followed by "DIVIDE" (cross the two hands, with the little finger resting on the left index finger. Drop both hands down and separate them simultaneously, so that the palms face down; then sign "TWO".

Origin: cell dividing into two.

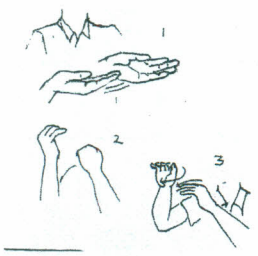
Usage: in mitotic division, each parent produces two daughter cells.

MEIOSIS

Sign "NUCLEUS" followed by "DIVIDE" (cross the two hands, with the little finger resting on the left index finger. Drop both hands down and separate them simultaneously, so that the palms face down; then sign "TWO".

Origin: cell dividing into four.

Usage: sex cells (gametes) divide meiotically.



CARRYING CAPACITY

Sign, "CARRY": Both open hands, palms up, move from right to left in front of the body+ "CAPACITY": The right-angled hands, palms facing, are held before the body, the right above the left. They swing out 45 degrees simultaneously, pivoted from their wrists.

Origin: support limit.

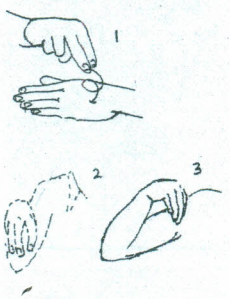
Usage: areas with low annual rainfall have a lower carrying capacity than those that receive higher annual rainfall.

EVOLVE/EVOLUTION

Both "E" hands, place the right "E" so that the palm of the right hand faces forward, with the left "E" facing it. Twist the hands around until they have reversed positions.

Origin: hands changing positions.

Usage: Darwin advanced the theory of evolution.



NATURAL SELECTION

Sign "NATURAL": Circle the right "N" over the left hand and then place it on the back of the left hand; + "SELECTION": The fingertips and thumbtip of the downturned open right hand come together, and the hand moves up a short distance, as in picking something.

Origin: sign for "natural" and "selection".

Usage: in natural selection only the fittest organisms survive.

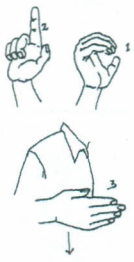
FOOD CHAIN

The closed right hand goes through the natural motion of placing food in the mouth. This movement is repeated. Then the thumbs and the index fingers of both hands interlock, separate, reverse their relative positions, and interlock again.

Origin: Sign for "food" and "chain".

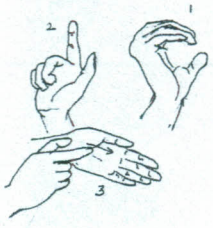
Usage: a food chain indicates organisms dependent upon other organisms for food in an ecosystem.

CELL
Place the "Y" hands in front of you, palms facing down and thumb tips touching each other.
Usage: a group of cells constitute a tissue.
OR
Sign "C", move slightly to the right and sign "L".

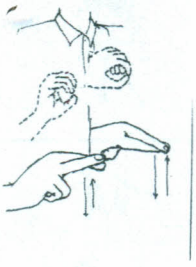


CELL WALL
Sign "C" + "L" +"WALL" (The right open hand, facing left, is brought down the side of the body).
Usage: plant and animal cells have a cell wall.

MEMBRANE
Left hand palm facing up, pass the right "G" hand across left palm.
Origin: "G" hand representing a thin layer.
Usage: plant cells have a semi-permeable cell membrane.



CELL MEMBRANE
Sign "C" + "L"; then "MEMBRANE": left hand palm facing up, pass the right "G" hand across left palm.
Usage: the cell membrane controls movement of substances in a cell.



OSMOREGULATION
Put both "O" hands in front of you, palms facing each other, change simultaneously to "R" hands, palms down, then raise and lower them alternately.
Origin: balancing levels of substances.
Usage: the level of substances in the body is controlled through the process of Osmoregulation.

POPULATION
The "P" hands side by side are moved alternately in continuous counterclockwise circles.
Usage: plant population is usually high where soils are highly fertile.

REPRODUCTIVE SYSTEM

Sign "REPRODUCE": both "R" hands beside the hips, move them in a down-out motion simultaneously; + "SYSTEM": Place the index-finger side of the right "S" hand, on the palm of the left hand, palm facing forward and pass it downwards.

Origin: sign for "reproduce" + "system".

Usage: ovaries are a part of human reproductive system.

DIGEST/DIGESTION

Place "D" hand at the side of the mouth, palm facing left, and move it down the body in a cyclic motion.

Origin: food moving down the digestive system.

Usage: digested food is absorbed in the ileum.

DIGESTIVE SYSTEM

Sign, "DIGESTION": Place "D" hand at the side of the mouth, palm facing left, and move it down the body in a cyclic motion; +"SYSTEM": Place the index -finger side of the right "S" hand, on the palm of the left hand, palm facing forward and move it downwards.

Origin: sign for "digest" and "system".

Usage: food is broken down in the digestive system.

NERVOUS SYSTEM

Place the five hands in front of you (palm down) and shake them slightly from the wrist; then sign, "SYSTEM": Place the index -finger side of the right "S" hand, on the palm of the left hand, palm facing forward and move it downwards.

Origin: sign for "nerve" and "system".

Usage: the nervous system helps us to detect danger in our environment.

LIVER

Touch the area of the liver with the middle finger.

Origin: position of liver in the body.

Usage: hepatic portal vein carries blood to the liver.

EXCRETORY SYSTEM

Sign "EXCRETE": Place the fingertips of the right curved hand (palm down) against the left palm and move it down, ending in an "A" position + "SYSTEM": Place the index -finger side of the right "S" hand, on the palm of the left hand, palm facing forward and move it downwards.

Origin: sign for "excrete" + "system"

Usage: waste products of digestion are eliminated from the body through the excretory system.

HORMONES

Raise and lower the left and right "H" alternately in front of you.

Origin: The rising and falling of hormonal levels in the body.

Usage: female growth hormones are known as estrogen.

PROTEINS

Sign "BUILD: Place one "B" hand on the other, palms in, reverse and repeat several times, raising the hands a little higher each time; +"FOOD": The closed right hand goes through the natural motion of placing food in the mouth. This motion is repeated.

Origin: proteins repair worn out tissues.

Usage: children need proteins for proper development.

CARBOHYDRATES

Sign "ENERGY": The left hand, clenched into a fist, is held up, palm facing the body. Move the left "P" hand in an arc over the left biceps muscle, from the shoulder to the crook of the elbow+ "FOOD": The closed right hand goes through the natural motion of placing food in the mouth. This motion is repeated.

Origin: carbohydrates provide energy to the body.

Usage: a balanced diet must contain carbohydrates.

GERMS

Strike the tips of the right "G" hand, palm facing left, against the left palm which is facing to the right.

Origin: coming against something.

VIRUS

With the thumb resting on the cheek bone, the index finger opens and closes repeatedly.

Usage: the human immune-deficiency virus (HIV) is the cause of aids.

ACQUIRED IMMUNO DEFICIENCY SYNDROME (AIDS)

With the thumbs resting on cheek bones, the index fingers of both hands open and close repeatedly.

Origin: protruding cheek bones of a HIV/AIDS infected individual.

Usage: AIDS is mainly transmitted through sexual intercourse.

IMMUNE/IMMUNITY

Place the left 'I', hand behind the right "S" and push hands out slightly.

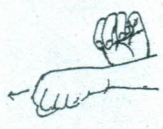
Origin: Pushing away or resisting danger.

ANTIBODIES

Place the left 'A' behind the right "S" and push hands out slightly.

Origin: Pushing away or resisting danger.

Usage: antibodies give a new-born animal protection against certain diseases.



MINERAL SALTS

Place the left 'M', behind the right "S" and push hands out slightly.

Origin: mineral salts as protective foods.

Usage: mineral salts are necessary in building body immunity.

STOMATA

Hold the left hand in front of you, palm in, fingers pointing upwards. With the tip of the right index finger, touch different parts of the back of the left palm.

Origin: left hand representing a leaf, the right index touching stomata on the leaf.

Usage: transpiration takes place through stomata.

TRANSPIRATION

Move the right fingertips (fingers slightly spread) upwards along the left palm which is facing in and pointing upwards, until the right palm leaves contact with left and faces down.

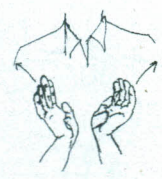
Origin: left palm representing a leaf; right palm indicating loss of water.

Usage: the rate of transpiration increases with increase in environmental temperature.

BUDDING (Flower)
Place the right hand in front of you, slightly curved, fingers spread apart (palm out); close the tips slowly.
Usage: budding in flowers occurs during hot season.

FLOWER BUD
With the right index finger, make a counter-clockwise movement on the upturned tips of the left "AND" hand.
Origin: Shape of a flower bud.
Usage: flowers develop from buds.

PETALS
Place slightly curved hands in front of you, palm bases almost touching, palms facing up; Move them in an out- up motion.
Origin: shape of petals
Usage: Some petals are brightly colored.

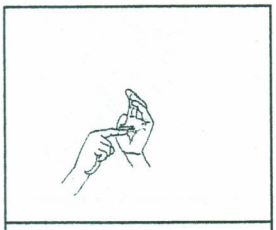


SEPALS
Place slightly curved hands in front of you ,palm bases a few inches apart; draw them sideways to indicate the shape of the sepals.
Origin: the shape of the sepals beginning from the stalk.
Usage: sepals are green.

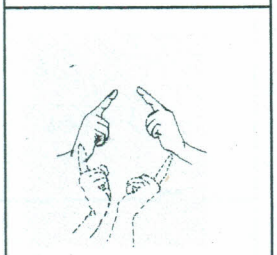
STIGMA
Place the tip of the right index finger on top of the left index finger.
Origin: position of the stigma on the style.
Usage: pollen grains germinate on the stigma.

STYLE
Pass the right index finger upwards along the left index finger which is pointing upwards, palm facing right.
Origin: tracing the shape of the style.
Usage: a pollen tube grows down the style.

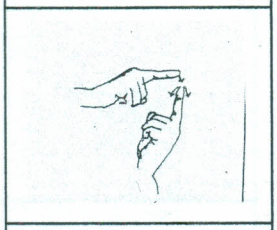
OVARY (plant's)
Both curved hands touch at the wrist and the finger tips.
Origin: shape of the ovary.
Usage: ovules are found in the ovaries.



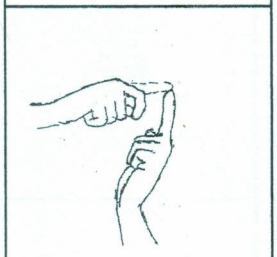
OVULES
Touch different parts of the left curved hand with the tips of the right index finger.
Origin: pointing at imaginary ovules in an ovary.
Usage: ovules develop into seeds after fertilization



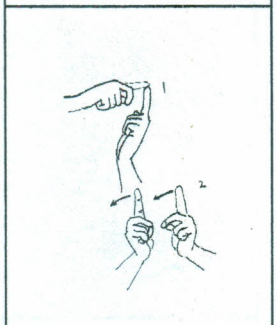
FILAMENT
Place "D" hands in front of you, close together, palms facing each other. Move them in an out-upward motion. This sign can be done using one hand.
Origin: "D" hands representing small slender objects.
Usage: anthers are found on the tips of filaments.



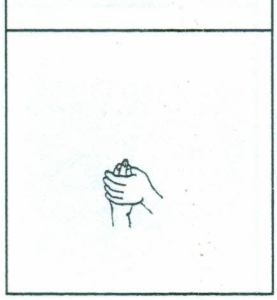
ANTHER
Sign "FILAMENT" using left hand; then with the right index draw an anther at the tip of the left index.
Origin: shape of anther.
Usage: pollen grains are found on anthers.



POLLEN GRAINS
Sign "FILAMENT" with the left hand then rub end of the thumb against the tip of the left index finger.
Usage: pollen grains germinate on the stigma.



POLLINATION
Sign "POLLEN GRAINS": sign "FILAMENT" with the left hand then rub end of the thumb against the tip of the left index finger.; + "TRANSFER": both "D" hands in front of you palms facing, pivoted at the wrists, are moved simultaneously towards the right .
Origin: sign for "pollen" + "transfer".
Usage: There are two types of pollination; self pollination and cross pollination.



GERMINATE
Push the right "AND" hand slowly through the left "C", which is held in front of you with the palm facing right.
Origin: Right hand indicates that which is coming from the ground.
Usage: the maize seeds germinate one week after planting.

RADICAL

Hold an imaginary germinated seed between the left index and thumb. With the right index and thumb, tips touching, trace the downward growth of the radical.

Origin: tracing the downward growth of a radical.

Usage: radical develops into a root.

PLUMULE

Hold an imaginary germinated seed between the left index and thumb. With the right index and thumb, tips touching, trace the upward growth of a Plumule.

Origin: tracing the upward growth of a plumule.

Usage: Plumule develops into a shoot.

LOCOMOTION

"V" hand pointing downward; bend and unbend the index and the middle fingers several times.

Origin: "V" hand pointing down representing an animal in motion.

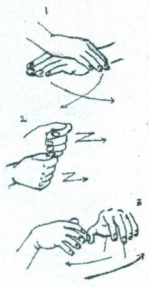
Usage: locomotion is a common characteristic in all animals.

HIBERNATE

Move the right palm under the left downturned palm.

Origin: going under.

Usage: some animals hibernate during severe weather conditions.



REFLEX ACTION/INVOLUNTARY ACTION

Sign –UN: The downturned open hands are crossed at the wrists. They are drawn apart rather quickly. +"CONTROL": move both modified "A" hands back and forth as if holding reigns.+ "ACTION": open hands, palms down, are swung left and right before the chest.

Origin: sign for "-un", "control" and "action".

Usage: a knee jerk is a reflex action.

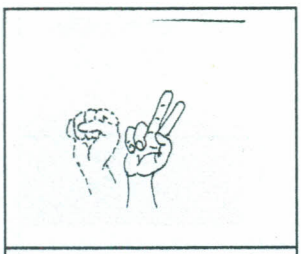
VOLUNTARY ACTION

Sign "VOLUNTEER": With the thumb and the forefinger of the right hand grasp your clothing and pull it forward; +"ACTION": Both open hands, palms down, are swung left and right before the chest.

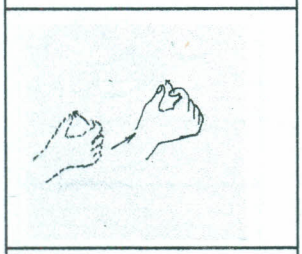
Origin: sign for "volunteer" + "action".

Usage: walking is a voluntary action.

SIGNS FOR PHYSICS TERMS

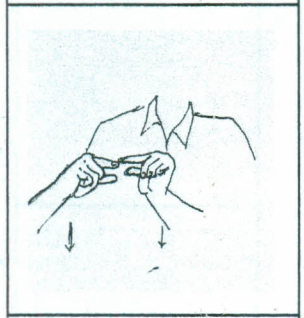


VELOCITY
Palm facing forward, the index and the middle fingers of the right "S" are flicked quickly off the right thumb to end in "V" position.
Origin: sign for "speed".
Usage: velocity is a vector quantity.

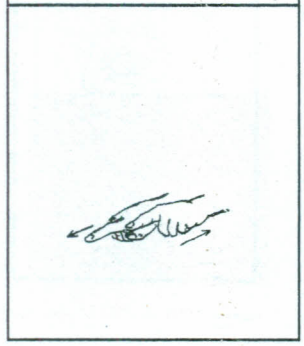


ACCELERATION
Quickly flick the thumb of the right hand off the right index finger, as if shooting a marble, ending in a modified "A" as the hand moves forward.
Usage: the car accelerated up the hill.

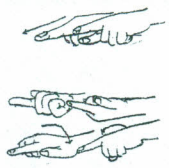
FORCE
Place the wrist of the right "F" (palm down) on the wrist of the left "S" (palm down) and push downward.
Origin: inclining body to motion.
Usage: the force of attraction or repulsion between two charged particles at infinite separation is zero.



GRAVITATIONAL FORCE/FORCE OF GRAVITY
Both "G" hands in front of the chest, palms facing each other, and a few inches apart, simultaneously move them down firmly.
Origin: force pulling objects towards the center of the earth.
Usage: all objects are pulled towards the centre of the earth by gravitational force.



RAY
Using index position, palm facing down and fingers pointing forward, move the right index finger (palm down) along the side of the left index.
Usage: light rays travel in a straight line.



RAY OF INCIDENCE

Sign "RAY" : Using index position, palm facing down and fingers pointing forward, move the right index finger(palm down) along the side of the left index; + "INCIDENCE": both "D" hands, index fingers pointing away from the body, are simultaneously pivoted over so that the palms face down.

Origin: sign for "ray" + "incidence".

Usage: the incident ray, the refracted ray and the normal at the point of incidence all lie on the same plane.

CONVERGE

Place both open hands in front of you, with fingers together and pointing forward, palms facing each other; move hands forwards and towards each other.

Origin: indicating rays of light coming together.

Usage: light rays are converged by a concave mirror.

DIVERGE

Both open hands with fingers pointing forward, palms facing, are moved forwards and outwards.

Origin: indicating rays of light scattering.

Usage: light rays are diverged by a convex mirror.

REFRACT/REFRACTION

Place the tips of the open "FIVE" hands against the left palm, which is facing right; then move the right away from the left in a slanting manner.

Origin: light rays bending as the medium changes.

Usage: when a ray of light travels from one medium to another at an angle, its direction changes.

OBJECT

Stretch out the right hand, palm up, and hold it before the chest. Drop it slightly and bring it over a bit to the right.

Origin: something shown in the hand.

Usage: when the object is far away from a concave mirror, the image is real, inverted and smaller than the object.

IMAGE

Hold both "A" hands about a foot apart before the face, with palms facing each other; move them down simultaneously in a wavy, undulating motion.

Origin: indicating or outlining contours.

Usage: Images formed by convex mirrors are always upright and smaller than the object.

LATENT HEAT

Sign "HEAT": Place the right "C" at the mouth, palm facing in; give the wrist a quick twist so the palm faces out; + "CONVERT" (Hold both " A" hands, thumbs up before the chest, several inches apart; pivot the left hand over so that its thumb points to the right. Simultaneously, move the right hand up and over the left, describing a small arc, with its thumb pointing to the left.

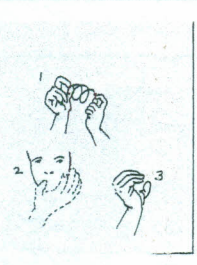
Origin: sign for "heat" and "convert".

Usage: latent heat changes ice at 0 ^{o} C to water at the same temperature.

ABSOLUTE TEMPERATURE

The index finger of the right "D" hand, palm facing left, is placed against the lips. It moves up an inch or two and then describes a small arc forward and away from the lips; + "TEMPERATURE": The index finger of the right "D" hand, pointing left, moves slowly up and down the index finger of the left "D" hand; which is held pointing up.

Usage: Charles' law states that the volume of a fixed mass of gas is directly proportional to its absolute temperature if the pressure remains constant.



SPECIFIC HEAT

Thumb and index finger of each hand, palms facing, the right above the left, form circles. They are brought together with a deliberate movement, so that the fingers and thumbs now touch; then sign "HEAT": Place the right "C" at the mouth, palm facing in; give the wrist a quick twist so the palm faces out

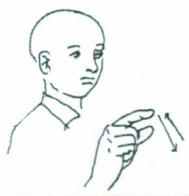
Origin: sign for "specific" and "heat".

HEAT CAPACITY

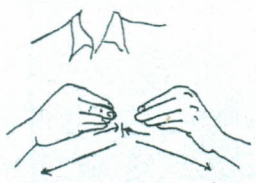
Sign, "HEAT": place the right "C" at the mouth, palm facing in; give the wrist a quick twist so the palm faces out + "CAPACITY": the right angle hands palms facing, are held before the body, the right above the left. They swing out 45^{0} simultaneously, pivoted from the wrist.

Origin: sign for "heat" + "capacity".

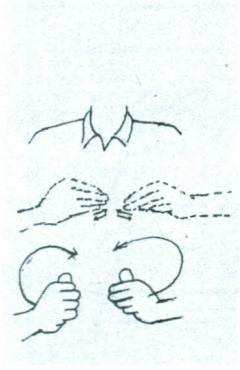
Usage: the SI unit of heat capacity is JK^{-1} .



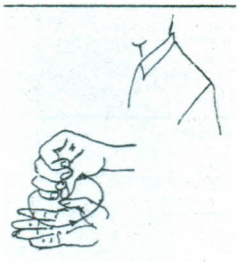
MAGNIFYING LENS
Place "G" hand in front of the eye and move it in a forward-down motion then backward slowly.
Origin: raising and lowering a magnifying glass.
Usage: small objects appear larger when viewed under a magnifying lens



MAGNET
Bring both "AND" hands steadily towards each other from the sides then draw them suddenly to the sides just before the fingertips meet.
Origin: The like poles of a magnet repelling each other and the unlike attracting.
Usage: the suspended magnet always comes to rest with its axis pointing roughly north-south direction.



MAGNETIC FIELD
Sign "MAGNET": Bring both "AND "hands steadily towards each other from the sides then draw them suddenly to the sides just before the fingertips meet; + "AREA" :Touch the tips of the thumbs of "A" hands; draw them apart; circle them toward self and touch the fingertips again.
Origin: drawing a circle to show the limits of an area.
Usage: Magnetic field is stronger near the poles of the magnet and is weaker further away from the poles.



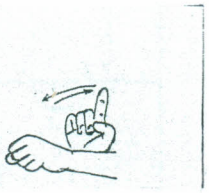
CURRENT
Hold right" C" hand in front of you and move it in a counterclockwise circle while raising the "C" hand.
Origin: symbol for electric current.
Usage: the unit of electric current is the ampere.

SWITCH

Using the thumb of "A" hand, push an imaginary switch at on and off positions.

Origin: action of switching electric power on and off.

Usage: fix a two-way switch.



AMMETER

The "D" hand palm forward is placed on the left "S" hand, palm down, and the "D" hand is moved back and forth from left to right while pivoted at the wrist.

Origin: movement of the hand of an ammeter when current is on.

Usage: the electric current passing through a device is measured by an instrument called an ammeter.

FRICTION

Rub the tips of the thumb and index finger of the "F" hand (palm down) against the palm of the left.

Origin: rubbing action.

Usage: the more the friction the less the mechanical advantage.

REVOLVE/REVOLUTION

Circle the right index finger forward-down-up around the left index several times.

Usage: the wheels of a car revolve to initiate movement.

FULCRUM/PIVOT

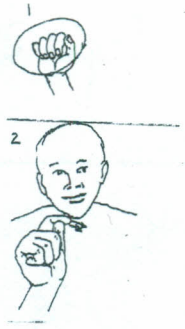
Place the right "P" hand under the "left S" and push upward.

Origin: the right hand supports the left.

Usage: in a lever, the effort arm is the perpendicular distance from the pivot to the line of action of the load.

SIGNS FOR PHYSICS / CHEMISTRY TERMS

ATOM
With "A" hand in front of you describe a small clockwise circle.
Origin: shape of an atom.
Usage: atoms are made up of sub-atomic particles- protons, neutrons and electrons.

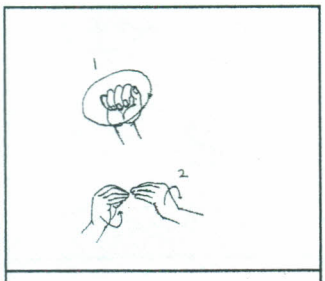


ATOMIC THEORY
Sign, "ATOM": With "A" hand in front of you describe a small clockwise circle; then sign, "THEORY": "T" hand at the side of chain is moved twice forward in succession.
Origin: sign for "atom and "theory".
Usage: according to the Dalton's atomic theory (1807), atoms can be neither created nor destroyed.

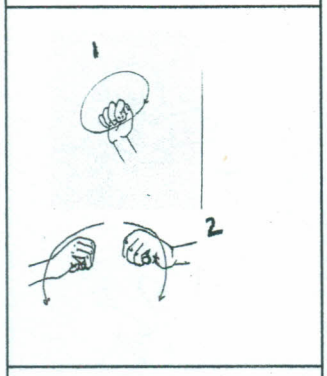
PROTON
Place the tip of the middle finger of the right "P" in the middle of the left palm, which is facing up.
Origin: position of protons in an atom.
Usage: protons are positively charged.

NEUTRON
Place the right "N" in the centre of the palm.
Origin: position of neutrons in an atom.
Usage: the number of neutrons in an atom is the neutron number.

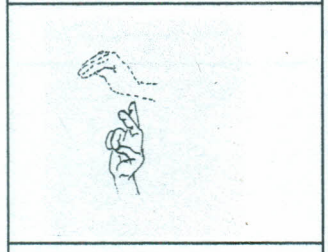
ELECTRON
Hold the right "E" above the left hand, palm facing up; move the right "E" in a counterclockwise circle.
Origin: electrons move in orbitals around the nucleus.



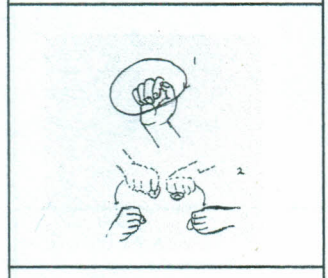
ATOMIC NUMBER
Sign, "ATOM": with "A" hand in front of you describe a small clockwise circle + "NUMBER": both "A" hands, bring the tips of the fingers of the hands to touch as the hands are twisted, while pivoted at the wrist.
Origin: sign for "atom" and "number".
Usage: the atomic number of carbon is 6.



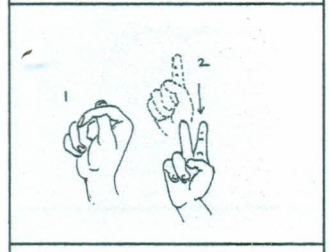
ATOMIC MASS / MASS NUMBER
Sign, "ATOM": with "A" hand in front of you describe a small clockwise circle; + "MASS": both "M" hands, palms down, are moved slightly apart and down, ending with palms facing each other.
Origin: sign for "atom and "mass".
Usage: mass number =proton number + neutron number.



RELATIVE MOLECULAR MASS
Sign' "M" then "R".
Origin: conventional symbol.
Usage: The relative molecular mass of hydrogen is 2.016.



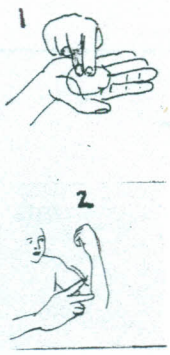
RADIOACTIVITY
Sign "ATOM": with "A" hand in front of you describe a small clockwise circle + "BREAK"(Hold the "S" hands side by side, palms down, and give them a sudden outward twist) several times.
Origin: sign for "atom" + "break".
Usage: natural radioactivity is shown only by a few elements with large mass numbers e.g. Uranium.



HALF-LIFE
Sign "T" + "HALF" (sign "ONE", then lower the hand slightly and sign "TWO").
Usage: The half-life of Uranium-238 is 4.5×10^9 years.

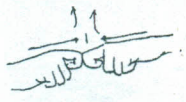
NUCLEAR FUSION
Sign, "ATOM: With "A" hand in front of you describe a small clockwise circle + "COMBINE": Hook the right index and thumb into the left index and thumb (other three fingers separated).Move the hands in this position from yourself and back several times.
Origin: Sign for "atom" + "combine".
Usage: in the sun at temperatures of millions of degrees, 4 hydrogen atoms join to form one 1 helium atom.

ATOMIC ENERGY
Sign, "ATOM": With "A" hand in front of you describe a small clockwise circle; + "ENERGY": Clench the left hand into a fist, hold it up, palm facing the body. Move the right "E" hand in an arc over the left biceps muscle, from the shoulder to the crook of the elbow.
Origin: sign for "atom" and "energy".
Usage: a uranium 235 atom can split into two parts and set free energy.

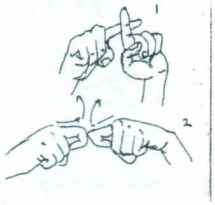


NUCLEAR POWER
Sign, "NUCLEUS": With the right "N", make a counterclockwise circle over the middle of an upturned left palm; then "POWER": clench the left hand into a fist, hold it up, palm facing the body. Move the right "P" hand in an arc over the left biceps muscle, from the shoulder to the crook of the elbow.
Origin: sign for "nucleus" and "power".
Usage: nuclear power can be very destructive.

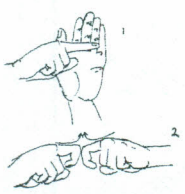
NUCLEAR ENERGY
Sign, "NUCLEUS": With the right "N", make a counterclockwise circle over the middle of an upturned left palm; + "ENERGY": clench the left hand into a fist, hold it up, palm facing the body. Move the right "E" hand in an arc over the left biceps muscle, from the shoulder to the crook of the elbow.
Origin: sign for "nucleus" + "energy".
Usage: in nuclear fission, matter is destroyed and energy equivalent of this matter is free.



CHARGE
Bend the index fingers of both hands and strike the joints together.
Usage: protons are positively charged.



POSITIVE CHARGE
Sign, "POSITIVE": Place the left index finger in front of you, palm side facing right; cross it with the right index (palm side down) + "CHARGE": Bend the index fingers of both hands and strike the joints together.
Origin: sign for "positive" + "charge".
Usage: hydrogen ions have a positive charge.



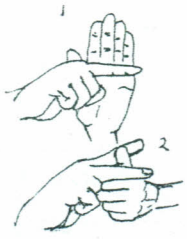
NEGATIVE CHARGE
Sign, "NEGATIVE": face the left open palm outward, tips pointing up; place the right index across the left palm (palm side down) ; + "CHARGE": Bend the index fingers of both hands and strike the joints together.
Origin: sign for "negative" and "charge".
Usage: chloride ions are negatively charged.

CONDUCT/ CONDUCTION
Both "C" hands, palms down, are swung right and left before the chest.
Origin: heat being passed from one molecule to another.
Usage: solids are good conductors of heat.

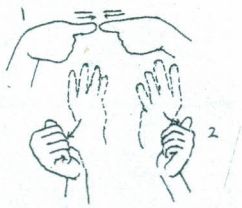
ELECTROLYTE
Both "E" hands, palms out, are swung right and left before the chest
Origin: conducting an electric current.
Usage: Water is a very weak electrolyte (because it is only slightly ionized).

ELECTRODE
The thumb of the modified left "A" hand, palm facing right, is placed between the index and middle fingers of the right "V" (palm down).
Origin: the "A" handshape with the thumb pointing up represents stationary objects and their placement. The "V" hand represents an electric terminal.
Usage: there are two types of electrodes, the anode and cathode.

ANODE
Sign, "POSITIVE": The index fingers are crossed at right angles; then sign, "ELECTRODE": The thumb of the modified left "A" hand, palm facing right, is placed between the index and middle fingers of the right "V" (palm down).
Origin: sign for "positive"+ "anode".
Usage: electrons enter the electrolyte through the anode.



CATHODE
Place the left open palm outward, tips pointing up; place the right index across the left palm (palm side down) , then sign "ELECRODE" : The thumb of the modified left "A" hand, palm facing right, is placed between the index and middle fingers of the right "V" (palm down).
Origin: sign for "negative" and "electrode".
Usage: Electrons leave the electrolyte through the cathode.

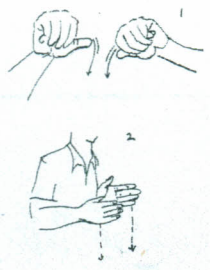


ELECTROLYSIS
Sign, "ELECTRIC": The "X" hands are held palms facing the body, thumb edges up. The knuckles of the index fingers touch each other repeatedly; then sign "DISSOLVE": Hold up both "AND" hands, palms facing you and tips pointing up. As hands are drawn apart to the sides, pass the thumb along fingertips, ending in "A" positions.
Origin: Sign for "electric" and "dissolve".

AVOGADRO CONSTANT
Sign, "L".
Origin: chemical symbol.
Usage: The Avogadro constant is a physical quantity with dimensions and is not just a number.

PERIODIC TABLE
Move the right "G" palm forward, twice from left to right, the hand moving lower the second time; then sign "TABLE": Both hands side by side, palms down, move apart a few inches, then to palm facing.
Origin: periods in a periodic table.
Usage: elements are arranged in the periodic table in order of their increasing atomic number.

SIGNS FOR BIOLOGY/PHYSICS /CHEMISTRY TERMS

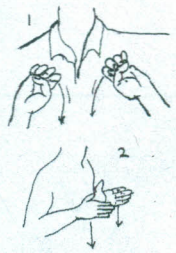


SCIENTIST

Sign "SCIENCE": Place both "A" hands in front you, palms forward, alternately move the right to the left and down, and move the left to the right and down + "PERSON" ENDING: Both open hands, palms facing each other, move down the side of the body, tracing its outline to the hips.

Origin: sign for "science"+ "person" ending.

Usage: Isaac Newton is the scientist who discovered the force of gravity.

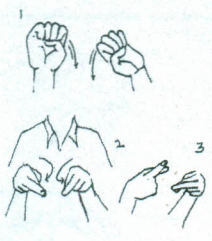


EXPERIMENTALIST

Sign, "EXPERIMENT": Place both "E" hands in front of you, palms forward; alternately move the right to the left and down, and move the left to the right and down; then sign "PERSON" ENDING: both open hands facing each other are brought down in front of the body , tracing its outline to the hips.

Origin: sign for "science".

Usage: the experimentalist recorded his observations after carrying out the experiment.



LABORATORY

Sign, "EXPERIMENT": Place both "E" hands in front of you, palms forward; alternately move the right to the left and down, and move the left to the right and down, + "ROOM": " R" hands, palms facing , are dropped an inch or two simultaneously. They then shift their relative positions so that palms face the body, with one hand in front of the other. In this position, they again drop an inch or two simultaneously.

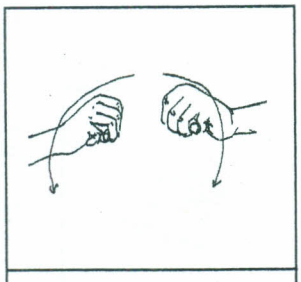
Origin: experiment room.

Usage: the students are carrying out an experiment in the laboratory.

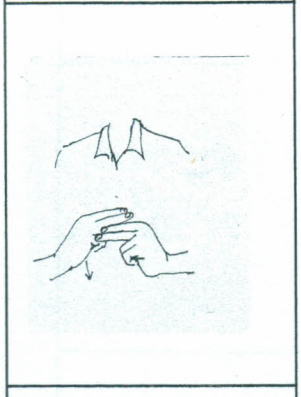
APPARATUS

Stretch out the right "A" hand, palm facing left, and hold it before the chest. Drop it slightly and bring it over a bit to the right.

Usage: set up the apparatus for a science experiment.

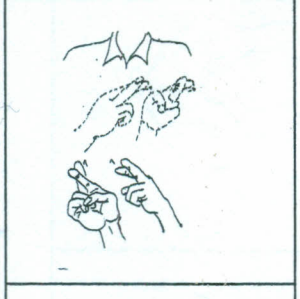


MASS
Both "M" hands, palms down, are moved slightly apart and down, ending with palms facing each other.
Usage: Force= massxacceleration

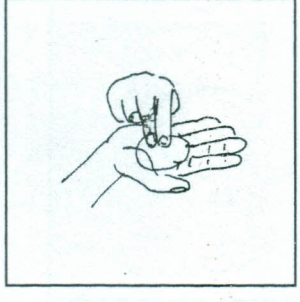


WEIGHT
Place the middle finger of the right "H" across the index of the left "H" and slightly lower the right arm.
Origin: indicating the lowering of a scale balance when some weight is placed on it.
Usage: weight = mass / volume.

VOLUME
The right "V" hand is moved twice forward and backward in the left "C".
Usage: volume= mass / Weight.

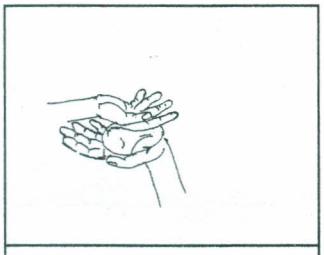


REACTION
Both "R" hands are held in front of the body, with the palm of the left facing right and that of the right facing down. The two are simultaneously twisted while pivoted at the wrists to end with the left "R", palm down and the right "R" palm facing left.
Usage: hydrogen reacts with oxygen to form water.

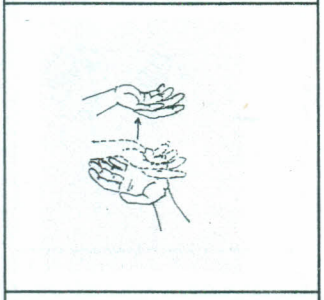


NUCLEUS
With the right "N", make a counterclockwise circle over the middle of an upturned left palm.
Origin: shape of nucleus of an atom.
Usage: an atom consists of electrons moving around a nucleus in the centre of the atom.
The nucleus of an animal cell is surrounded by a nuclear membrane.

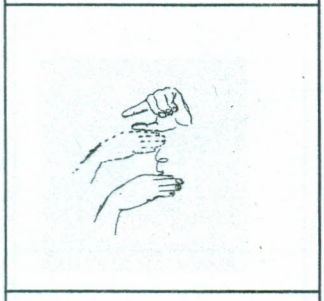
SIGNS FOR BIOLOGY / CHEMISTRY TERMS



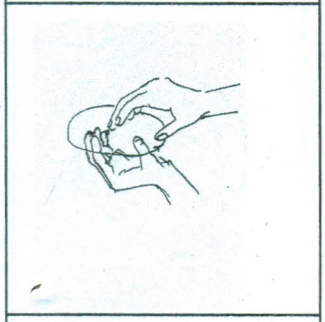
FILTER/FILTRATION
Hold the left open hand, slightly curved, palm up under the right open hand, and palm up fingers slightly apart; move the right in a counterclockwise circle.
Origin: indicating a sieve.
Usage: an insoluble solid is separated from a soluble one by filtration.



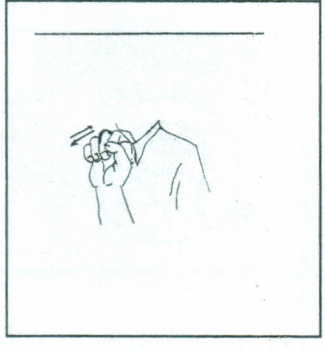
FILTRATE
Place the right slightly curved hand above a slightly curved left hand, palms up and lift the right palm.
Usage: when a mixture of sand and common salt are dissolved in water, sand is filtered off.



PRECIPITATE/PRECIPITATION
With the right "G" (palm down) , hold an imaginary test tube; then slowly but steadily move the right hand which is slightly curved and facing down, downwards along the imaginary test-tube.
Origin: particles moving to settle at the bottom of a test-tube.
Usage: the student determined by precipitation the number of barium ions and carbonate ions that react.



MIXTURE
Both curved hands held in front of you, fingers slightly apart, and palms down; right hand circles clockwise alternately.
Usage: usually no heat change occurs when a mixture is formed.



SOLUTION
Shake the right "S" in front of the body.
Origin: shaking a solution in a beaker during an experiment.
Usage: a standard solution is one which contains a known mass of a solute in a given volume of solution.

LITMUS PAPER

Use the modified "A" hands to grasp an imaginary piece of paper and then tear it; right hand moving towards the right, the other stationary; then sign "PAPER": shake an imaginary sheet of paper.

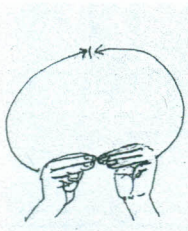
Origin: tearing a leaf from litmus paper booklet to test for acidity or alkalinity of a solution.

Usage: blue litmus paper turns red when dipped in an acidic solution.

TEST - TUBE

Sign "T" twice.

Usage: boil that solution in a test-tube.



MOLECULE

Place both "M" hands in front of you, middle fingers touching. Move them apart in an up-sideways- inward- motion until the middle fingers touch again.

Usage: A molecule of a compound contains at least two atoms.

NITROGEN CYCLE

The right "N" describes small clockwise circles several times.

Origin: repeated series of changes.

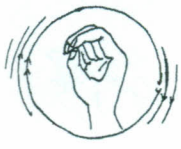
Usage: through nitrogen cycle plants are able to obtain nitrogen for proper growth.

CARBON CYCLE

The right "C" describes small clockwise circles several times.

Origin: repeated series of changes.

Usage: photosynthesis is a part of carbon cycle.



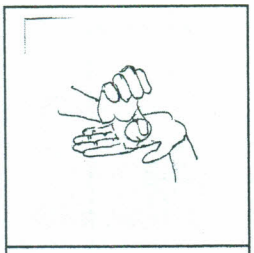
OXYGEN CYCLE

The right "O" describes small clockwise circles several times.

Origin: repeated series of changes.

Usage: oxygen level is reduced in the atmosphere during respiration.

SIGNS FOR CHEMISTRY TERMS



CHEMICAL

Left open palm, fingers facing right, place the thumb of the right "C" at the middle of the palm and make a continuous counterclockwise movement.

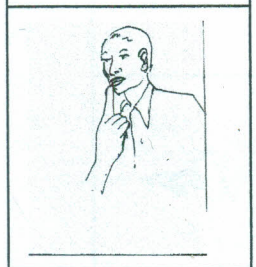
Origin: Initial letter and stirring motion.

Usage: Calcium oxide is a hygroscopic chemical.

BASE

Shake "B" hand several times below the lower lip.

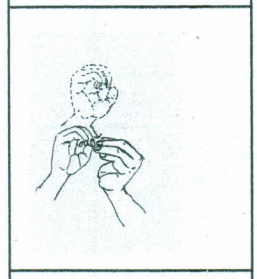
Usage: Bases are substances which combine with hydrogen ions to form water.



ACID

Touch the tip of the tongue with the index finger.

Usage: Acids are substances which dissociate in water to form hydrogen ions.

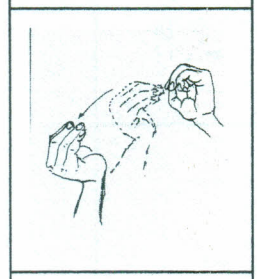


OXIDATION

Place the right "O" hand on the tips of the left "AND" hand, which has the palm facing up; repeat, bringing the left hand higher each time.

Origin: Adding oxygen.

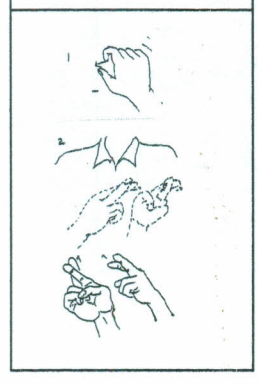
Usage: Oxidation is the addition of oxygen to, or the removal of hydrogen from, a substance.



REDUCTION

Right "O" (palm facing down) is on the tips of the left "O", which has the palm facing up ; move the right "O" down , repeat bringing the left hand lower each time.

Usage: reduction is the removal of oxygen or the addition of hydrogen, to a substance.



CATALYST

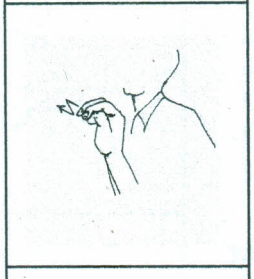
Sign, "SPEED": Right thumb is snapped out of the curved index finger as if shooting a marble; then sign "REACTION": both "R" hands are held in front of the body, with the palm of the left facing right and that of the right facing down. The two are simultaneously twisted while pivoted at the wrist to end with the left "R", palm down and the right "R" palm facing left.

Origin: sign for "speed" and "reaction"

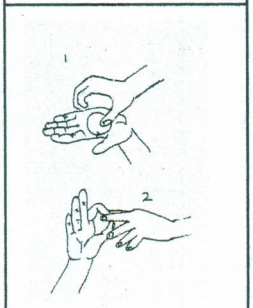
Usage: the catalyst speeded up the reaction.

EQUILIBRIUM
Shake the right "E" in front of you.
Usage: factors that affect equilibrium are concentration, pressure, temperature and catalyst.

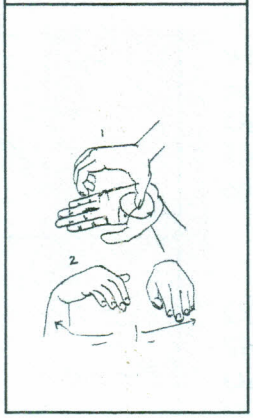
SOLUTION
Shake the right "S" in front of the body.
Origin: shaking a solution in a beaker during an experiment.
Usage: a standard solution is one which contains a known mass of a solute in a given volume of solution.



NEUTRAL/NEUTRALIZATION
Shake the right "N" in front of you.
Usage: Alkalis neutralize acids to form a salt and water.

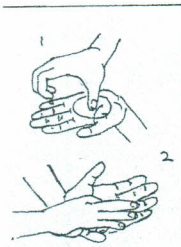


CHEMICAL BOND/BONDING
Sign , "CHEMICAL" :Left open palm, fingers facing right, place the thumb of the right "C" at the middle of the palm and make a continuous counterclockwise movement; then link together the index and thumb of each hand fingers extended.
Origin: particles joining together to form a structure.
Usage: atoms, ions or molecules are held together by forces known as chemical bonds.



CHEMICAL EQUATION
Left open palm, fingers facing right, place the thumb of the right "C" at the middle of the palm and make a continuous counterclockwise movement; then place bent hands in front of you, palm sides down; bring tips together several times.
Usage: the physical state of reactants and products should be indicated in a chemical equation.

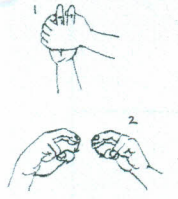
COMPOUND
Interlock the fingers of both "FIVE" hands, palms facing the body and tips pointing in.
Origin: forming bonds.
Usage: A compound cannot be separated into constituent elements by physical means.



CHEMICAL FORMULA
Sign "CHEMICAL": Left open palm, fingers facing right, place the thumb of the right "C" at the middle of the palm and make a continuous counterclockwise movement; + "FORMULAR" :Place the right "F" with palm facing down, against the palm of the left hand.
Origin: sign for "chemical" + "formula".
Usage: the number in front of a formula shows the number of molecules.

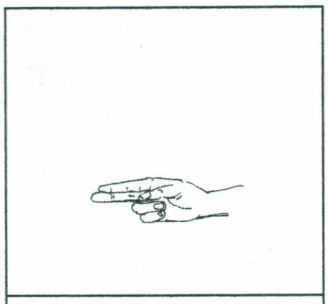
TITRATE/TITRATION/PIPPETE
Place the modified "A" in front of the mouth; move the thumb forth and back while the left "G" hand, palm down is moved upward and downward .
Origin: the titration action.
Usage: sodium hydroxide was titrated against standard hydrochloric acid during the experiment.

BURRET
Move the left "G" hand, palm facing down, upwards while the right "G" hand, directly below the left, makes a motion as if turning on a tap.
Origin: controlling the flow of a solution from a burette during titration.

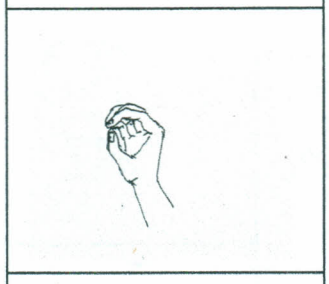


VOLUMETRIC ANALYSIS
The right "V" hand is moved twice forward and backward in the left "C". Then, place the bent "V" hands in front of you, facing each other with palms down; move them towards and away from each other several times.
Origin: sign for "volume" and "analyze".
Usage: The objective of volumetric analysis is to determine the concentration of solutes in solutions.

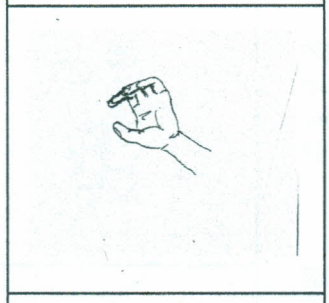
COBALT
Sign, "C" then "O".
Origin: chemical symbol.
Usage: the atomic number for cobalt is 27.



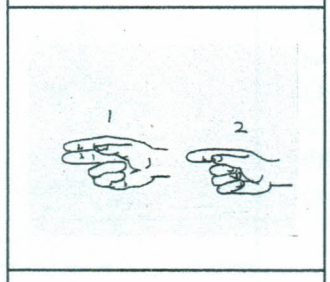
HYDROGEN
Sign, "H".
Origin: chemical symbol.
Usage: water is formed when hydrogen combines with oxygen.



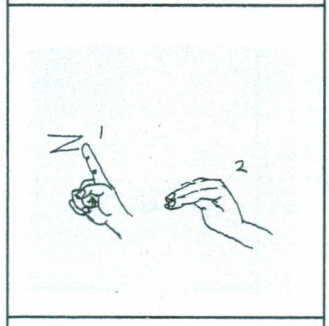
OXYGEN
Sign," O".
Usage: there are two possible methods of industrial Preparation of oxygen.



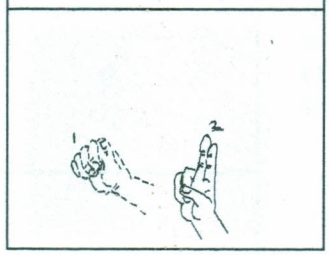
CARBON
Sign "C".
Usage: diamond and graphite are the common crystalline forms of carbon.



MERCURY
Fingerspell "H", "G".
Origin: chemical symbol.
Usage: mercury is a heavy liquid metal.

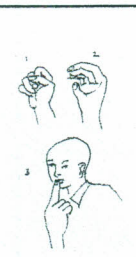


ZINC
Fingerspell "Z", " N".
Usage: zinc does not corrode and is use to coat iron.

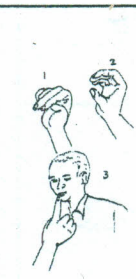


GOLD
Fingerspell "A", "U".
Origin: chemical symbol.
Usage: the Latin name for gold is Aurum.

HYDROCHLORIC ACID
Fingerspell "H", "C", + "ACID": Touch the tip of the tongue with the index finger.
Origin: chemical formula.
Usage: hydrochloric acid is used in pickling.



SULPHURIC ACID
Sign "S" "C" + "ACID": Touch the tip of the tongue with the index finger.
Usage: concentrated Sulphuric acid is hygroscopic and dehydrating.

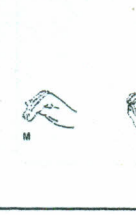


NITRIC ACID
Sign, "N","C" + "ACID": Touch the tip of the tongue with the index finger.
Usage: pure nitric acid is a colorless solution.

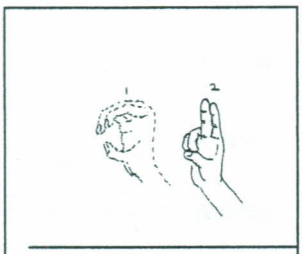
SILVER NITRATE
Touch the ear with the index finger and bring it forward with a quick twist into an "S" hand; then sign, "N", "T".
Origin: sign for "silver".
Usage: when a soluble chloride is dissolved in distilled water and dilute nitric acid and silver nitrate solution are added, a white precipitate forms.

IRON
Sign, "F" and "E".
Origin: chemical symbol.
Usage: iron rusts in moist air.

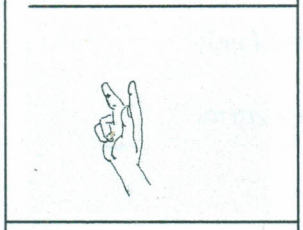
FLUORINE
Sign, "F".
Origin: chemical symbol.
Usage: fluorine is a halogen



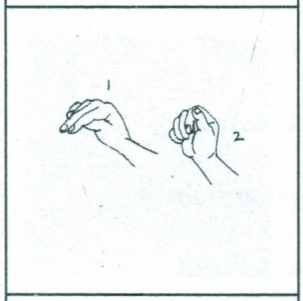
MOLYBDENUM
Sign, "M" then "O"
Origin: chemical symbol.
Usage: the melting point of molybdenum is 2620 ° C



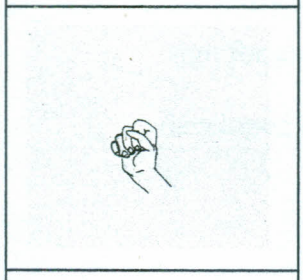
COPPER
Sign, "C" and "U".
Origin: first two letters of the Latin name for copper, Cuprum.
Usage: anhydrous copper sulphate decomposes at very high temperatures.



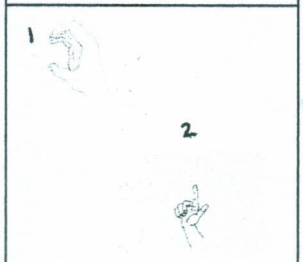
POTASSIUM
Fingerspell "K".
Origin: chemical symbol.
Usage: potassium is stored under liquid paraffin or kerosene.



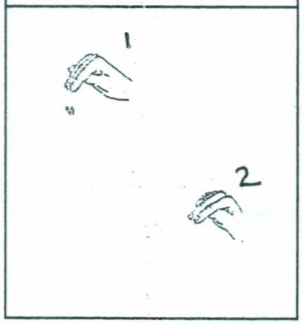
SODIUM
Fingerspell "N", "A".
Origin: chemical symbol.
Usage: sodium burns in oxygen with a brilliant light flame.



SULPHUR
Sign, "S".
Origin: chemical symbol.
Usage: sulphur is used in vulcanization of rubber.



CHLORINE (element)
Sign, "C" and "L".
Origin: chemical symbol.
Usage: chlorine is a halogen



MANGANESE
Sign, "M" and "N".
Origin: chemical symbol.
Usage: the atomic number of manganese is 25.

4.2 Summary of results.

The following is a summary of the study in relation to each research question:

1. The first question was: "which scientific terms, important to the Subject matter, do not have existing signs?" This question was answered because over two hundred terms were ticked in the checklist and others suggested. From these, two hundred terms were nominated for signs to be developed for them.

2. The second question asked what signs could be suitable to represent scientific terms, ideas or concepts encountered during teaching and learning of sciences in schools for the hearing impaired. From the discussion by the participants, a sign for each of the nominated terms, concepts or ideas was developed or invented in cases where no signs existed.

CHAPTER FIVE

5.0 DISCUSSION

This chapter addressed itself to the interpretation and discussion of results of the study to find out which scientific terms did not have an existing sign and which signs could be suitable to represent them. It came out clearly from the results of the study that most of the scientific terms did not have any existing signs. This was due to the fact that the deaf children are not exposed to these terms early in life. Actually, it was not until recently that the deaf students started following the 8-4-4 curriculum of education. Previously their curriculum emphasized the specialist subjects rather than academic ones. Consequently, there was less likelihood of the deaf individuals encountering the scientific terms and possibly invent signs for them. Thus most signs in the study were invented. Examination of the researches done on development of Kenyan Sign Language also revealed that none of these researches concerned itself with development or invention of signs for scientific terms. Actually, the participants were very eager to participants in the development of signs for the nominated terms. Thus, they developed a sign for each of those terms. They felt that they should have included more terms since this field of study seriously lacks in sign language lexicon.

5.1 IMPLICATIONS

Two implications are presented from the findings of this study.

First, it was found out that most of the scientific terms encountered in day-to-day learning and teaching of science do not have an existing sign. This situation may

have negative impact on the learning and teaching of science subjects in the schools. Therefore, there is an urgent need to carry out further research in order to increase the science lexicon. This will in turn enhance the teaching and learning of science in the schools for the hearing-impaired. The second implication is that the relevant departments of the Ministry of Education should carry out research to establish the adequacy of Kenya sign language lexicon in all other subjects in the curriculum for the hearing-impaired; otherwise the dismal academic performance by the hearing-impaired individuals may become persistent to the detriment of these learners.

5.2 RECOMMENDATIONS

5.2.1 Recommendation to the Kenya Institute of Education

The K.I.E should consider the signs developed in this research for possible use in the instruction of the deaf learners in science subjects in Kenyan schools.

5.2.2 Recommendations to the Ministry of Education, Science and technology

The ministry of Education Science and Technology should urgently set up a nationally based project for collection, evaluation, selection and recording of signs and fingerspelled words used in academic and career environments. This will reduce the controversies that surround development of Kenyan Sign Language.

5.2.3 Recommendation to the Kenya Institute of Special Education

The Kenya Institute of Special Education should evaluate the signs developed in this research for possible use in the training of the teachers of special needs learners.

5.2.4 Recommendation for further research

- The results indicated that there is a serious lack of science lexicon. There is therefore urgent need for further research in this area.
- Similar research is also necessary in other areas of study such as the technical subjects.

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APPENDICES

Appendix A

A Checklist of Scientific Terms

INSTRUCTIONS

This checklist consists of scientific terms. It consists of three sections. Section one consists of biology terms, section two chemistry terms and section three physics terms. In each of these sections tick the terms for which you feel signs should be developed.

SECTION ONE

BIOLOGY TERMS

- Adaptation
- Agglutination
- Amniotic fluid
- Anther
- Stigma
- Antibodies
- Antitoxins
- Artery
- Assimilation
- Auricle
- Auxins
- Bile
- Blood
- Budding (a) (hydra)
- Budding (b) (flower)
- Budding (c) (yeast)
- Calyx
- Carbohydrates
- Cell
- Cell membrane
- Cellulose
- Cell-wall
- Centromere
- Cervix
- Chemotropism
- Chlorophyll
- Chloroplast
- Chromatid
- Chromosome
- Circulatory system
- Diffusion
- Digestion
- Egestrone

- Embryo
- Enzymes
- Evaporation
- Evolution
- Fallopian tube
- Fertilization
- Filament
- Flaccid
- Foetus
- Gall bladder
- Genes
- Genetics
- Germination
- Gestation period
- Glucose
- Guard cells
- Hepatic artery
- Hepatic portal vein
- Heredity
- Hormones
- Hybrid
- Hydrotropism
- Immunity
- Implantation
- Linkage
- Liver
- Lymphatic nodes
- Meiosis
- Mineral salts
- Mitosis
- Mutation
- Nectar
- Nerve
- Nucleus
- Oestrogen
- Organ
- Osmosis
- Ovary
- Ovulation
- Ovum
- Parasite
- Petals
- Phloem
- Photosynthesis
- Phototropism
- Physiology
- Placenta
- Plasma
- Plasmolysis
- Population
- Progesterone
- Prolactin
- Prostate gland
- Proteins
- Respiration
- Roughage
- Scrotum
- Semen
- Sperm
- Sperm duct
- Spermatogenesis

- Starch
- Stem
- Stomata
- Style
- Symbiosis
- Synthesis
- Testis
- Tissue
- Turgidity
- Umbilical cord
- Valve
- Vein
- Ventricle
- Villi
- Vitamins
- Womb should
- Xylem
- Any other

SECTION II

CHEMISTRY TERMS

Tick the terms for which you feel signs should be invented or developed.

- ❖ Acid
- ❖ Anion
- ❖ Atom
- ❖ Base\Alkali
- ❖ Beaker
- ❖ Bond
- ❖ Bonding
- ❖ Burette
- ❖ Cation
- ❖ Charge
- ❖ Chromatography
- ❖ Compound
- ❖ Conical flask
- ❖ Crucible
- ❖ Crystal
- ❖ Crystallize
- ❖ Decantation
- ❖ Dehydrate
- ❖ Density
- ❖ Dissolve
- ❖ Distillation
- ❖ Electrons
- ❖ Element
- ❖ Equilibrium
- ❖ Filter funnel
- ❖ Filtrate
- ❖ Halogen
- ❖ Hydrolysis
- ❖ Ion
- ❖ Isomer
- ❖ Matter
- ❖ Measuring cylinder
- ❖ Neutralize
- ❖ Neutrons
- ❖ Oxidation
- ❖ Oxidation
- ❖ Periodic table
- ❖ Pipette
- ❖ Precipitate
- ❖ Precipitation
- ❖ Protons
- ❖ Radioactivity
- ❖ React
- ❖ Reagent
- ❖ Reduction
- ❖ Residue
- ❖ Solute
- ❖ Solution
- ❖ Solvent
- ❖ Suspension
- ❖ Test-tube
- ❖ Valence
- ❖ Vapour
- ❖ Volumetric analysis

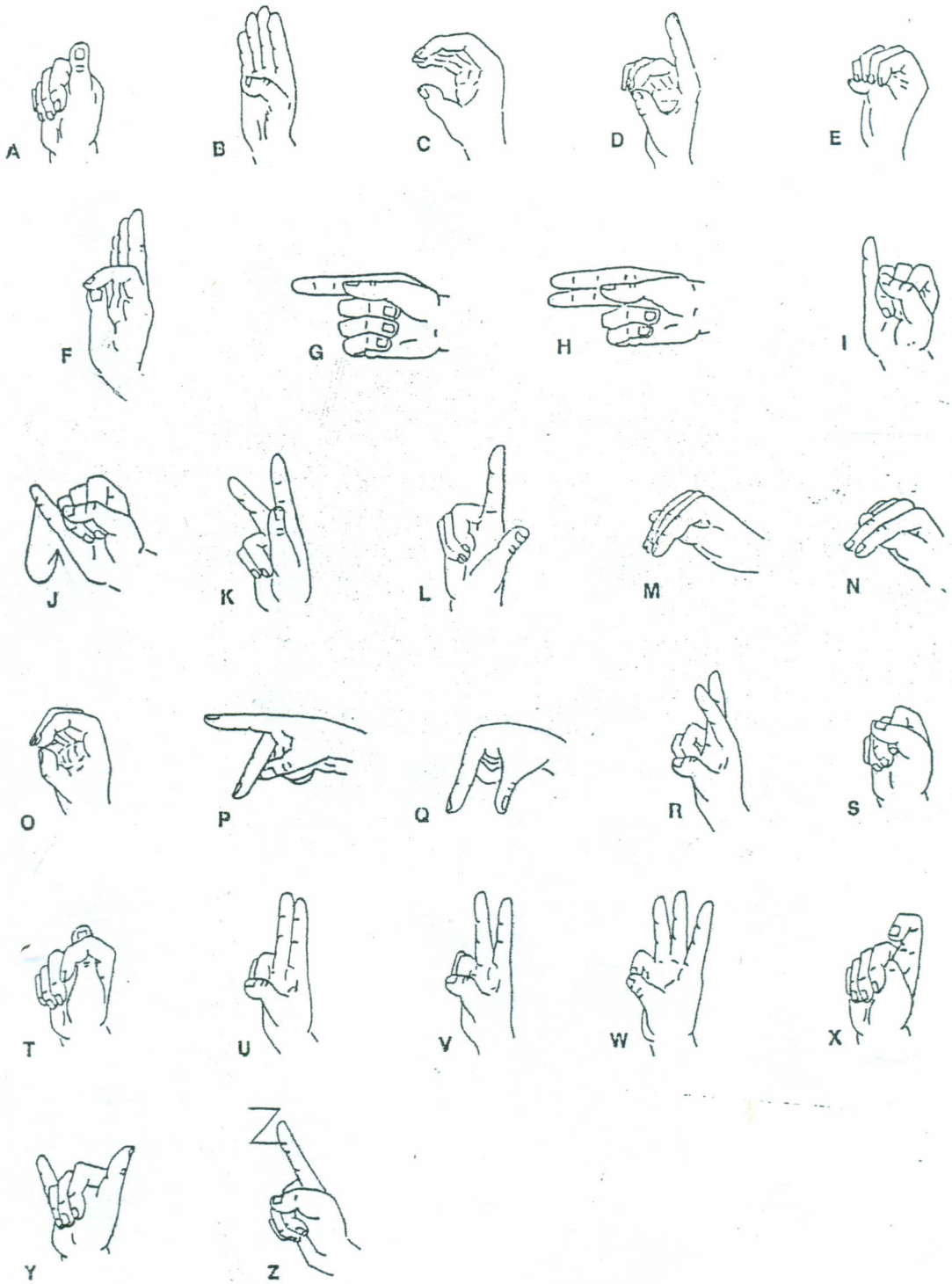
SECTION III

PHYSICS TERMS

Tick the terms for which you feel signs should be invented or developed.

- ❖ Mass
- ❖ Volume
- ❖ Weight
- ❖ Force
- ❖ Gravity
- ❖ Pressure
- ❖ Reflection
- ❖ Electricity
- ❖ Heat
- ❖ Latent heat
- ❖ Conduction
- ❖ Accumulator
- ❖ Electrolyte
- ❖ Electrode
- ❖ Potential difference
- ❖ Manometer
- ❖ Ray of incidence
- ❖ Angle of incidence
- ❖ Lens
- ❖ Convergence
- ❖ Divergence
- ❖ Callipers
- ❖ Lever
- ❖ Pivot
- ❖ Fulcrum
- ❖ Distance
- ❖ Magnet
- ❖ Magnetic field
- ❖ Magnetize
- ❖ Gas jar
- ❖ Electrolyte
- ❖ Refraction
- ❖ Distance
- ❖ Magnet
- ❖ Any other

Appendix B: The American Manual Alphabet



Source: Wilbur, 1979

Appendix C

American Sign Language handshapes

Source :Wilbur,1979.

Appendix D

Explanatory notes

It is important to note the following in regard to the developed signs.

i. Signs are made in this study for the right-handed individual; they should be made in the reverse by the left-handed person.

ii. Verbal description.

The sign and its formation are described verbally. Such terms as" S" hand , "D" position, both "B" hands , refer to the positions of the hand or hands as they are depicted in the American manual alphabet in appendix B.

Terms such as counterclockwise, clockwise, refer to movement from the signer's orientation. Care should be taken not to become confused by illustrations which appear at first glance to contradict a verbal description. In all cases the verbal description should be the one of choice with the illustration reinforcing it. The reader should place himself/herself mentally in the position of the signer that is the illustration in order to assume the correct orientation for signing a word.

iii. Illustrations appearing in sequence should not be regarded as separate depictions of a sign. They are fluid and continuous, and should be used in conjunction with the verbal description of a sign, for they illustrate the main features of a sign as one movement flows into the next.

iv. Arrows, broken or solid, indicate direction of movement. Again, they are designed to reinforce the verbal description and, where confusion may arise, the reader is cautioned to review the verbal description, always keeping himself/herself mentally in the position of the illustration (the signer).

v. As a general rule, a hand drawn with dotted lines indicates the sign's initial movement or position of the hand. This is especially true if a similar drawing appears next to it using solid lines. This indicates terminal position in a continuum.

vi. Groups of illustrations have been arranged as far as possible in visually logical order. They are read from left to right or from top to bottom. Where confusion is possible, they have been captioned with letters numerals 1, 2, 3, and so on.

vii. Small lines outlining parts of the hand, especially when they are repeated; indicate small, repeated, or wavy or jerky motion, as described in the verbal section of an entry. BURRETE is an example.

viii. Arrows drawn side by side but pointing in opposite directions indicates repeated movement, as described in the verbal section of an entry. LITMUS PAPER is an example.

ix. Illustrations giving side or three-quarter views have been so placed to afford maximum visibility and to avoid foreshortening problems. The reader of the thesis should not assume a similar orientation when making the sign. As a general rule, the signer faces the person he/she is signing to.

x. Inclusion of the head in the figures permits proper orientation in the formation of certain signs. The head is omitted where there is no question of ambiguity.

xi. Capital letters in quotes ("") or upper case have been used to indicate word-sign.

Appendix E

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Appendix F

BUDGET

ROPOSAL	KSH
Writing draft proposal…typing	1300 .00
Preparation for presentation (department); photocopy and binding-21 copies	2900.00
Preparation for presentation (faculty)-4 copies	900.00
TOTAL	5100.00
Stationary for 35 checklists	2500.00
FIELDWORK DURATION-TEN DAYS Subsistence for researcher @ Shs.750 per day for 8 days	6000.00
Stationary for 35 checklists	1500.00
Video recording	21000.00
Transcribing of signs	15000.00
Typing of thesis draft	3000.00
Typing and binding of thesis (final draft) (4copies)	4800.00
TOTAL	53800.00
GRAND TOTAL	58900.00

TIME FRAME

TIME	ACTIVITY
May- July	Literature search and review
August –December	Proposal writing
January	Defense (department and at the school)
February-March	Fieldwork
April	Data collection
May-July	Report writing
August	Submission of report
September	Seminar presentation
October	Graduation