EFFECTS OF COMPUTER-AIDED LEARNING ON HEARING-IMPAIRED LEARNERS' ACHIEVEMENT IN STANDARD THREE GEOMETRY AND PERCEPTION OF THEIR LEARNING ENVIRONMENT IN RIFT VALLEY, KENYA

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By

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DECLARATION

This study is my original work and has NOT been presented for the award of any degree or diploma in any other College or University.

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DEDICATION

This work is dedicated to my loving wife, Loice and our children Lorraine, Laura, Raisa and Nadine for their love, patience, company and encouragement.

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ABSTRACT

Achievement in mathematics has been an issue of great concern to students, parents, employers and researchers over the years. Poor achievement in this subject has resulted in a search to establish its various causes. The Kenya National Examination Council (KNEC) continues to deliver dismal results annually. One area that is noteworthy is geometry which according to KNEC reports, presents difficulties to both the instructor during instructional sessions, and the learner during the learning process (Kenya National Examination Council, 1999; 2000; 2002; 2004 & 2006). The purpose of the study was to develop a special CAL geometry software package and to investigate its effects on the learners' achievement in geometry, and perception of their mathematics learning environment in schools for hearing-impaired learners. This was done by developing Computer-Aided Learning (CAL) software, which was used to investigate hearing-impaired learners' achievement in primary school geometry. The study sought to determine whether the use of CAL would enhance the learning of geometry in standard three where learners start learning basic geometry. Sixty respondents from four special education schools in four districts in Rift Valley were purposively sampled on the basis of the school's accessibility. The study employed the Solomon-Four Group Design for experimental research. Learners' achievement in geometry and their perception of the mathematics classroom environment formed the dependent variables of the study, which were examined in the light of Computer-Aided Learning. Measurement was conducted using a Mathematics Achievement Test (MAT) and a Mathematics Classroom Environment Questionnaire (MCEQ) respectively. MAT's face, content and sampling validity were determined by subject experts, while reliability was computed with the K-R20 formula. Data was analysed using both descriptive (percentages, means & std-deviations) and inferential statistics (t-test, chi-square & ANCOVA) with the aid of the Statistical Package for Social Sciences (SPSS) version 11.5. The study established that CAL improves achievement in geometry among hearing-impaired learners. However, no significant improvement was observed in learners' perception of their learning environment

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LIST OF ABBREVIATIONS AND ACRONYMS

AMESLAN	American Sign Language
ANCOVA	Analysis of Covariance
CAL	Computer-Aided Learning
ITS	Intelligent Tutoring Systems
KCPE	Kenya Certificate of Primary Education
KCSE	Kenya Certificate of Secondary Education
KIE	Kenya Institute of Education
KISE	Kenya Institute of Special Education
KNEC	Kenya National Examination Council
MAT	Mathematics Achievement Test
MCEQ	Mathematics Classroom Environment Questionnaire
MMB	Multi Media Builder
MOEST	Ministry of Education Science and Technology
SNE	Special Needs Education
SNED	Special Needs Education Division
SPSS	Statistical Package for Social Sciences

CHAPTER 1

INTRODUCTION

1.1 Background Information

Mathematics encompasses many aspects of human life. It provides a language of communication that is powerful, concise and unambiguous. It is no great wonder therefore that the subject's easy mode of expressing ideas and concepts has made its mark in our day to day lives at home, in the office, workshop, industry, commerce, science, technological development and research (Cockroft, 1982; Mondoh & Yadav, 1995).

Mathematics is a compulsory subject in our primary and secondary schools. This affirms the significance of teaching mathematics. The subject is deemed difficult and inaccessible by many students. Its failure rate is higher than in any other subject, and yet the subject remains a prerequisite for science and engineering courses. Mathematics presents special difficulties to hearing-impaired learners (Yushau, 2004; Durkin & Shire, 1995). Difficulties include inability to hear and the conceptualisation of facts in the absence of a language. The teaching of foundational concepts which include concepts in geometry begins in standard three and continues to higher levels.

The Kenya National Examination Council (KNEC) recommends a change in strategies used in teaching mathematics. It is therefore imperative that teachers adopt a mode of instruction at early stages of a child's education that captures and sustains the attention and interest of learners, while enhancing their sensory perception (Kenya National Examination Council, 1999; 2000, 2001, 2002, 2003, 2004 & 2005).

A general objective of the mathematics curriculum is to develop the learner's ability to use and construct mathematical models of physical situations. This involves complex visualisation and employment of mental images, made possible through the learner's exposure to situations entailing the solution(s) to geometrical problems. Geometry provides a tool for performing mental deductions that sharpen learners' reasoning capabilities, thus exercising learners' brains in organising mental models. Deductive reasoning helps the learner to cope better with life's problems and other challenging issues in their environment, hence the need to gain mathematical skills (Costello, 1991; Papert, 1993; Kenya National Examination Council, 2001; Kenya Institute of Education, 1992).

Hearing- impaired learners take the common curriculum that is offered in regular schools for purposes of easily assimilating them in the society where they live. This has been implemented by all special education schools. The poor achievement in mathematics is attributed to various factors which include lack of personnel, resources, textbooks and poor instructional techniques, hence failure among learners to grasp basic skills. (Kenya National Examination Council, 2000; 2001; 2002; 2003; 2004 & 2006).

Table 1 shows a summary of national mean scores in Kenya Certificate of Primary Education (KCPE) mathematics examination over a period of eight years between 1998 and 2005.

Table 1:

A summary of the national mean scores in KCPE mathematics

Year	1998	1999	2000	2001	2002	2003	2004	2005
KCPE Mean	44.22%	49.50%	50.18%	50.76%	48.63%	49.70%	37.56%	23.57%

Source: Kenya National Examination Council, 2002; 2003; 2004; 2006.

The data in Table 1 indicate that the eight–year period KCPE mathematics mean score can be rounded off to 44.265 %. This mean falls below the average mark of 50%. Such a lower than average achievement at primary school level is bound to reflect upon a learner's future achievement in secondary school mathematics, not to mention its impact on other related subjects.

Table 2:

Mathematics topics and their percentage scores

Topic	Percentage of candidates scoring correctly						
	Year						
	1998	1999	2000	2001	2002	2003	2004
1. Arithmetic							
a) Mechanical Arithmetic	64.46	57.25	51.71	66.90	56.34	60.41	55.87
b) Applied number problems	41.69	51.42	52.11	46.40	45.62	50.11	47.17
c) Using data from tables	58.69	62.02	45.42	50.08	60.01	55.45	46.82
2. Geometry	40.72	39.20	41.62	46.76	39.72	40.13	39.89
3. Algebra	37.63	40.58	46.72	42.02	38.33	39.67	38.67
4. Graphs	48.07	32.23	38.62	59.19	36.23	45.14	50.25

Source: Kenya National Examination Council, 2002; 2003; 2004.

The trend in Table 1 is further revealed in Table 2, which shows the area of syllabus coverage in primary mathematics and the percentage of candidates scoring correctly in various sections of the syllabus. Table 2 also shows a general below average achievement in geometry compared to other syllabus topics in primary mathematics from 1998 to 2004. Poor achievement in certain topics within the syllabus aggregates in the learner's overall score in their final examination. The Kenya National Examination Council consistently reports that a majority of candidates who attempted questions in geometry displayed poor skills in the use of geometrical sketches (Kenya National Examination Council, 2000; 2001; 2002; 2003; 2004 & 2006).

The 2005 KCPE Examinations report indicates that learners' achievement in geometry has been declining with time (Kenya National Examination Council, 2006). The achievement of all special educational schools is included in these reports in line with the law that opposes segregation of the handicapped, and hence is not displayed separately. The Ministry of Education's 2004 KCPE analysis report indicates that none of the schools for hearing-impaired learners registered a mean score above 150 points out of the expected total of 500 points, except Mumias School for the Deaf which got a mean score of 154.50 points, compared with the national mean of 250.42 points. The worst achievement at the national level was registered by Kibarani School for the Deaf in Kilifi District with a candidature of 9 and a mean score of 121.87. This raised questions whether special schools should or should not continue taking common examinations with regular schools (Ministry of Education Science and Technology, 2005).

Computer-Aided Learning (CAL) has emerged as a major instructional strategy. It refers to the kind of teaching/learning where a computer presents part of the visual learning environment. Difficult concepts can be explained using animations and graphical display capabilities of the computer (Yushau, 2004). Various studies have been conducted to investigate the usefulness of CAL as an instructional strategy. In a study to establish the effects of CAL as a Hypermedia Learning Environment (HMLE) in the teaching of algebra, Multisilta (1996) observed that HMLE supports learning by providing a means of organising and presenting information in alternative ways which include linear text, implicit links from mathematical concepts to their concept maps. He also noted that the method increased team learning, cooperation and discussion in class.

Mevarech and Rich (1985) reported that CAL led to gains in mathematics achievement with positive cognitive and affective development of disadvantaged elementary school pupils from the third to the fifth grade. Yushau (2004) observed that learners' aptitude in mathematics and their proficiency in english language were the most significant contributors to students' mathematics achievement in a study to establish the effects of CAL on achievement in mathematics. Marion (2004) sought to establish the effects of using a new CAL software in a school and recorded a positive relationship between students who received the 'Fast ForWord' reading program intervention and those who did not receive the intervention in reading and language. Blomeyer and Martin (1991) report that CAL presents a powerful innovation which has great potential for the improvement of learning and teaching. Studies conducted in other countries have therefore reported many positive effects where CAL has been used to augment instruction. In view of the above, the computer has thus been considered as a cognitive tool for not only disseminating knowledge, but enhancing learning.

However, existing evidence that has been highlighted above suggests that CAL has mainly been explored as a teaching in teaching mathematics. CAL has not been explored as a learning strategy in the teaching of geometry or in studies conducted in Kenya. This is evidenced by lack of information on the topic in both printed media (books and journals) and digital electronic media on the internet. Many scholars in Kenya have not ventured into research to study the effectiveness of CAL. A few studies conducted in Kenya have mainly concentrated on computer based instruction among more senior learners in secondary schools. These studies have also concentrated upon normal learners who have no special disabilities. This offers a

contrast from this study which specifically targets the use of CAL among hearing-impaired learners in primary schools in Kenya. Therefore, this study does not replicate any other study of a similar nature in Kenya.

1.2 Statement of the Problem

Students in Kenya have continued to perform poorly in the Kenya Certificate of Primary Education (KCPE) national examination over time. Learner's achievement in mathematics in regular public primary schools has been very poor over the years. This is evidenced by national examination results, which apart from portraying learners' level of understanding of mathematical concepts point to methods of teaching mathematics among other factors. The problem is much more profound in special schools among the hearing-impaired learners, owing to their hearing disabilities. One area in which learners' achievement has been relatively low at KCPE is geometry. Intervention in methods of instruction employed at primary three levels where the inculcation of geometrical skills commences and presumably, the beginning of difficulties in the learning process, is necessary. The study therefore sought to establish whether hearing-impaired learners could benefit from Computer-Aided Learning when this strategy is used in the teaching of mathematics in Kenya's special schools.

1.3 Purpose of Study

The purpose of the study was to develop a Computer-Aided Learning geometry software as a teaching strategy, and to investigate its effects on learners' achievement in geometry, and perception of their mathematics learning environment in schools that have hearing-impaired learners.

1.4 Objectives of the Study

The study was guided by the following two objectives:

1) To determine the effects of using the CAL geometry software on hearing-impaired learners' achievement in geometry.
2) To determine the effects of using the CAL geometry software on hearing-impaired learners' perception of their learning environment.

1.5 Hypotheses

The following null hypotheses were tested in the study:

Ho1: The use of the CAL software in the teaching of geometry in standard three has no statistically significant effect on hearing-impaired learners' achievement in geometry.

Ho2: The use of CAL software in teaching geometry in standard three has no statistically significant effect on the perception of the classroom environment between hearing-impaired learners exposed to CAL and those not exposed to it.

1.6 Significance of the Study

Apart from adding to the existing body of knowledge on the use of computers for classroom instruction, this study's findings might play a significant role towards improving the learning of geometry among hearing-impaired learners. It may also enable curriculum specialists to find in CAL an instructional alternative in the teaching of geometry among hearing-impaired learners. Teachers in special schools for hearing-impaired learners may find a useful tool of instruction in the CAL software. Teachers of mathematics in special schools for hearing-impaired learners

will be assisted through this study to delve into the production of CAL software in subject areas where they experience difficulties.

1.7 Scope

This study concentrated on hearing-impaired learners in special schools for the hearing-impaired in Rift Valley Province, Kenya. The province has a population of seven primary schools for the hearing-impaired, two of which are units. This is followed by Central province and coast which have five schools each. Every district has one school for hearing-impaired learners. (See Appendix C). Rift Valley has the highest number of districts and hence the greatest concentration of schools for hearing-impaired learners. The four schools sampled in the province were representative of the population of hearing-impaired learners in the province.

1.8 Assumptions

The study was conducted under the following assumptions:

i) That every learner's socio-economic status would be relatively similar to that of any other learner involved in the study, with very slight inconsequential variations.

ii) That all sampled schools would provide normal learning environments that exposed all sampled learners to normal learning experiences provided for in special schools.

iii) That a majority of learners would not have very severe hearing impairments with regard to loss of hearing, as to negatively affect their ability to learn concepts during classroom instruction.

1.9 Limitations of the study

Computers were provided by the researcher for use in the study considering that special schools had no computers of their own. Insufficient funds led to the purchase of few computers. This limited the experimental group's access to computers to three machines per school. Many schools for hearing-impaired learners are located in remote areas that have no access to electricity. Lack of electricity in some schools limited sampling only to those schools that had electricity.

1.10 Definition of Terms

Achievement: A person's success attained through effort and skill which can be assessed by means of a testing device. In this study, this was represented by scores attained after administering the Mathematics Achievement Test (MAT).

Computer-Aided Learning: Computer Aided Learning (CAL) refers to special learning software written in form of tutorials, simulations, drills, and animated activities based in a computer program that is used to supplement traditional instruction by an instructor (Walker & Rostron,1998). . In this study, this referred to the mode of instruction where a computer-based program was developed by the researcher and then used in teaching geometry, to augment the learning process.

Classroom environment: Refers to the surroundings, circumstances or influences in a room where learning is taking place (Hornby, 1979). In this study, this referred to physical surroundings, resource distribution, learner participation or level of engagement.

Conventional Teaching: This refers to the traditional mode of instruction used in the regular school system where instruction is conducted through speech while giving

illustrations and explanations on the chalkboard. In this study, the term referred to the mode of instruction that was used to teach the control groups.

Decibel: Refers to the unit of measuring levels of sound to establish the loudness of sound. In this study, the term was used as defined.

Hearing-impaired: A person whose hearing faculties operate above the normal hearing range of approximately 60 decibels(dB) on the hearing loss scale (Cartwright, Cartwright & Ward, 1984; Mayberry, 2002). In this study, the definition included both the deaf and the hard-of-hearing.

Mathematics: The abstract science of numbers, quantities and space (Hornby, 1979). In this study, the term referred to the branch of mathematics namely geometry taught in standard three. Geometry was regarded to be a branch of mathematics. It was considered that the score in mathematics comprises of achievement in all questions including those that contain concepts in geometry. The score attained in mathematics is therefore, partly determined by the learner's score in questions relating to geometry in the examination. The term 'mathematics' was therefore used holistically, incorporating various branches of the subject, part of which is geometry. This was in view of the fact that learners take a national examination in mathematics and not in geometry, due to the fact that mathematics is inclusive of geometry.

Multimedia Builder: An object-oriented programming software for microcomputers developed by Roman Voska. It was used by the researcher to author the CAL software in this study.

Perception: Learners' sensory discernment or a process by which learners become aware of changes through their senses (Hornby, 1979). In this study, this referred to learners' views and opinions about their learning environment during the geometry lessons, which were measured using scores attained on administering the Mathematics Classroom Environment Questionnaire (MCEQ).

Socio-economic Status: An individual's / parents' stand in society with regard to resources and wealth, which is categorised as upper (rich), middle and low (poor) class.

***Special Schools*:** Schools that offer education to children with physical and learning disabilities in order to help them realise their potential (Republic of Kenya, 1988; Ndurumo, 1990).

Special Needs Units **(Units):** These are special classes located in regular schools to cater for children with mild degrees of impairment. Kenya's special classes are called 'units', and are usually found in regions that lack special schools (Ndurumo, 1990).

Total communication: A mode of communication that combines speech, lip reading, signs, gestures, finger spelling, reading and writing, in an effort to reach out to hearing-impaired learners (Ndurumo, 1990).

1.11 Overview of the study

This study is organised into five chapters. Chapter 1 discusses the background of the study, the statement of the problem, objectives of the study, hypothesis and significance of the study, research assumptions, limitations and an overview of the study.

Chapter 2 reviews literature relating to the world of the hearing-impaired and causes of the disability, government policy on education for the hearing-impaired, objectives of teaching mathematics in primary schools, language difficulties among hearing-impaired learners, management of the learning environment in Kenya's special educational system, teaching strategies for both normal and hearing-impaired learners. It also discusses the use of CAL in the teaching of mathematics and geometry among hearing-impaired learners and concludes with the conceptual framework upon which the study is based.

Chapter 3 contains research methodology. Information on the research design is given with regard to the target population, sample and variables addressed by the study. Pertinent literature on the design and development of the CAL software is discussed. The chapter includes the implementation of the software, data collection procedures and the analysis of data.

Chapter 4 presents the results and their related discussions.

Chapter 5 presents a summary of the findings in the light of the background of the study and related literature, conclusions, implications, recommendations and further suggestions for research.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter reviews literature of the hearing-impaired, causes of hearing impairment, Kenya government policy on education with regard to special education and hearing-impaired learners since independence in 1963 to the present day. The chapter discusses educational programs for the hearing-impaired, strategies employed in classroom instruction, the relationship between hearing-impairment and learning, intervention strategies employed in communication with hearing-impaired learners, medium of instruction, language policy in Kenya's educational system and the management of the learning environment in special schools. A review of literature has been done on the use of CAL in the teaching of mathematics among hearing-impaired learners. The Information Processing Theory of Learning and the conceptual framework upon which the study is based have also been elucidated and illustrated with the use of a diagram at the end of the chapter.

2.2 The World of the Hearing-impaired

Individuals who are physically normal tend to assume that everybody has the capacity to hear and reciprocate in verbal communication until they confront a hearing-impaired individual. It is at this juncture that basic communication skills pose a challenge to both the hearing and the hearing-impaired. Despite this, the hearing-impaired have always been part of our communities. The inability among the hearing-impaired to communicate effectively led many societies to ignore the hearing-

impaired, especially with regard to education all over the world until welfare and religious organisations intervened (Ndurumo, 1990). It was then that special education originated after various schools of thought established that the hearing-impaired were not very different from other people except for their inability to hear and hence speak. Special education programs were established in various parts of the world with variations based on policies, practices, politics, economics and coercion from pressure groups.

Special education programs become mandatory in USA in 1975 through the Education of All Handicapped Children's Act (Public Law 94-142) which sought to entitle free and fair education for disabled children as is accorded other children (Ndurumo, 1990; Wikipedia, 2006). In Britain and Scotland, the Special Educational Needs (SEN) programs were established to meet the educational requirements of the disabled child by providing appropriate support to facilitate education. In Australia, the government started the provision of special education in 1920, which became formalised in 1980 (Ndurumo, 1990; Wikipedia, 2006). In Kenya, special education was not formally recognised by the government until 1964 when the Kenya Education Commission addressed the issue seriously, thereby warranting government intervention (Ndurumo, 1990; Republic of Kenya, 1988).

Mayberry (2002) defines hearing as "the sensory modality through which people perceive speech, which is the universe of talk that ties individuals, families and societies together". Hearing gives children the ability to relate to their environment. Hence, those who are deaf miss a lot of worldly experiences. She further points out that children with hearing losses that are severe (70-89 decibels or dB) or profound (>90 dB) are referred to as deaf, cannot hear conversational speech and consequently

do not spontaneously learn how to talk (See Appendix D). She further adds that inability to talk at the right age is one of the initial indications that a child cannot hear (Mayberry, 2002).

Conversational speech falls within the range of 54 to 60 decibels (dB). In their inability to communicate using sign language or otherwise, the individual who has normal hearing tends to ignore the hearing-impaired under an ignorantly pre-conceived notion that the hearing-impaired person cannot communicate and hence is incapable of doing anything. Persistent ignorance towards the hearing-impaired ensures the normal person is oblivious of the negative effects this poses to the hearing-impaired. Basically, an individual with normal hearing often assumes that everybody can hear. A person's inability to hear or speak leads other people to assume that this particular individual is being rude, unfairly quiet or simply shy (Were, 2006; Hyde, 2006).

In school, more often than not, teachers misconstrue deafness in learners for rudeness which ignorantly elicits punishment for failure by the pupil to respond to a verbal question or teacher's command. Few hearing-impaired students in Kenya manage to rise academically, acquired a masters degree, and go on to attain a doctorate degree (Were, 2006).

This mistreatment leads to isolation, anger and frustration in the offended person. Impairment in hearing tends to block the development of spoken language and its comprehension. This in turn interferes with the development of a child's mental life. It is worth considering the fact that the child's brain is growing rapidly in line with the

inevitable physical development inherent among young children. A reasonable degree of cognitive development and learning is registered as the child attempts to understand everything around him/her (Steel, 2000; Mayberry, 2002).

At this stage, it is imperative for the child to adopt an effective mode of communication in an endeavour to express his/her thoughts. This also helps them to link their feelings and experiences to their environment. Later in this stage, the child quickly falls back to the use of mother tongue-based signs and gestures inherited from their parents since birth especially when communicating with parents. In a schooling environment, this child is able to perfect communication using a bit of the sign language taught in school while connecting it to experiences in their immediate community.

Many hearing-impaired learners experience difficulties in their pursuit for academic excellence. Ability in hearing-impaired students to communicate with teachers and classmates empowers them through stimulation to explore and grow in their endeavour to forge ahead both socially and academically. Most of the existing special schools in Kenya offer vocationally oriented primary education, thus limiting progress for many disabled aspirants, except those inclined towards craft-based careers. Very few schools offer secondary education. Out of 600,000 hearing-impaired in Kenya, only 8 have managed to proceed on to acquire a university education. Although studies indicate a less than average academic achievement among hearing-impaired learners, this does not in any way relate to their intellectual prowess (Were, 2006; Mayberry, 2002).

Research shows that the language of communication is the culprit. On graduation from high school where very few manage to reach, they still face difficulties in their attempts to get employment. This is due to the fact that employers tend to discriminate against people with disabilities under the notion that these employees cannot function appropriately like other members of society (Were, 2006; Mayberry, 2002).

Communication poses another major challenge for the hearing-impaired. There is always need for an interpreter to mediate between people who hear and the hearing-impaired. Where help is not available, one is compelled to communicate through writing or better still, use sign language where the audience is deaf (Hyde, 2006).

Despite the government's effort to empower the disabled, much remains to be done because the world of the disabled always remains the same. The plight of many handicapped individuals emphasises the need for a government policy that recognises every individual citizen's basic rights, if these members of the society are to make any progress. Electronic media should be used to influence the public's perception of the hearing-impaired and the disabled in general. This might change the negative general consensus among people who have normal hearing that hearing-impaired persons are incapable of achieving anything (Were, 2006). There is therefore an urgent need to empower the hearing-impaired through education in an attempt to bridge the gap between them and other members of society who have normal hearing.

2.3 Government policy on education for the hearing-impaired in Kenya

The constitution of Kenya maintains that education is a basic right for every child. This right includes children with normal functions and those with disabilities. This implies that equal treatment should be accorded all children without any form of discrimination in any setting. Contrary treatment is punishable by law (Republic of Kenya, 1988). Government policy on education is established upon factual recommendations by educational commissions. Research has proven that a higher than normal IQ score has previously been registered among hearing-impaired populations all over the world. There is therefore no ground for any form of discrimination with regard to academic prowess in education for the hearing-impaired learner (Mayberry, 2002).

On attaining independence, the Kenya government felt the need to educate handicapped children like other children instead of leaving the responsibility to charitable organisations, churches and foundations as had been the case prior to independence. To address this issue among others, the government addressed itself to the needs of handicapped children and observed that:

i) There was a need for special education and training for handicapped children with mild to moderate degree of impairment and those with severe to profound degrees of impairment.

ii) There was need to integrate the training of mild and moderately impaired children with the one offered in regular schools while catering for the impaired learners psychologically to enable them to adjust and follow the regular education curriculum.

iii) Handicapped persons/learners have both emotional and psychological needs arising from attempts to adjust to the society in which they live.

iv) Teacher training colleges should offer a special education course to enable student teachers acquaint themselves with effects of disability on learners' intellectual, social and general development in order to manage children with handicaps who may be in regular schools.

Recommendations from an education commission made Kenya a leading advocate of education for exceptional children in Africa. This has ensured the initiation of many special educational programmes and schools where handicapped children get education like other children in regular schools under a common syllabus for better social adjustment, considering the fact that handicapped persons form 10 percent of our population. One percent is hearing-impaired (Republic of Kenya, 1988 & Ndurumo, 1990).

2.4 Special education for the disabled learner

Special education is a mode of education that is administered to children with physical and learning disabilities in order to help them realise their potential. These children include those who are deaf, the hard-of-hearing, the blind, the speech impaired, the physically handicapped, the mentally retarded, emotionally disturbed and multiply handicapped. This education is given in special schools. Regions that lack special schools integrate special education in regular schools which are then refered to as special school units. (Republic of Kenya, 1988; Ndurumo, 1990).

The origin of special education traces back to the 18th century when educators became aware of the link between a child's abilities and the learning environment. Special

schools established in Germany became models for special education up to the early years of the 20th Century. England's Act of 1880 made education compulsory for all children, delaying the establishment of special schools until the 1890s. In Italy, Maria Montessori emphasised learning through discovery and the use of materials in developing children's sensitivity to their environment. Her ideas have continued to change the academic world with regard to the needs of disabled learners (Ashman & Conway, 1989). The placement of exceptional children in special schools was aimed at providing an environment that was conducive to learning while catering for individual differences among learners. However, the ultimate goal was the eventual return of handicapped pupils to regular schools to enable them to interact freely with their peers. (Cartwright, Cartwright & Ward, 1984).

In Kenya, special education is meant for exceptional children who cannot benefit from regular education due to their varied degrees of ability or disability. These children's academic needs were formerly ignored. African history reveals that such children were often isolated and left to perish in forests. Hearing-impairment is still treated with contempt in Kenya and is often viewed as deviant or abnormal. This lack of acceptance by society results in denial of the basic rights enjoyed by children of normal hearing (Ndurumo, 1990; Ramani & Ogodo, 2001).

The Ministry of Education in Kenya defines Special Education as the type of "education which provides appropriate modification in Curriculum, teaching methods, Educational resource, medium of communication or the learning environment in order to cater for individual differences in learning". The ministry aims at creating a

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conducive learning environment for all learners with special needs (Ministry of Education Science and Technology, 2005).

The aims of education for hearing-impaired learners are the same as those for all children. Secondly, disabilities do not diminish the right to equal access to education (Galloway, Armstrong & Tomlinson, 1994). The provision of special education was sanctioned to help these learners to utilise their potential to the maximum, as long as education was prepared to suit their needs. The Ministry of Education seeks to attain its objectives through the Special Needs Education Division (SNED) by:

i) Coordination and administration of special schools, units, integrated programmes for the disabled.

ii) Educational Assessment and Resource Services (EARS).

iii) Appointment of Board of Governors for Special Schools and Institutes.

iv) Allocation and disbursement of funds to special schools.

v) Coordination of recruitment of residential students for the Diploma Course in Special Education at the Kenya Institute of Special Education (KISE).

vi) Creation of awareness and sensitization on issues pertaining to children with special needs.

vii) Facilitation of clearance of imported specialized equipment and goods destined to special schools.

Special education programmes in Kenya are categorised according to the various types of impairments for ease of management of learners' specific unique needs. Existing programmes are based on the following categories of disabilities:

i) The Blind

ii) The Deaf

iii) The Deaf/Blind

iv) The Physically Handicapped

v) The Mentally Handicapped

vi) Cerebral Palsy

vii) Autism

There are 97 special schools and four Vocational and Technical Institutions that offer training in practical skills. This often leads to employment or self employment. Schools offering various special educational programs are listed in Table 3, which also shows the number of schools in the country.

Table: 3

The number and kind of schools offering special education programs

INSTITUTION	NUMBER
Special Primary Schools	
Hearing Impaired	41
Visually Impaired	10
Mentally Handicapped	38
Physically Handicapped	9
TOTAL	**98**

Special Secondary Schools	
Visually Impaired	1
Physically Handicapped	3
Hearing Impaired	3
TOTAL	7
Universities/Colleges/Schools and Resource Centres	
Technical/Vocational Institutes	4
Resource Centre for Blind	1
Schools with Special Units	1100
Educational Assessment & Resource Centres (EARC)	73
Provincial Assessment & Resource workshops	7
District under Kenya Integrated Education Programmes	34
Educational Assessment & Resource Centres	10
Primary Teachers Colleges Integrating Visually Impaired	2
Primary Teacher Colleges Integrating Hearing Impaired	1
College offering specialized certificate & Diploma Courses	1
Universities offering Special Education Degree	2

Source: (Ministry of Education Science and Technology, 2005)

A few special primary schools offer not only regular education, but also vocational training. Skills offered in these schools include carpentry, joinery and cabinet-making. This enables learners to acquire menial skills that enable them to earn a living after school. This aspect of education was incorporated in special education after considering the fact that many hearing-impaired learners drop out of the school system after primary education. In December 2004, the number of students enrolled in all special primary, secondary, technical and vocational institutions was 26,885, of whom 15,129 were boys and 11, 756 were girls. The overall school and college enrolment of handicapped students is shown in Table 4.

Table: 4

The overall school and college enrolment of handicapped students

INSTITUTION	BOYS	GIRLS	TOTAL
Special Primary	13,353	10,106	23,459
Special Secondary	6,490	536	1,026
Special Technical/Vocational	1,114	986	2,100
Vocational Institutions	172	128	300
TOTAL	**15,129**	**11,756**	**26,885**

Source: (Ministry of Education Science and Technology, 2005)

According to the Ministry of Education Science and Technology, there are cases where ignorant parents prefer to keep their handicapped children at home instead of taking them to school hence the low enrolment figures depicted in Table 4. Both the regular and Special Needs Education (SNE) is disseminated through a centralised curriculum where all learners go through the same learning experiences without regard for their varied handicaps. This grossly puts handicapped learners at a disadvantage. The mandate of developing a curriculum for educating learners with special needs lies with the Special Education Division of the Kenya Institute of Education (Ministry of Education Science and Technology, 2005).

National examinations for all learners including those with special needs are developed and administered by the Kenya National Examination Council (KNEC), which does not have its own trained personnel in Special Needs Education. KNEC contracts professionals and subject specialists for Special Needs Education services. Due to disabilities among the handicapped, KNEC examinations are adapted for

candidates with impairments by allowing candidates with special needs some extra time in which to do their examinations. Prior to being assigned in their respective schools, handicapped learners have to undergo a careful assessment in order to ascertain their impairment and appropriately allocate them to the right schools. Assessment is usually conducted at the various Educational Assessment and Resource Centres (EARCS) available in all districts at the District Education Offices (Ministry of Education Science and Technology, 2005). The Educational Assessment and Resource Centres at the District Education Offices provide the following services;

i) Identification and assessment

ii) Guidance and Counselling of parents of children with special needs

iii) Running courses for parents of children with Special Needs

iv) Establishment of special needs units (special class) in regular schools

v) Making referrals of children with special needs to special schools, units, integrated programmes or for medical examination and treatment.

vi) Running seminars for teachers handling children with special needs, field officers, local administrators, health and social workers

vii) Provision of hearing aids

viii) Collection of information which forms the basis for central planning and special needs education survey research

ix) Provincial Education Assessment and Resources Workshops.

All the eight provincial headquarters have a provincial workshop each which is staffed with technically trained personnel who produce teaching and learning

material, helpful devices and other support facilities required in special needs education (Ministry of Education Science and Technology, 2005).

2.5 The Relationship between the Hearing-impairment Handicap and Learning

The main documented relationship existing between hearing impairment and learning is a person's inability to communicate in a meaningful manner. Inability to hear does not in any way suggest that these learners cannot acquire academic skills. Evidence suggests that many such learners have proceeded to acquire higher education in universities. Language is a basic primary tool for communication. The absence of a medium of communication removes sense from normal life situations. It is only when we make sense out of our immediate environment that we are able to express our feelings, and hence give meaning to whatever we perceive visually, physically or mentally. The use of language in our day to day communication eases a child's ability to learn a language. While the social and communicative skills of a child with normal hearing ends up in speech, that of a hearing-impaired child ends up in a sign or gesture, owing to the fact that their receptive channel of communication tends to be visual (Mukhopadhyay & Sison, 2006).

This channel of perception is indicative of a child's ineptitude in processing audible sounds, commonly referred to as hearing loss. Hearing loss tends to affect a person's acquisition of communicative skills. This also tends to influence an individual's interactions with other people. Inability to hear also affects their ability to make sense out of the world in which they live, grossly affecting their acquisition of academic skills. The earlier the defect is identified, the better the child's academic and

emotional adjustment. When hearing loss occurs during the early stages of a child's development, all areas of development tend to be affected significantly (Easterbrooks, 2001).

In a growing child, Physical, mental and psychological growth spurts feature prominently with the passage of time, where growth occurs naturally in various aspects of the human body. The child's brain also tends to grow rapidly in line with the mentioned spurts and hence, a certain degree of cognitive development and learning is registered as the child seeks to understand and assimilate everything around him/her. Engler, Jeschke, Ndjeka, Sieler and Steinmuller (2006) maintain that language has an influence on an individual's cognitive skills. Cognition or intelligence includes perception, memory, mental imagery, concept formation, problem solution, language learning, academic achievement and navigation (Mayberry, 2002).

During classroom instruction, La Porta (2005) advocates for the teacher's usage of the established 'order of difficulty' in learning that is generally used in teaching all children in our attempt to meet specific instructional goals. Thus, all learning tasks should be so arranged as to develop from concrete to abstract especially in the selection of vocabulary, order of concept presentation, syntax and choices of materials and experiences to be presented. This ensures a progressive and systematic acquisition of concepts that is unhindered by extreme difficulty in learning. She further maintains that learning should be planned and implemented from a general to a specific conclusion in our choice of vocabulary. The teacher's use of language should be

restricted to words that are familiar to the learner for the simple fact that handicapped learners depend heavily on words, phrases or clause meanings.

The teacher should be careful enough to control the lengths of phrases or clauses when interacting with the learners, which helps them to recall what they are learning better. The use of pictures and objects is greatly emphasised as visual perceptual stimuli against verbal/spoken or signed stimuli. This ensures the capturing of a learners attention (La Porta, 2005). La Porta advocates for repetition of new vocabulary, new concepts, sentence structures and multiple presentations to increase understanding in the course of instruction. One should also ensure to use simple pictures when introducing new or unfamiliar vocabulary or concepts. From the arguments above, it is evident that language and mode of presentation play a key role in the education of hearing-impaired students.

2.5.1 Intervention strategies employed in communication with hearing-impaired learners

The world in which we live is moulded around speech and one's ability to hear the spoken word. Such an environment presents enormous problems to people with speech or hearing handicaps. Their inability to speak, form coherent words and make meaningful speech cuts the hearing-impaired from their social environment. Various strategies have to be employed to bridge the communication gap between the hearing-impaired and the society in general. This is especially so when deaf students have difficulties in language learning, specific intervention strategies must be employed towards addressing this specific need (La Porta, 2005).

According to Easterbrooks (2001), it is generally recognised that no single system of communication is right for all children with hearing loss. The choice of a communication system must take into account a child's characteristics, available resources and family's commitment to a method of communication.

Zak (2005) suggests that parents and doctors have to decide whether a child will find it beneficial to take an Oral based or Sign based education. One of the criteria is the amount of hearing the child has. Some of the interventions in use include:

(i) Auditory-Verbal Communication

(ii) Lip-reading or Speech-reading

(iii) Cued Speech

(iv) Sign Language

(v) Total Communication

(vi) Writing

(vii) Typing

Auditory-Verbal Communication is guided by a set of principles that come under the Auditory-Verbal philosophy. Among other researchers, Hyde (2006) and Goldberg (1997) define the Auditory-Verbal philosophy as a set of guiding principles that outline the prerequisites of hearing-impaired learners' likelihood to improve their education by increasing their usage of any residual (remaining) hearing. Amplified residual hearing enables learners who are hard-of-hearing to learn to listen, process verbal language, and to eventually speak. When done early during a child's development, this approach enables these children to learn how to speak. This implies

that implementation of auditory-verbal principles must begin with the parents of young children who have impaired hearing.

The prime aim of auditory-verbal practice is to enable hearing-impaired children, including those who are hard-of-hearing, to grow up in natural learning environments that enable them to become independent, participating, and contributing citizens in society. The philosophy supports basic human right that children with all degrees of hearing loss deserve an opportunity to develop the ability to listen and use verbal communication within their own family and their communities (Goldberg, 1997). Goldberg (1997) enumerates the principles of auditory-verbal practice as follows:

(i) Working toward the earliest possible identification of hearing loss in infants and young children.

(ii) Seeking the best available sources of medical treatment and technological amplification of sound for the child who has impaired hearing or is hard of hearing as early as possible.

(iii) Helping the child understand the meaning of any sounds heard, including spoken language, and teaching the child's parents how to make sound meaningful to the child.

(iv) Helping the child learn to respond and to use sound in the same way that children with normal hearing learn.

(v) Using the child's parents as the most important models for learning speech and spoken communication.

(vi) Working to help children develop an inner auditory system so that they are aware of their own voice and will work to match what they say with what they hear others saying.

(vii) Knowing how children with normal hearing develop sound awareness, listening, language, and intellect and using this knowledge to help children with hearing impairments learn new skills.

(viii) Observing and evaluating the child's development in all areas. Changing the child's training program when need arises.

(ix) Helping children hearing impairment participate educationally and socially with children who have normal hearing by supporting them in regular education classes.

Lip-reading which is also known as speech-reading is a system where the hearing-impaired try to derive meaning out of communication through speech by carefully observing the speaker's face, lip movement, tongue and jaws. Various sounds tend to produce different pattern on our faces. However, not all audible sound can be visualised. Many more sounds are produced in the vocal tract and hence invisible to the eye. This leads to loss of fractions of speech to lip readers and hence their failure to recognise full meanings of the spoken word. Thus, lip-reading and audition operate in a mutually supportive manner (Hyde, 2006).

Cued Speech is a sound-based system of hand cues that supplement speech-reading. It comprises of a set of hand shapes made at various locations around the face. It helps in distinguishing between sounds that look similar on the lips and to make speech-reading easier (Zak, 2005). Sign Language is a manual mode of communication involving the use of hand symbols to convey ideas, concepts or words (Cartwright, Cartwright & Ward 1984). This mode of communication employs manual symbols resembling gestures for expressions and emotions. Sign language varies with regard to

location. The mode in use in a particular location may not be applicable elsewhere. Total Communication refers to the mode of communication that is used most often by hearing-impaired learners at any given time. This mode of Communication involves simultaneous use of speech and sign language providing the most general mode of communication in use. Total communication is preferred for instructional purposes. Hearing-impaired learners may often resort to simple writing with pen and paper or typing using a type writer or computer when available, in their attempt to communicate.

2.5.2 Special educational programs for hearing-impaired learners

According to Ndurumo (1990), the first educational programs for the handicapped were established prior to independence by church-based organisations. After independence, the government established special programs which form an integral part of every cycle of formal education. There are currently several types of educational programs for hearing-impaired learners categorised as:

a) *Boarding school programs*: these cater for particular handicaps while providing fulltime instruction and residence to hearing-impaired learners. Most schools offer vocational education (Ndurumo, 1990).

b) *Special day school programs*: these programs aim at having pupils attend day schools while they live with their parents. They are also meant to assist the child to develop a positive self concept (Ndurumo, 1990).

c) *Special Unit Programs:* these are special classes within regular schools to cater for children with mild degrees of impairment. (Ndurumo, 1990).

d) *Peripatetic service programs*: these are special programs given by itinerant teachers as they move from one regular school to another providing assistance to handicapped learners at given times of the week (Ndurumo, 1990).

e) *Mainstream programs*: these are programs that enable handicapped pupils to interact with their families and peers while being integrated with those in regular schools (Ndurumo, 1990).

According to Ndurumo (1990), education for hearing-impaired learners originates from the establishment of the Kenya Society for Deaf Children in 1958. By 1985, there were 2187 hearing-impaired pupils in schools. In 1988, there were 2475 pupils' in 22 residential primary schools and two units in regular primary schools. The number of pupils in special schools for hearing-impaired learners have continued to grow steadily such that, there are 41 schools for hearing-impaired learners in Kenya today (Ministry of Education Science and Technology, 2005).

The number of special programs available in Kenya testify to the need for more comprehensive programs that will not only entirely cater for an individual learner's needs , but also address the needs of many learners in a shorter period of time than it now takes to educate a hearing-impaired learner. The number of hearing-impaired learners continues to increase with the passage of time. Machines deliver results in

large masses within the shortest spans of time. Educational strategies that include mechanisation should be promoted in our educational system.

2.6 Objectives of teaching mathematics in primary schools

According to the primary school syllabus, mathematics should serve its instrumental purpose of facilitating the ends of other disciplines apart from helping individuals to function effectively in the community. This is in view of the terminal aspect of primary education to many pupils in Kenya (Kenya Institute of Education, 1992). The subject is therefore instrumental in partly determining the academic destiny of a learner. Many children fall out of school after primary education. Few if any proceed to acquire secondary education. Handicapped children are more likely to drop out of school than normal children. There is therefore a need to examine the primary school curriculum in an attempt to establish the reason behind premature termination of education at such a basic level. The primary school curriculum is organised in two cycles:

a) Lower Primary Cycle (Standard 1-3)

b) Upper Primary Cycle (Standard 4-8

The main objectives of teaching mathematics at primary level are to produce a person of sound mind who is also numerate, literate, accurate and logical. Thus, the mathematics syllabus for the lower primary cycle aims at developing numeracy and literacy, while the one offered in upper primary aim at developing practical skills that prepare learners for work (Asiachi & Oketch, 1988; Kenya Institute of Education, 1992).

Mathematical concepts taught in standard three in Kenya's primary schools include numbers, addition, subtraction, multiplication, division, area, volume, capacity, length, weight, time, algebra, graphs, temperature, rates, simple geometry which includes the identification of shapes like circles, triangles, squares, rectangles, and the making of patterns using circles, triangles and rectangles, squares and rectangles (Jomo Kenyatta Foundation, 1998). Greater attention should be directed towards ensuring these young learners absorb most of the concepts presented to them at this level with an aim of internalising relevant bodies of knowledge for use in future at a higher level of education when concepts become more and more abstract and complex. Efforts should be directed to relating ideas absorbed in class to real life experiences. The need for better learning strategies is necessary.

2.7 Language policy, medium of instruction and language difficulties among hearing-impaired learners

Learners who are hard-of-hearing rely upon hearing aids, while the deaf who are incapable of hearing rely totally upon sight and touch. The two groups of learners rely on different modes of communication, namely manual, oral and total communication which blends the normal and oral modes. Hearing-impaired children start learning sign language after they join school. Cartwright, Cartwright and Ward, (1984) argue that manual communication involves using hand symbols to convey ideas, concepts or words. This mode of communication, referred to as sign language, employs manual symbols resembling gestures for expressions and emotions. Sign language varies with regard to locations where it is used. American Sign Language (AMESLAN or ASL) has been developed as the standard sign language for the hearing-impaired in U.S.A. Finger spelling is another form of manual communication where each letter of a word

is spelled using fingers. Finger spelling and sign language are used together for greater effect (Cartwright, Cartwright & Ward, 1984).

Language is fundamental to the formation of concepts and mental processes. It is at the centre of all difficulties in the teaching of mathematics to hearing-impaired learners. Engler, Jeschke, Ndjeka, Sieler, and Steinmuller (2006) point out that a learner's acquisition of mathematical concepts is influenced by the linguistic structure of his/her native tongue. Hearing-impaired learners lack an elaborate way of expressing ideas. Their inability to speak, hear and pronounce words compels the teacher to explain the meaning of every word before putting it into use. The four areas of listening, talking, reading and writing are intertwined in a complex manner such that they depend and develop from one another (Durkin & Shire, 1995).

Kenya's Sign Language Research Project has codified and standardised the country's Sign Language to ensure its effectiveness as a medium of communication by publishing a dictionary containing 2,314 signs that are relevant to the local context. The dictionary is expected to ease communication and learning (Ramani & Ogodo, 2001). Teachers of hearing-impaired learners are often confronted with language difficulties during classroom instruction. Donaldson (1986), Furth (1966) and Stone (1980) argue that hearing-impaired learners experience difficulties with connectives/small words that form the basis of our thinking and talking. Speaking and thinking go hand in hand. Hearing-impaired learners who are born deaf do not know their native tongue. Teachers of hearing-impaired learners have to explain the meaning of each word during instruction in order to effect communication.

Cockroft (1982) agrees that language plays an essential role in the formation and expression of mathematical ideas. This is also affirmed by Okech and Ngumba (1991). Language problems among hearing-impaired learners introduce an inhibition in sensory perception, calling for the enhancement of their learning environment in order to maximise perception. One way of maximizing perception may be in the introduction of the BALDI tutor, software which plays recorded speech while showing expressions of one's face coupled with articulations of the tongue. This enables the learner to visualise speech and corresponding mouth formations, further enhancing learning among hearing-impaired learners through lip-reading, by offering audiovisual stimuli (Noppenberg, 2002).

Learners with language disorders, especially those with hearing-impairment, are aware that their communication patterns deviate from those of other children whose language development is normal. This awareness stirs up personality and social development issues which may include:

i) Hostility

ii) Aggressiveness

iii) Withdrawal

iv) Tantrums

v) Denial

vi) Anxiety

vii) Apprehensiveness

viii) Frustration

ix) Impulsiveness

x) Excessive self criticism

These characteristics tend to be more prevalent among hearing-impaired learners and to a lesser negligible degree among normal learners. In order to maximise learning, there is therefore need to control and manage the learning environment around hearing-impaired learners to enhance learning and improve their social adjustment. The teacher can supplement his/her energy through the use of a machine and still be more effective, with positive results.

2.8 Management of the learning environment in Kenya's special educational system

A number of considerations are necessary for instruction among hearing-impaired learners. They include the physical learning environment, presentation of instruction, feedback of pupils and classroom management. Since hearing-impaired learners rely mainly upon sight and touch, visually distractive stimuli should be reduced to a minimum. Theory shows that these pupils are easily distracted thus posing classroom management problems to teachers. Apart from visual teaching/learning aids, physical objects are availed to appeal to the sense of touch. For maximum attention, authoritative control and observation, a semicircular seating arrangement is recommended where the teacher's desk is placed in a central location. Grouping is recommended to cater for differences in rates of concept absorption and level of attainment in an attempt to develop group homogeneity (Ainscow, 1989; Gearheart, DeRuiter & Sileo, 1986; Kirk & Gallagher, 1986).

Dean et al (1996) allude that in order to enhance the learning environment; a single computer in the classroom can successfully achieve clearly defined results so long as there is proper configuration of the computer's hardware, peripherals, and the instructional software in the computer. Central listening and computer-aided learning require scheduled time limits. There is need to employ various methods of presentation including visual, demonstration and direct involvement of pupils. Hearing-impaired learners require continuous stimulation. Question-answer method should be used to sustain learners' attention and feedback. Praise is valued in that it contributes positively towards pupils' confidence and encouragement (Gearheart, DeRuiter & Sileo, 1986; Kirk & Gallagher, 1986; Ainscow, 1989).

In most schools for hearing-impaired learners in Kenya, the learning environment is usually organised carefully to attract much of the learners' attention. This is done by covering walls with charts, pictures, photographs and models of numerous animate and inanimate objects, to address relevant conceptual ideas during the instructional process. Hearing aids are then installed on desks in front of the learner, most of which tend to malfunction either due to misuse or disuse. Many of these hearing aids were not functioning. Learners' desks were then arranged in a semi-circular manner around the teacher's desk to ensure teachers maintain eye contact with the learner during instruction. This was to ensure maximum attention was directed to the teacher who would then give instructions using signs and gestures coined by hands and various parts of the body in what was called total communication. Learners often tended to be distracted by other learners and movements or intrusions in the environment, thus interfering with the flow of instructions. There was therefore an urgent need to create a more attractive, interesting, motivating and interactive learning environment that

could occupy the learner longer while extending their attention span. Computer-Aided Learning carries such a potential.

2.9 Teaching strategies for normal and hearing-impaired learners

Teaching is a process where a teacher guides a learner to acquire concepts, skills, values and attitudes in order to cognitively develop a learner's mind. Strategies are plans, actions, steps and processes that are designed to accomplish any learning or problem solving task (Olela & Bennars, 1993; Gearheart, DeRuiter & Sileo, 1986). A teaching strategy therefore refers to a method that helps to guide a teacher's decisions in what and how to teach. Mondoh and Yadav (1998) attribute learners' achievement in mathematics to effective usage of modern teaching techniques. They recommend methods that emphasise a heuristic approach towards learning. Different strategies are required for instructing learners of varying ages, ability levels and handicaps. Strategies must fit within pupils' cognitive and language abilities to be effective. There are tendencies among teachers to use expository instructional approaches that are unsuitable for pupils with learning difficulties.

Changeiywo (2001) observes that the teaching of science and mathematics in Kenya's schools is theoretical, mainly characterised by the 'chalk-and-talk' style that is text-book oriented. The teaching of mathematics requires a practical approach based upon life experiences. Montgomery (1990) argues that the expository strategy is quick but inappropriate for teaching mathematics where comprehension depends upon practical activity. A multimodal learner-oriented strategy catering for learner needs is deemed to be a more effective mode of instruction in that teaching adapts a facilitative role while the learner has more unimpeded opportunities for exploration and discovery.

Strategies employed among hearing-impaired learners are mainly concerned with various aspects of communication. The invisible nature of this disability often makes teachers to forget that the student has a disability, with dire consequences and failure on the pupil's part to comprehend any relayed information. Research and actual practice in special schools indicates that teachers who are conscious of this disability will ensure to:

i) always face the student with a hearing impairment when communicating.

ii) attract the attention of a hearing-impaired learner before speaking or communicating.

iii) use facial expressions, gestures, and other body language to convey messages.

iv) gently touch the student to indicate that you want to talk to him/her if they are distracted.

v) reinforce repetitively.

vi) if necessary, the teacher should use legible written notes to communicate.

vii) avoid talking while writing on the chalkboard.

viii) obtain feedback from hearing impaired students often as a show of understanding.

ix) Speak slowly and clearly for the benefit of lip-reading student.

The teaching strategies mentioned above are commonly employed during instruction to hearing-impaired learners. Despite their usage, not much is achieved with regard to positive progress among these learners. The teachers still falls short of delivering

concepts effectively to learners as is evidenced by their scores. Most learning sessions tend to be boring and uninteresting. There is a need to create a more stimulating environment that is more conducive to learning in order to activate the learner's curiosity and direct them towards the intended goal.

2.10 The teaching of geometry in primary schools in Kenya

Concepts relating to geometry are introduced to learners at a very early stage of their school life. Geometry is first taught in the standard three level of primary school education, when most pupils are aged between 8 and 10 years. At this age, pupils tend to be poor and clumsy in handling objects and equipment used during the construction of geometrical shapes. Pupils at this stage are yet to be introduced to the use of geometrical instruments and hence use rudimentary aids e.g. pupils use coins or discs to draw circles. The teaching and learning of geometry involves manipulative skills and the use of geometrical instruments for accuracy. Learning tends to be more practically oriented before learners attempt to write concepts on paper. Concepts taught in standard three include:

i. Shapes ;
   a) Circles
   b) Triangles
   c) Squares
   d) Rectangles

ii. Pattern-making using;

a) Circles

b) Triangles

c) Squares

d) Rectangles

The absorption of cognitive skills at this basic level of education involves identification of geometrical shapes from the environment and making sense out of what the learner sees. Basic shapes and objects include; cuboids, cubes, spheres, balls, discs, oblongs, squares, circles, triangles (Jomo Kenyatta Foundation, 1998).

Teachers involve learners in exercises of sorting many objects according to their various shapes and sizes. This exercise is usually expected to lead to the identification of various shapes and contrasting between objects with regard to size. Learners are expected to identify flat objects, round objects, straight, curved, closed and open objects. This assists the learner to connect various objects with their distinctive characteristic shapes against other different objects. Learners should be able to identify big objects from small ones when exposed to physical objects in their immediate environment. The learning environment in primary schools contains coloured pictures, charts on walls, objects of various shapes, sizes and colour to make it more conducive to learning.

Cognitive skills attained at this stage are expected to increase to a higher level where pupils are supposed to make sense out of experiences acquired in class by making simple patterns. Manipulative skills at this level involves cutting paper to produce

specific shapes, folding paper to produce different shapes and colouring various objects using different shades of colour. The cutting and folding of paper helps the learner to identify objects with their respective nets.

The higher skills on division of objects are introduced during the cutting and folding exercises on plane shapes in paper form. The pupil is expected to fold squares, circles, triangles and rectangles into halves, quarters etc. the unfolding of these shapes blends concepts on the division of objects with the formation of patterns. The learner is expected to observe the connection between various shapes when exposed to mosaics that form common shapes, triangles, squares, circles and rectangles.

Learning therefore involves a lot of practical work, environmental experiences, guided instruction and the learner's eventual discovery of properties of common shapes in geometry. Thus, the learning of geometry can not be divorced from the learning environment in that, the learner borrows a lot from the environment. Learning environments in normal regular primary schools are basically similar to those in special schools except for the presence of special electronic hearing devices in special schools. However, the main difficulty lies in the nature of the learners. While pupils with normal hearing might quickly adapt to their learning environment, hearing-impaired learners are limited by their hearing disabilities.

There is need to create a learning environment that is conducive to the learning of geometrical concepts by making the immediate environment more appealing to the learner. The presence of physical real life objects in the learning environment ensures

the ease with which a learner distinguishes shapes relating to intended cognitive skills. In traditional teaching, the teacher often tends to limit instructional modes to the use of the chalk and the board, with little impact upon the learner, judging from national examination results (See Table 1). Teachers in special schools have to overcome this barrier to communication in order to effectively impart skills in geometry. New learning strategies are therefore required to help the learner to absorb geometrical concepts with ease. CAL can serve this purpose effectively.

2.10.1 The use of CAL in the teaching of mathematics among hearing-impaired learners

Computers have made major gains in our day to day lives and continue to gain acceptance in various spheres, especially academically. The discovery of the computer and the World Wide Web have revolutionised the entire educational system. Research has done a great deal to shape the use of computers in the teaching of mathematics. Computers are used to enhance the environment in which the teaching and learning of mathematics is being done (Yushau, 2004). A lot of studies conducted to investigate the use of the computer in classroom instruction have mainly concentrated on normal learners. Some of these studies are highlighted below with their findings.

Anderson reports that instructional CAL programs present information through drills, tutorials, simulations, tests and games. They give instant feedback while allowing for frequent mistakes by learners (Gearheart, DeRuiter & Sileo, 1986). These findings support the fact that computers are rich in educational and social benefits. Blomeyer and Martin (1991) observed a variety of physical, emotional, cognitive and social

behaviour among normal learners. During this experiment, enthusiasm, high degrees of attention and concentration among learners were observed during CAL. Computer-Aided Learning programs promoted group activity and competition where learners were allowed to work jointly on a drill or task.

Intelligent Tutoring Systems (ITS) that are capable of evaluating and assessing learners' responses to lesson questions have been developed by software developers. Developers of this software believe that learners' thought processes "can be modelled, traced, and corrected in the context of problem solving, using computers" (Noppenberg, 2002). Computers can be programmed to offer very dynamic classroom lessons on any subject at any learner's rate of comprehension by monitoring learners' progress in the subject, their motivation and through the presentation of information. This technology has made CAL indispensable in classroom instruction (Noppenberg, 2002).

Durkin and Shire (1995), Costello (1991), Favaro (1986), Light, Sheldon and Woodhead (1991) including the Dale Carnegie Forum on Education agree that the potential of the computer as an instructional tool for students with special needs is yet to be fully realised. This is due to the fact that few studies have focused on special education. There is therefore need to explore this branch of education. A few studies that have explored the effect of using CAL for instructional purposes are highlighted below. In their investigation of the impact of CAL on mathematical achievement and self-concept among disadvantaged learners, Mevarech and Rich (1985) established that these students scored higher on both cognitive and affective measures as opposed to those instructed using traditional methods. Their study compared the effects of

CAL and traditional instruction on the mathematics achievement and attitudes of disadvantaged Israeli students in grades 3, 4, and 5. The achievement of CAL participants was higher, and their attitudes toward school and toward themselves as math learners were more positive.

In special schools, the control of hearing-impaired learners can be rather difficult during classroom sessions. Much has to be done to attract and contain the handicapped learner in a way of elongating their attention span. A stimulating environment is created by the computer. Its rich visual displays are quite captivating and engaging to these pupils. The interactive aspect of the computer contains a motivating factor. The visual nature of the display renders the language handicap among hearing-impaired learners insignificant. Repetitive possibilities of the computer enable pattern learning without disturbance (Ray & Davis, 1991). A linguistically rich environment should be colourful, stimulating and challenging. The computer offers opportunities that enhance the language environment. CAL programs begin at a reasonable entry level for the learner towards increasing levels of complexity. Programs free teachers to concentrate upon learners' language development (Burham, 1988; Crompton, 1989).

In her review of studies involving the use of computers, Cotton (2001) summarises research findings of various studies that report the positive effects of CAL as follows:

(i) The use of CAL as a supplement to conventional instruction produces higher achievement than the use of conventional instruction alone.

(ii) Research is inconclusive regarding the comparative effectiveness of conventional instruction alone and CAL alone.

(iii) Computer-based education (CAL and other computer applications) produce higher achievement than conventional instruction alone.

(iv) Student use of word processors to develop writing skills leads to higher-quality written work than other writing methods (paper and pencil, conventional typewriters).

(v) Students learn material faster with CAL than with conventional instruction alone.

(vi) Students retain what they have learned better with CAL than with conventional instruction alone.

(vii) The use of CAL leads to more positive attitudes toward computers, course content, quality of instruction, school in general, and self-as-learner than the use of conventional instruction alone.

(viii) The use of CAL is associated with other beneficial outcomes, including greater internal locus of control, school attendance, motivation/time-on-task, and student-student cooperation and collaboration than the use of conventional instruction alone.

(ix) CAL is more beneficial for younger students than older ones.

(x) CAL is more beneficial with lower-achieving students than with higher-achieving ones.

(xi) Economically disadvantaged students benefit more from CAL than students from higher socioeconomic backgrounds.

(xii) CAL is more effective for teaching lower-cognitive material than higher-cognitive material.

(xiii) Most handicapped students, including learning disabled, mentally retarded, hearing impaired, emotionally disturbed, and language

disordered, achieve at higher levels with CAL than with conventional instruction alone.

(xiv) There are no significant differences in the effectiveness of CAL with male and female students.

(xv) Students' fondness for CAL activities centres upon the immediate, objective, and positive feedback provided by these activities.

(xvi) CAL activities appear to be at least as cost effective as, and sometimes more cost-effective than other instructional methods, such as teacher-directed instruction and tutoring.

These findings underscore the significance of CAL as an instructional strategy in modern education by corroborating with many other similar findings akin to a study conducted by Yushau (2004), who reports that a student can learn mathematics with a good computer-supplemented program without missing anything in basic computational skills upon which major examinations are based. The fore mentioned benefits help to underscore the use of CAL in classroom instruction.

2.11 The Theoretical Framework

The theoretical framework upon which this study is based is the cognitive approach of The Information Processing Theory of Learning which entails Encoding, Processing, Storage and Retrieval of information through the following process:

i) *Encoding*-Information is sensed or perceived.

ii) *Processing*-Information is attended to.

iii) *Storage*-The information is stored for either a brief or extended period of time.

iv) *Retrieval*-The information is found at the appropriate time, and reactivated for use on a current task.

The prime advocates of the theory who include Gagne, Brunner, Anderson and Novak among others maintain that the prerequisites for learning are the ability to receive (by sight, ear and touch), process (mentally), store (mentally) and utilise information. This study intervenes where the absence of the perceptive component of "hearing" in an individual interferes with ones ability to "perceive" information and hence failure to "learn" (Atkinson, 2003). Various variables were addressed in this study. The dependent variables in this study were the student's achievement in geometry and their perception of the mathematics learning environment. The independent variables were the use of a Computer-Aided Learning geometry software and the conventional method of teaching mathematics. The researcher sought to investigate the effects of using the Computer-Aided Learning geometry software in teaching geometry in the experimental groups while controlling through the teaching of geometry using the conventional method of teaching.

The extraneous variables that were expected to influence the study were the level of hearing loss among learners in view of the fact that hearing-impaired learners were not homogeneous with regard to this handicap and also the ages of learners. These extraneous variables were to be controlled statistically during analysis through the choice of the Solomon Four research design. Another variable was the learners' entry level which would be controlled by basing the study on pupils at the standard three level of education. This ensured a common entry level for all respondents. The choice of intact classes of boarding pupils controlled for the variation in socio-economic

levels. The risk of interaction was eliminated through the vast distances between sampled schools in that each school was separated from the others by being located in district headquarters, and no two schools could be found in the same district. All teachers who took part in the study were trained up to diploma level of education (See the Conceptual Framework in Figure 1).

2.12 The Conceptual Framework

In the absence of the hearing faculty, hearing-impaired learners are expected to maximise learning through visual perception and physical manipulation which account for over 65% of learning (Walklin, 1994). According to Engler, Jeschke, Ndjeka, Sieler, and Steinmuller (2006), visualisation of mathematical objects enhances the learning of abstract facts towards a deeper understanding of mathematical concepts. Representations of the learning process involves stimulating the formation of mental models in the learner's mind by manipulating relevant frameworks in which learning is expected to take place, namely; conditions of learning. The key principle is that learning is viewed as a change in the learner's state of knowledge, where the learner is an active participant in the learning process. Emphasis is on structuring, organising and sequencing information to facilitate optimal processing. The goal of instruction is to communicate or transfer knowledge in the most efficient and effective manner possible. Learning results when information is stored in memory in an organized, meaningful way (Brannon, 2006).

A variety of learning strategies are employed in classroom instruction. Some of the strategies employed include:

i) Explanations

ii) Demonstrations

iii) Illustrative examples

iv) Corrective feedback

v) Outlining

vi) Chunking Information

vii) Repetition

viii) Interactivity

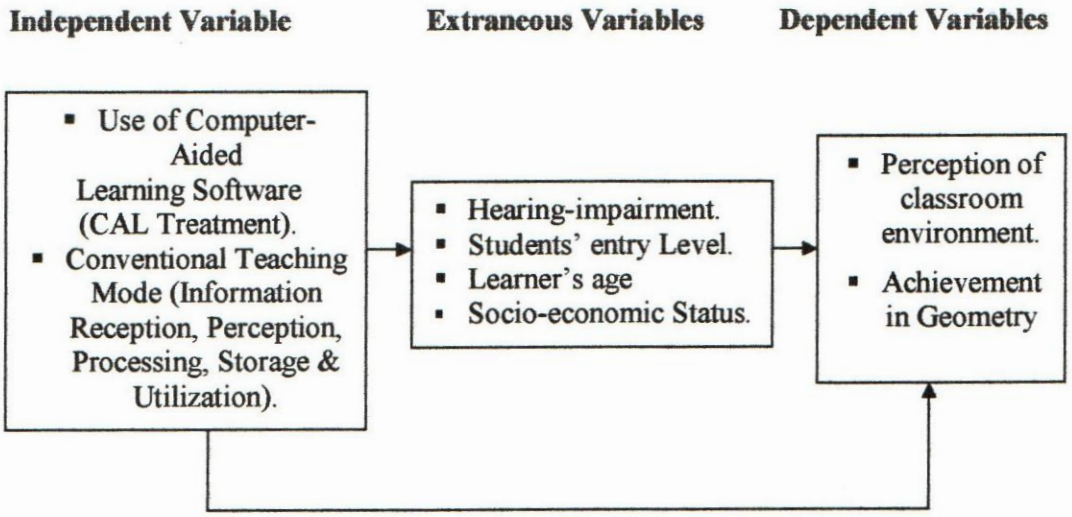
By providing a stimulating visually-oriented learning environment through the use of a carefully prepared computer based software, CAL is expected to enhance learning among hearing-impaired learners. This is to be effected by manipulating the learning environment through the shifting of active teaching from the teacher to the computer, while the teacher plays a facilitative role.

The study aims at exploiting the fact that visual images are better committed to memory than words or audible sounds. Visualised objects are understood without a language. This enables quick approximations by the learner despite the barrier presented by language. This is affirmed by the fact that lectures with considerable usage of visual and graphical aids are more effective than audio lectures (Engler, Jeschke, Ndjeka, Sieler, & Steinmuller, 2006).

Crompton (1989) argues that a linguistically rich environment should be colourful, stimulating, challenging and full of fun. The computer-based CAL software offers such an opportunity for visual learning. Piaget and Bruner's theories on cognitive

development affirmatively stress learners' abilities to select, extract, maintain and use environmental information as prerequisites to learning. This study aimed at introducing CAL as a means of imparting information, aiding the reception and processing of information in a motivating environment that stimulated sensory perception, comprehension and learning while catering for individual differences. The conceptual framework of the study is displayed in Figure 1.

Figure 1: The Conceptual Framework



NB: The arrows indicate how other variables affect the dependent variable.

In the conceptual framework, a comparison was to be made between the use of the conventional method of teaching geometry and CAL (treatment-independent variables) which was introduced as an intervention in the learning process by improving the learning environment hence perception of concepts visually among hearing-impaired learners whose perception is impaired by the absence of hearing (extraneous variable) and lack of the normal language of communication. The main aim was to improve learners' achievement in geometry (dependent variable) while controlling other extraneous variables (students' entry level, learner's age and socio-economic status).

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter describes the research design used in the study, objectives of the study and the variables under observation. It also identifies the location and target population of the study, sampling procedure and sample size that were used. It describes the instrumentation of data collection tools, the design and development of the Computer-Aided Learning (CAL) software, its implementation, data collection procedure and data analysis techniques employed in this study.

3.2 Research Design

The study employed the Solomon-Four Group design, a type of design under quasi-experimental research. This design was chosen because respondents who were purposively sampled also had differences in their degrees of hearing disability, which could easily affect the outcome of the experiment. The design is recommended by both Cook and Campbell (1979) and Frankfort-Nachmias and Nachmias (2003) due to its effectiveness in statistically controlling most extraneous variables that posed a threat to validity in the study but could not be controlled by the researcher. Intact classes from each school constituted units of analysis to ensure effective control of interactive effects among respondents (Cook & Campbell, 1979).

The design assigns respondents into four groups, one experimental group and three control groups. In this study, Group E was taken to be the experimental group while

groups C_1, C_2 and C_3 were taken to be the control groups respectively. Prior to administering CAL, the experimental groups E and the control group C_2 were exposed to the pre-test while control groups C_1 and C_3 were not. The experimental group E and the control group C_1 were then exposed to CAL while control groups C_2 and C_3 were instructed using the conventional mode of teaching in the same instructional syllabus contents, namely, Shapes and Pattern-making in Primary Geometry. All groups in the study (E & C_1, C_2, C_3) were finally subjected to a post test after CAL had been administered. The design is shown in Table 5.

Table 5:

The Solomon-Four Group Design

Groups	Pre-test	Independent Variable	Post test
E	T_1	CAL	T_2
.....			
C_1		CAL	T_3
.....			
C_2	T_4	Conventional Teaching Approach	T_5
.....			
C_3		Conventional Teaching Approach	T_6

Source: Adapted from Borg, Gall and Gall, (2003)

Key:

E	- Experimental Groups
C1, C2, C3	- Control Groups
T1, T4	- Pre-tests
T2, T3, T5, T6	- Post-tests
CAL	- Computer-Aided Learning
.....	- Groups were not homogeneous because the classes were already constituted

3.3 Variables

The independent variable in this study was the use of the CAL software, which was administered to the experimental group E and control group C_1. The dependent variable was the pupils' achievement which was measured by scores obtained on the Mathematics Achievement Test (MAT), and pupils' perception of their learning environment, which was represented by scores obtained on the Mathematics Classroom Environment Questionnaire (MCEQ).

3.4 Population

The target population for this study consisted of all Standard Three pupils based in special education schools for hearing-impaired learners in Rift Valley province, Kenya. Compared to other provinces, Rift Valley province hosts the largest number of districts and hence, population of special primary schools for hearing-impaired learners. The province has seven districts with a school per district, two of which are units. The province has an accessible population of 105 hearing-impaired boys and girls aged between eight and eleven years.

3.5 Sampling procedure

The sampling frame consisted of all special schools for hearing-impaired learners in Rift Valley province. Considering the limited number of schools for the hearing-impaired, purposive sampling was employed in the selection of the four schools. This was based on both accessibility and the availability of electricity in these schools. A simple ballot was conducted to assign sampled schools into experimental and control groups. Each group was used intact without any modification such as shifting, relocation or alteration of sitting arrangement.

3.6 Sample size

Four schools were purposively sampled from the seven schools for hearing-impaired learners in Rift Valley province. One stream from each sampled school was included in the study sample. A Standard Three class was taken as the unit of analysis in each school to prevent any possibility of interaction among students. Special education classroom populations average 15 pupils per teacher, a figure that is considered excessive with regard to the requirements of learners with hearing impairments per class. The average national pupil-teacher ratio in public schools in Kenya is 32:9, while that of Rift Valley Province alone is 33:1. Smaller classes of ten pupils are recommended for special schools in order to cater for individual differences (Ministry of Education Science and Technology, 2005).

Borg, Gall and Gall (2003) recommend a minimum of 15 respondents per group in experimental research. This sample size is also recommended by Kathuri and Pals (1993). Therefore, the actual sample size for this study comprised of 66 pupils. Two groups (E & C_2) had 15 pupils each; another group (C_3) had 17 pupils, while one class had 19 pupils, giving a total population of 66 pupils. The sample comprised of 34 boys and 32 girls aged between 9 and 14 years. Some pupils join special schools at an advanced chronological stage due to ignorance by their parents on knowledge of the locations of special schools, or complications in the child's deformities which improve with treatment, enabling the learner to join school after treatment after their age has advanced considerably.

3.7 Instrumentation

Three types of instruments were used. They included:

i. The Mathematics Achievement Test (MAT)

ii. The Mathematics Classroom Environment Questionnaire (MCEQ)

i) The Mathematics Achievement Test (MAT)

The Mathematics Achievement Test (MAT),(See Appendix F), was developed by the researcher and used to collect data on student's achievement in geometry. Information required by MAT included school, gender, age and question items on concepts in geometry.

a) Table of Specifications

The setting of MAT was conducted with the help of the special education cooperating teachers and standardised upon a two-way classification grid reflecting both the course content (Shapes and Pattern-making in Primary Geometry) and expected cognitive behaviour. Six items were classified as knowledge items, 18 as comprehension and six on application, with weights ranging from one to three. These were reduced to 7 question items at the cognitive level of knowledge, 9 at the comprehensive cognitive level and 4 question items at the application level of cognition.

Table 6 depicts the Table of Specifications based on Bloom's Taxonomy of Cognitive human behaviour that determines the alignment between the curriculum, assessment or evaluation, and instruction.

Table 6: Table of specifications based on Bloom's Cognitive Taxonomy of human behaviour

Primary 3 Geometry	**Bloom's Cognitive Taxonomy**					
Contents	**Knowledge**	**Comprehension**	**Application**	**Analysis**	**Synthesis**	**Evaluation**
1.0 Shapes						
1.1 Identify and name shapes		1				
1.2 Identify squares and rectangles		2				
1.3 Identify squares and triangles		3				
1.4 Identify circles		4				
1.5 Identify shapes in abstract forms		5				
1.6 Observe / count sides of a circle	6					
1.7 Observe / count sides of a triangle	7					
1.8 Observe / count sides of a rectangle	8					
1.9 Observe / count corners in a circle	9					
2.0 Pattern-Making						
2.1 Formation of shapes			10			
2.2 Division of shapes			11			
2.3 Division of shapes into patterns			12			
2.4 Identify triangles in patterns	13					
2.5 Observe solids & identify squares	14					
2.6 Divide square into smaller squares			15			
2.7 Identify triangles in other shapes		16				
2.8 Identify circles in other shapes		17				
2.9 Identify rectangles in other shapes		18				
2.10 Identify squares in other shapes		19				
2.11 Matching shapes	20					
TOTALS	**7**	**9**	**4**	**0**	**0**	**0**

The table of specifications helps identify a learning goal and its intended taxonomic difficulty and level of cognitive behaviour for purposes of assessment. It shows questions on knowledge, comprehension, application, analysis, synthesis and evaluation against instructional content.

It also documents the extent to which the geometry primary three syllabus has been addressed as required by the ministry of education.

b) Item difficulty

The Field-Testing approach (Popham, 1990) of determining item difficulty was adopted by the researcher where test items were administered to pupils with traits similar to those in the experimental groups. A difficulty index of 0.5 was used to select learners' responses based on questions that were answered correctly by half of the pupils.

c) Item discrimination

According to Frankfort-Nachmias and Nachmias (2003), the discriminative power of a test item may be determined through either the internal consistency method, or the item analysis method. The researcher chose the item analysis approach where scores for each pupil were added up and weighted and then placed in an array from lowest to highest. The Discriminative Power (DP) for each item was calculated as the difference between the weighted means of the scores above the upper quartile and of those below the lower quartile. Frankfort-Nachmias and Nachmias (2003) formula was used to compute the Weights. The formula is shown below:

$$\text{Weighted Total} = \text{Score} \times \text{Number who checked that score}$$

$$\text{Weighted Mean} = \frac{\text{Weighted Total}}{\text{Number in Group}}$$

$$\text{Discriminative Power (DP)} = Q_1 - Q_3$$

Where Q_1 and Q_3 represent the first and third quartiles of the number of pupils.

Items with the highest DP values were selected for inclusion in the questionnaire.

d) Reliability

MAT's reliability was determined by use of the split-half technique and then computed with the Kuder-Richardson formula (K-R20);

$$\text{K-R20 Reliability coefficient} = \frac{K}{K-1}\left(1 - \frac{\sum pq}{s^2}\right)$$

Where: K-R20 - Kuder Richardson's formula 20
K - number of items in the test
$\sum pq$ - sum of variance of items scored dichotomously (right or wrong)
s^2 - variance of the total test

Source: Popham (1990)

This formula was chosen for its accuracy and for the single administration of the tool. The tool was pilot tested in a school outside this study's jurisdiction to avoid possible interaction and was found to have a reliability coefficient of 0.7691. A coefficient of 0.7 is considered acceptable (Borg, Gall & Gall, 2003).

e) Validity

- **Face validity**

In order to ensure the tool not only measured what it was intended to measure, but also asked the right questions, the face validity of the tool was determined through a subjective evaluation which was conducted by cooperating mathematics teachers in a special school for hearing-impaired learners, and mathematics experts from Egerton University.

- **Content validity**

The researcher ensured question items in the tool sampled the content area which was to be measured by setting 30 question items that were based on the area of study. The questions were later reduced to 20 items (See table 6). These questions were broken down according to two topical categories of the syllabus, namely Shapes and Pattern-making with regard to four geometrical objects comprising of triangles, squares, rectangle and circles.

- **Sampling validity**

The sampling validity of the instrument was ascertained by cooperating mathematics teachers in special schools for hearing-impaired learners and mathematics experts from Egerton University who examined the items systematically and indicated the items which sufficiently represented the content area, qualities and behaviour to be measured. The table of specifications was used to help balance question items with regard to the topics (See Table 6).

ii) The Mathematics Classroom Environment Questionnaire (MCEQ)

A Mathematics Classroom Environment Questionnaire (MCEQ See Appendix G) was adapted from Kiboss (1997). It was restructured by simplifying the language to suit data collection among learners' at the primary school level. It had 20 categorical response mode items offering two response possibilities for each item (YES or NO). The items were then pre-coded and categorically scaled on score ranges of 1-0 for 'yes' or 'no' and 4-1 for 'a', 'b', 'c' or 'd' respectively, with responses to the right reflecting low scores progressively. The instrument's reliability was found to have a

reliability coefficient of 0.75 using the K-R 21 formula by Kiboss (1997). This instrument was pilot tested again for validity and reliability, and found to have a reliability coefficient of 0.7231.

3.8 The CAL Software

The Computer-Aided Learning software was designed and developed by the researcher using content drawn from the recommended syllabus for primary schools, relevant teaching guides and class textbooks (Jomo Kenyatta Foundation, 1998). It was evaluated by curriculum experts at Egerton University who recommended it for use in classroom instruction. The software was authored using the Multimedia Builder, an object-oriented programming software for microcomputers developed by Roman Voska in the year 2002. The software was considered appropriate due to its capability to combine text, graphics, animation and sound display editors during the authoring process.

The CAL software consisted of eight lessons, each running for 35 minutes. Lessons contained instructions on two subtopics in geometry namely:

(i) Shapes (circles, triangles, squares and rectangles)

(ii) Pattern making (using circles, using triangles and rectangles, using squares and rectangles).

These topics were extracted from the primary school syllabus which is recommended by the Kenya Institute of Education, and were due to be taught to learners during the school term when this study was conducted. The design of the software incorporated

learning concepts with the following cognitive skills which were to be acquired in the course of instruction:

(i) The recognition of basic shapes namely: cuboids, cubes, spheres, discs, oblongs, squares, circles, triangles among others, as specified in the syllabus.

(ii) Sorting objects according to shape and size.

(iii) Manipulative skills involving acts of cutting, folding and colouring.

(iv) Learners were expected to make simple patterns and also identify equivalent shapes by cutting and combining parts shapes to make nets of objects.

(v) Identification of flat, round, straight, curved cornered, closed and open objects.

(vi) Comparison between two like shapes by size i.e. larger against smaller objects.

(vii) Recognition of shapes in the environment.

(viii) Division of shapes into various parts i.e. whole-part relationships where folding makes halves and quarters etc.

(ix) Patterns formed by combing shapes such as mosaics to form triangle, square circles and rectangles.

(x) Discovering simple properties of common shapes.

The software comprised of sequenced learning activities arranged in lesson format, which were accessible to respondents via an appropriate simplified Graphical User

Interface using the mouse as a pointing device. The keyboard was avoided due to inherent difficulties it poses to young learners.

3.8.1 Technical design and development of the Computer-Aided Learning (CAL) software

The CAL software was designed and developed for use in teaching geometry in primary schools for the hearing-impaired learners. Course outline was based on the primary school syllabus currently in use under recommendation by the Kenya Institute of Education (KIE). Various guiding questions were suggested by Alessi and Trollip (1991) for the successful construction of relevant software. These questions were answered during the design and developmental stages of the software. The guiding questions were:

(i) Does the software run on the type of computer that students will have access to? (YES)

(ii) What special features of the computer if any does the program require? (NONE).

(iii) Where will students use this software? (During normal teaching sessions)

(iv) Does the software have any copyright or licensing restrictions that would hinder its use in class? (NO)

(v) What learning objectives does the software claim to achieve or could it be used to achieve? Are these objectives clearly stated? How close are these objectives to those of the course? (Course outline based on primary school syllabus used as recommended by Kenya Institute of Education-KIE)

(vi) Is the program instructionally sound? Are the facts in it accurate and up to date? (YES)

(vii) What instructional strategies does the program employ? (Animated visual presentation + written instructions + Kenya's sign language). Does it use a variety of strategies? (YES See Strategies).

(viii) Does the program have graphics, colour, sound or video? (Has graphics and colour but NO sound or video). If so, do these features make the program more interesting to students and more effective pedagogically? (Graphics and colour made the program very effective).

(ix) How easy is it to use the software? (Only required the use of a mouse. Keyboard was not necessary). What and how much training will students need before they can use it effectively? (24 hours).

(x) How clear is the software's documentation (manual or other printed matter) that comes with it? (The manual was very clear and easy to understand).

(xi) Are there any 'help' functions built into the program itself? (YES). If so, how helpful and easy to use are they? (These aided the comprehension of symbols and instructions that were not very clear to the user).

(xii) How much time will students spend in using the program? (Two weeks). Is the program's usefulness great enough to justify the amount of time spent on it? (YES).

(xiii) What does the program ask students to do? (Practice concepts taught during the lesson). How appropriate are these activities for students' level of ability and learning objectives of the course? (Very appropriate with regard to syllabus requirements for teaching Geometry).

(xiv) What aspects of the program can students control or change? (Students could control the program through appropriate simplified Graphical User

Interface-GUI- using the mouse as a pointing device) How do they do this? (Pointing the mouse at appropriate buttons and clicking the mouse to access what they wanted).

(xv) Does the program score or evaluate student achievement in any way? (YES). What feedback if any does it provide after students make responses to it? (The responses varied according to one's achievement-GOOD-KEEP UP, FAIR-WORK HARD, FAIR-TRY AGAIN.) How helpful is this feedback? (It motivated the learner to keep trying if the score was low). Does the program provide scoring/ diagnostic information to the student? (YES- There was a self-evaluation examination at the end of the program which provided a final score showing one's level of achievement)

The software runs on a CD and can be loaded to run on the computer's hard disk drive. Allessi and Trollip (1991) maintain that successful instruction should include the following four activities:

i) Information presentation

ii) Guidance through initial use of the information

iii) Student practice for retention and fluency

iv) Assessment of learning

In order to cover the activities mentioned above more effectively while ensuring the software's suitability for instructional purposes, the CAL software had to include the following functions:

a) Introduction of the Tutorial

The learner was introduced to the tutorials via a simplified Graphical User Interface (GUI) which started with the title page displaying the software's title shown in figure 2

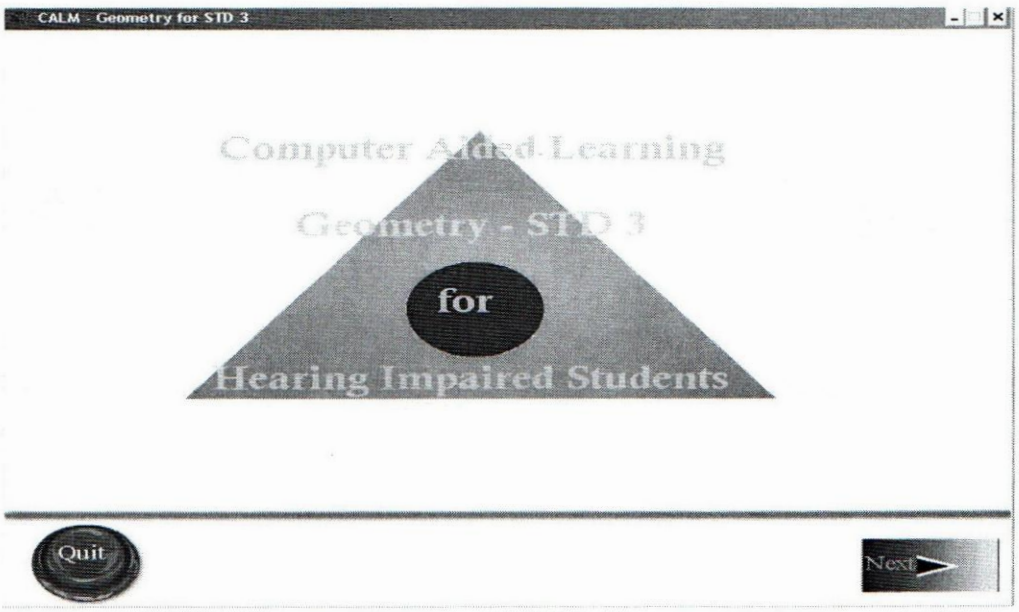


Figure 2: Introductory slide displaying the CAL software's Title Page

A "welcome" message was then displayed via animated sign language, and the words "**Welcome" "to" "Geometry**" written in text form in speech bubbles as displayed in figures 3, 4 and 5 which display a succession of three slides.



Figure 3: "Welcome" message Slide 1

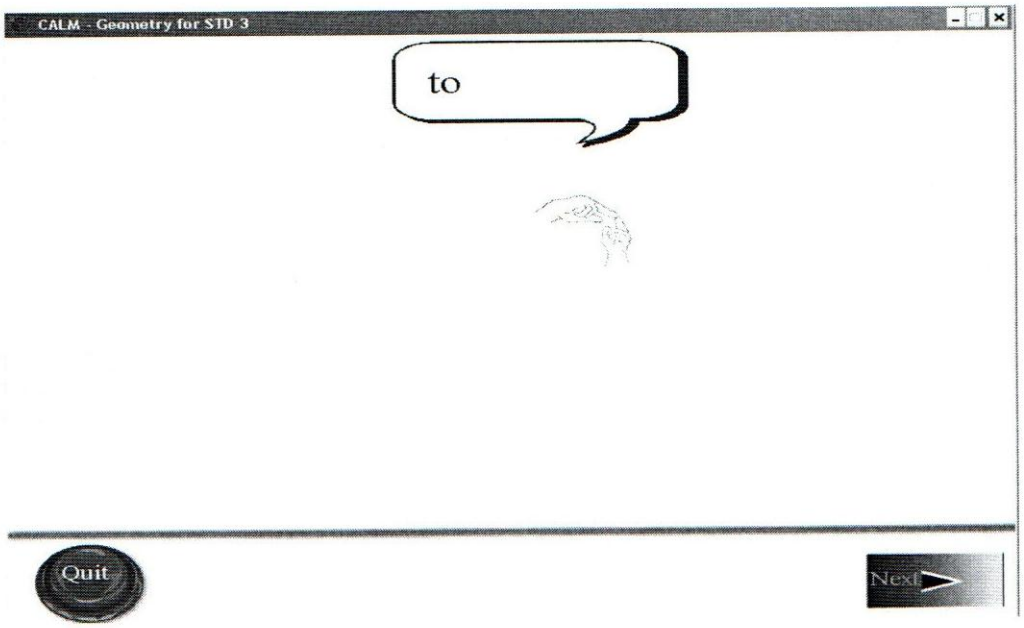


Figure 4: The "Welcome" message Slide 2

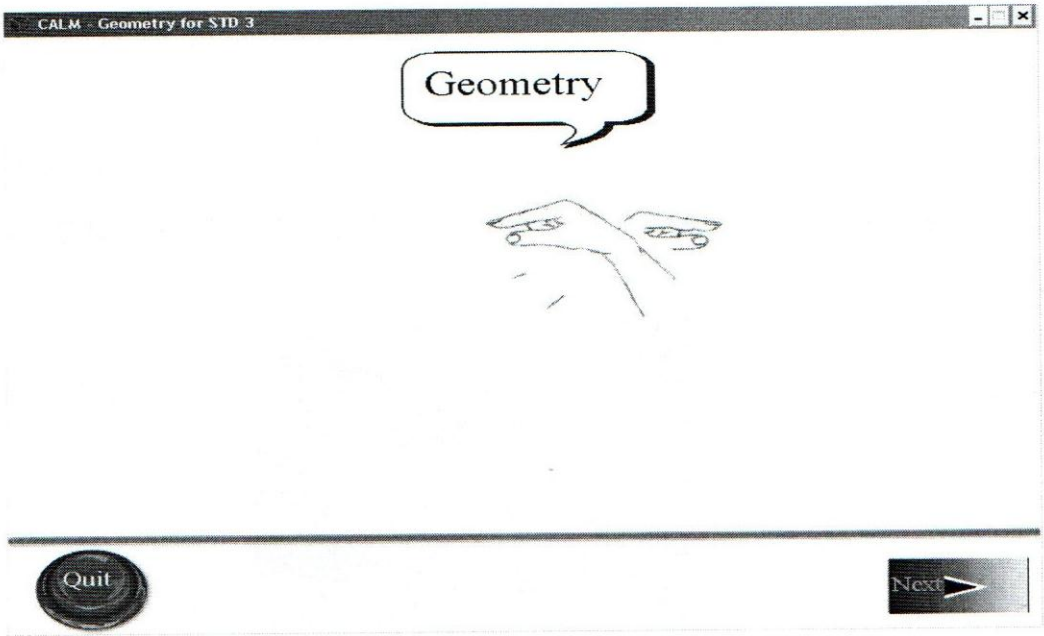


Figure 5: The "Welcome" message Slide 3

These were then followed by the main menu which is displayed in figure 6

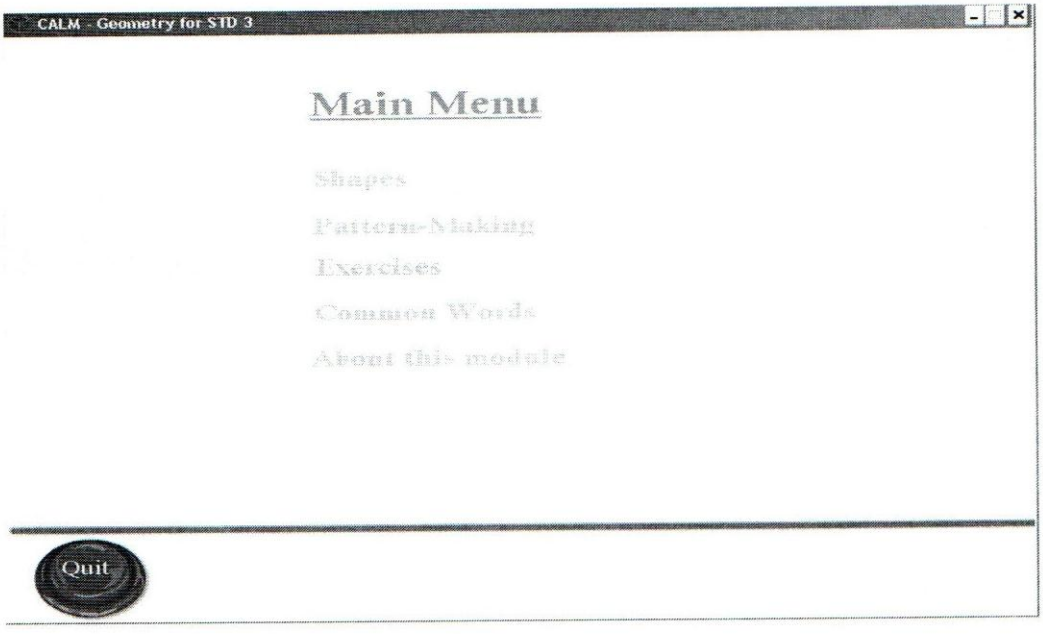


Figure 6: Main Menu Slide

A click on an item in the main menu displayed the contents of a sub-menu for each particular item that was chosen in the main menu. Figure 7 displays a slide showing the sub--topical menu for shapes.

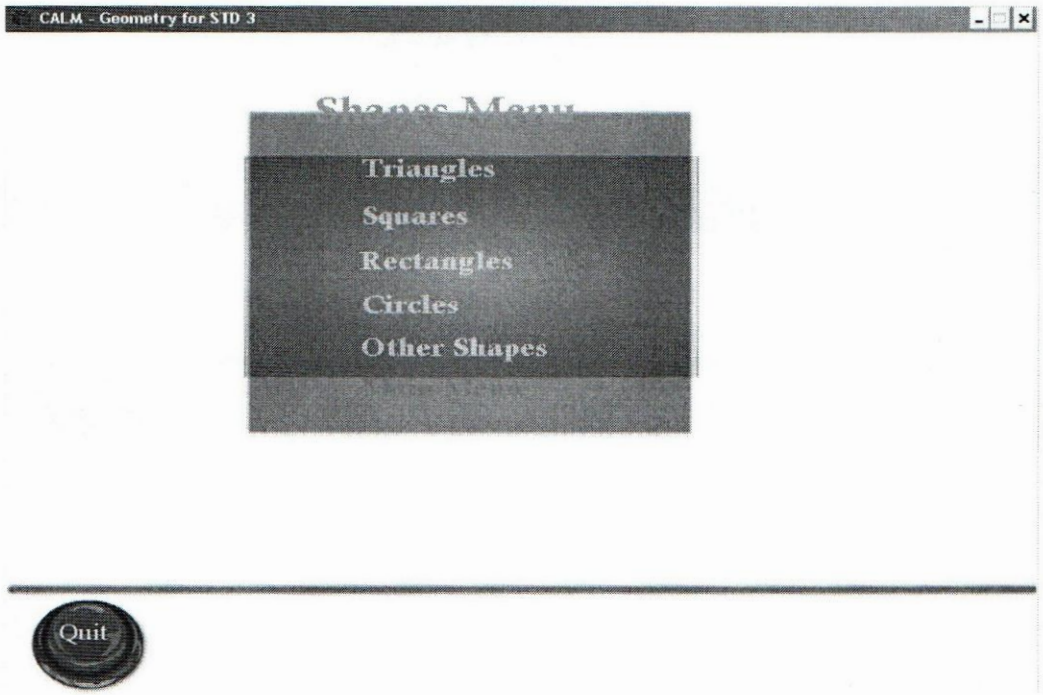


Figure 7: Sub-topical menu for Shapes

The shapes menu displayed another sub-menu that led to learning activities as shown in figure 8 which displays concepts on the triangle.

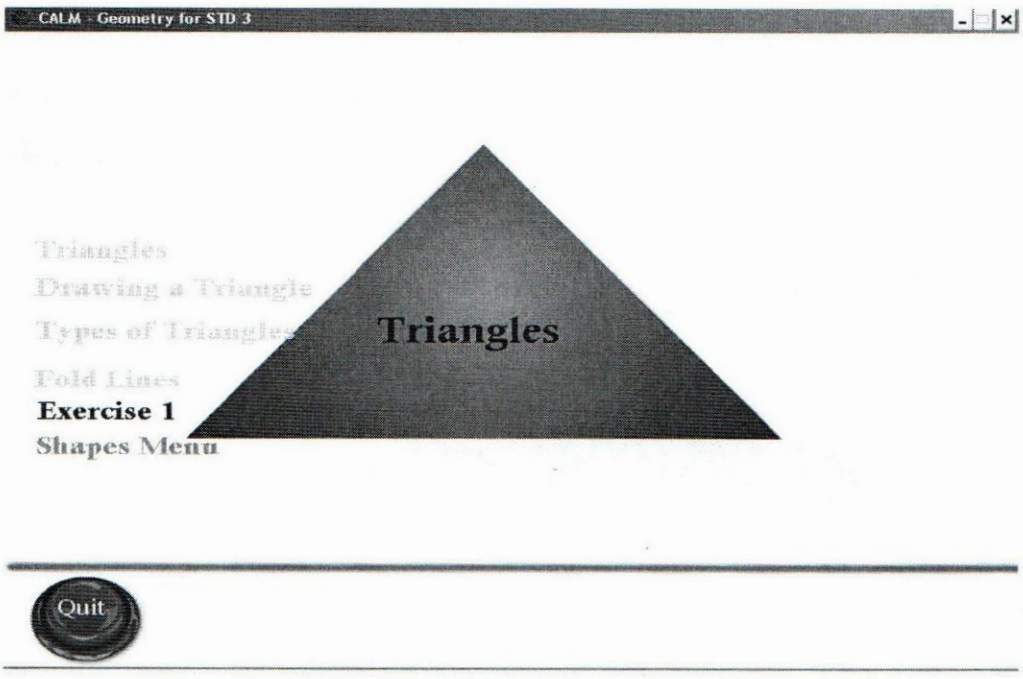


Figure 8: Sub-topical menu for Triangles

b) User's Control of the Lesson (Interactivity)

The mouse was chosen as the easiest mode of the user's control of the lesson. This was meant to improve the learner's attitude and motivation. The learner's interaction with the lesson's contents was ensured through the provision of four buttons activated through the mouse by pointing and clicking. They included:

i) The exit button labelled "**QUIT**"

ii) The menu button labelled "**MENU**"

iii) Action button labelled "**LEARN**"

iv) Review button labelled "**BACK**"

v) Progress button labelled "**NEXT**"

These user control buttons are displayed in figure 9. The buttons were located at the bottom of the page as recommended by Allesi and Trollip (1991). Four

buttons enabled the learners to manipulate their way through the tutorial. They also gave directions to learners.

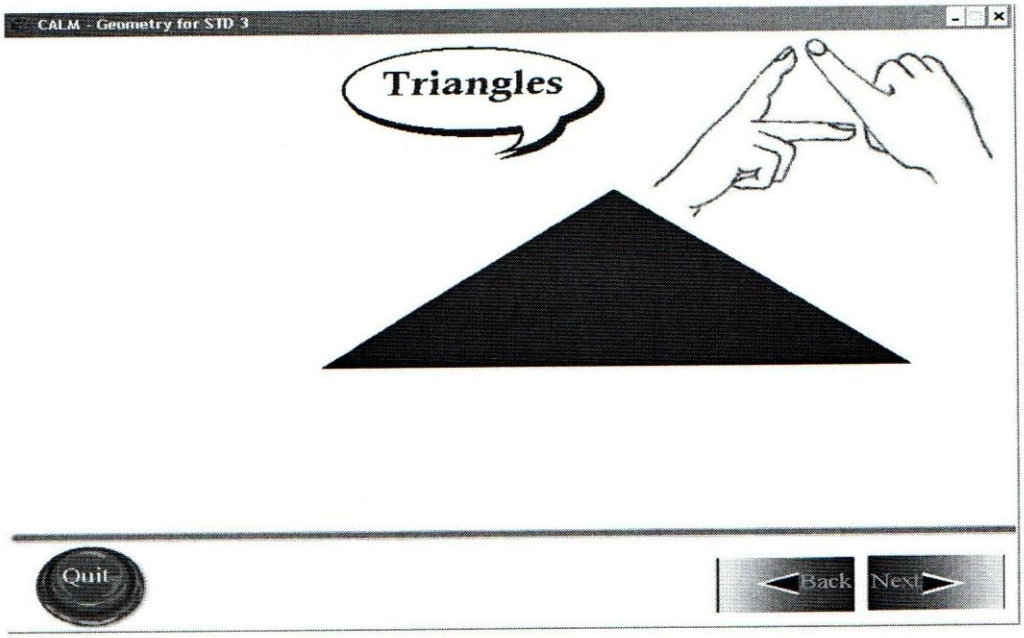


Figure 9: Transitional slide displaying Control Buttons

c) Presentation of the Information

The presentation of information began with a display of the menu to guide the learner to topics of their choice. Topics were activated by pointing at, and clicking on top of each topic using the left hand button of the mouse. This action launched sub topical menus. The learner had the option of learning the contents under a chosen topic by clicking the button labelled "**Learn**", proceeding by activating the button labelled "**Next**" or quitting the tutorial using the "**Quit**" button.

Content for each lesson was displayed in four ways using:

i) **Normal Text Format** - information was written in normal text to convey concepts and ideas.

ii) **Animated Objects** – animation was geared towards stirring motivation and creating a dynamic learning environment.

iii) **Speech Bubble** – this was meant to attract the learner's attention where learning concepts and activities were to be perceived visually.

iv) **Graphics** – these appeared in form of sign language and also in diagrams as shown in figure 10.

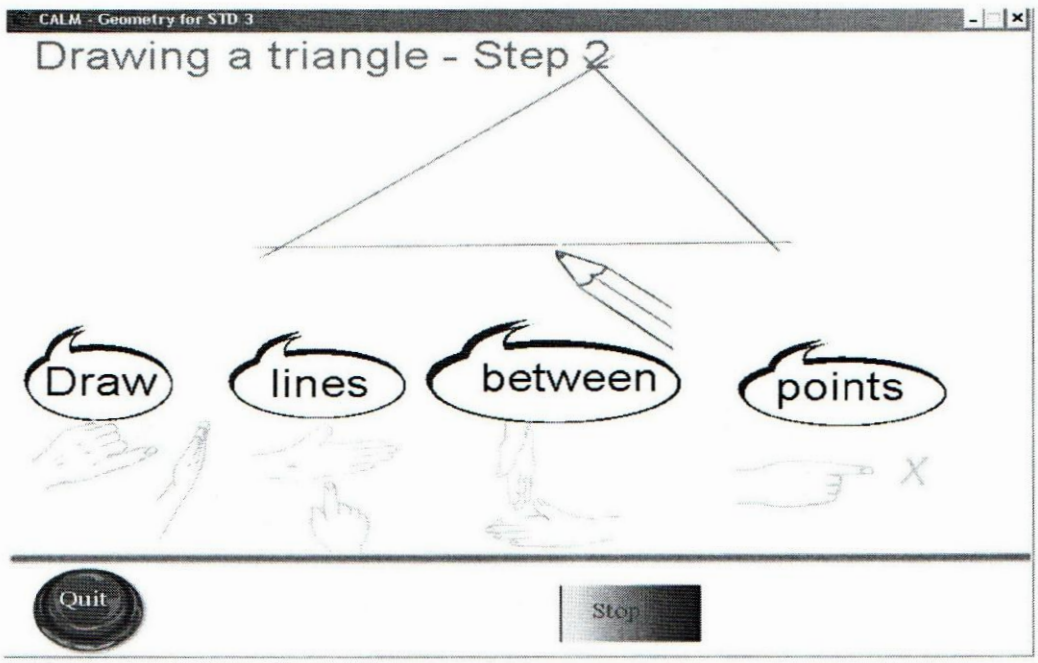


Figure 10: Transitional learning slide

The software was designed to make maximum use of the hearing-impaired learner's visual perception while transmitting information in both text format and their more familiar sign language format.

d) Questions and Responses

Questions were linked to a bank of correct responses. These were included in the tutorial as short exercises at the end of each topic. The learner was expected to respond to short multiple choice questions based on the lesson's contents. This is displayed in figure 11.

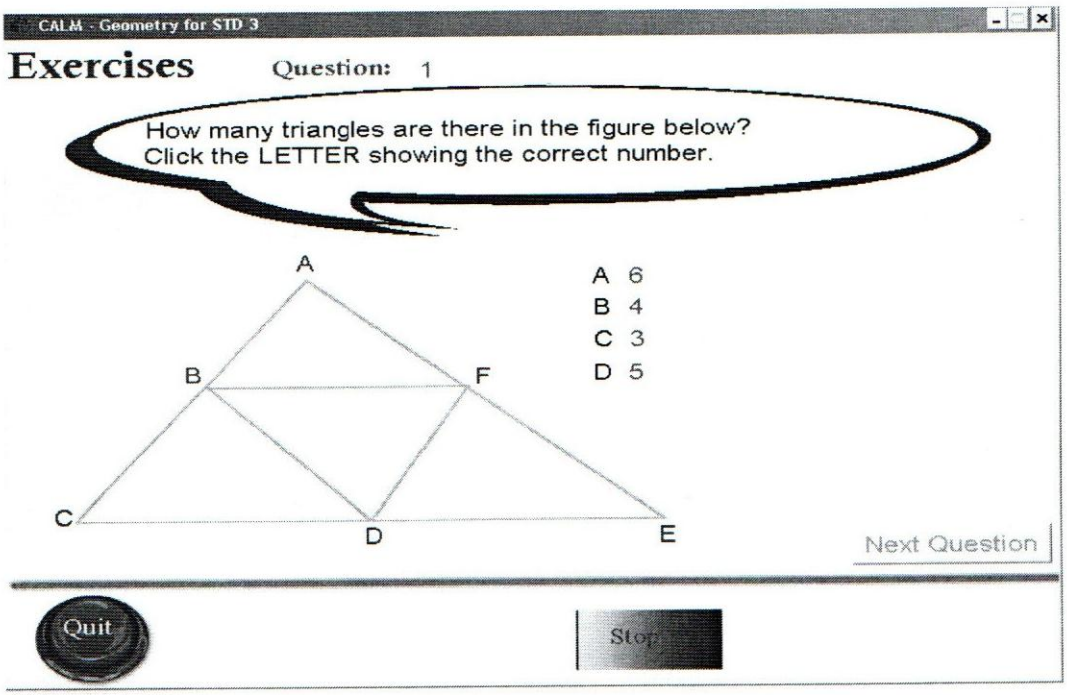


Figure 11: Exercises slide

e) Judgment of Responses

Learners' correct or incorrect responses were judged with a visual display of the score attained and a feedback with compliments e.g; " **Good**" or "**Work Hard**". The learner was motivated intrinsically through visual techniques, an exploratory environment, personal control of the lesson and encouragement even when errors were made. This is displayed in figure 12.

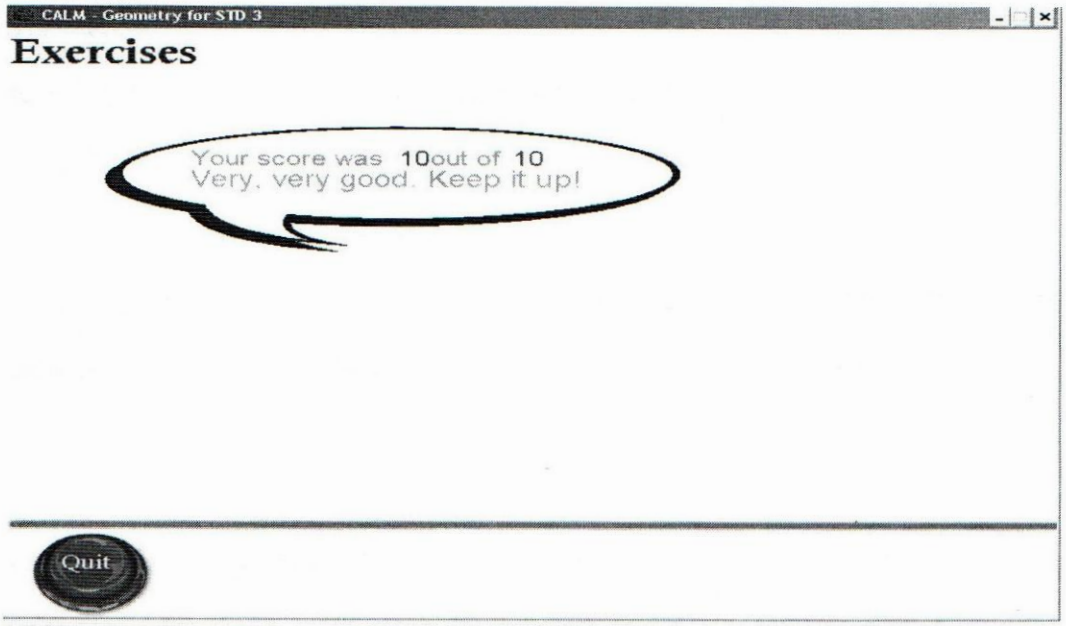


Figure 12: Feedback slide

f) Sequence of lesson Segments

The lesson's progress was in a linear sequence from one topic or concept to the next, and also hierarchically from simple to more complex information.

g) Remediation

Learners who were slow in grasping information relayed to them were not only catered for, by information being repeated three times during instruction, but also had a chance to review the entire lesson repeatedly via the review button.

h) Closing of tutorials

Permanent termination of the tutorial was done through the "**Quit**" button which was available on every page in case the learner wanted to stop learning at any time.

i) Assessment

The tutorials ended with the administration of a multiple choice examination to enable the learners to assess their achievement. One's achievement was displayed as a percentage score accompanied with a positive remark. Thus, a learner could appraise their achievement in the instructor's absence. This self assessment aspect of the software was designed to provide immediate positive reinforcement and corrective feedback through a graphical speech bubble.

The software runs best on a fast machine. A test conducted on Pentium II computers with processor speeds of 533 MHz made the software to run slowly. However, a better achievement was realised on Pentium III computers. Therefore, treatment was administered using two Pentium III and four Pentium IV computers with processor speeds of 1200 and 1800 MHz respectively.

3.9 Implementation of the CAL geometry course

The CAL geometry course was implemented within two weeks in normal classroom conditions provided for in schools hearing-impaired learners. The course was administered to the experimental group and one control group, while two control groups received instruction via the conventional method of teaching. A twenty hour orientation session was conducted by the researcher both theoretically and practically to familiarise both the pupils and their teachers to the software. Instructional manuals on the use of equipment were prepared by the researcher for use by both the respondents and their teachers (See Appendix E). A 20 hour training session was considered to be sufficient for familiarising respondents with the CAL program (Kiboss, 1997). All groups were supervised by their class teachers who were trained

on the use of CAL for each group of respondents. These teachers thus served as research assistants.

3.10 Data collection procedure

Prior to the start of the course, the experimental group (E_1) and the control group (C_2) had to undertake an orientation course using the CAL training manual under their teachers' supervision to familiarise with the computers and the CAL geometry software. The Mathematics Achievement Test (MAT) was administered to the experimental group (E_1) and the control group (C_2) as a pre-test.

The CAL geometry software course was administered to both the experimental group (E_1) and the control group (C_2) within a period of two weeks with help of cooperating teachers of mathematics while control groups (C_1) and (C_3) were taught using the traditional method of teaching hearing-impaired learners. MAT was administered as a post test to all the four groups at the end of the course. The Mathematics Classroom Environment Questionnaire (MCEQ was administered to both the experimental group (E_1) and the control group (C_2) at the end of the course with the help of participating teachers. Scores were then coded for analysis.

3.11 Data analysis

Data was analysed using both descriptive (percentages, means & std-deviations) and inferential statistics (t-test, chi-square & ANCOVA) with the aid of the Statistical Package for Social Sciences (SPSS) version 11.5. To compare whether mean scores were significantly different, t-test and chi-square (χ^2) at alpha = 0.05 were used. Pre-test and post test effects were analysed using ANCOVA. Apart from its ability to control the pre-test interaction effects, ANCOVA was chosen due to its suitability in

the analysis of data involving non-homogeneous respondents. It also statistically controls extraneous variables that would otherwise have confounded the study. Table 7 shows a summary of the analysis of data.

Table 7:

Summary table of the analysis of data

Hypotheses	**Independent Variable**	**Dependent Variable**	**Statistic used**
Ho1: The use of the CAL software in the teaching of geometry in standard three has no statistically significant effect on hearing-impaired learners' achievement in geometry.	CAL	Achievement	T-Test ANCOVA
Ho2: The use of CAL software in teaching geometry in standard three has no statistically significant effect on the perception of the classroom environment between hearing-impaired learners exposed to CAL and those not exposed to it.	CAL	Perception	χ^2 ANCOVA

CHAPTER 4

ANALYSIS OF DATA, RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents data analysis and findings of the study on the use of the Computer-Aided Learning geometry software among hearing-impaired learners in special schools in Standard Three, and their perception of the learning environment. The results have been tabulated. Conclusions have been made by either accepting or rejecting the hypotheses at a significance level of 0.05.

4.2 Data analysis

Data was analysed using both descriptive (percentages, means & std-deviations) and inferential statistics (t-test, chi-square & ANCOVA) with the aid of the Statistical Package for Social Sciences (SPSS) version 11.5. To compare whether mean scores were significantly different, t-test and chi-square (χ^2) at alpha = 0.05 were used. Pre-test and post test effects were analysed using ANCOVA.

4.3 Results

4.3.1 The effects of using the CAL software on students' achievement in geometry

The following null hypothesis was tested:

Ho1: The use of the CAL software in the teaching of geometry in standard three has no statistically significant effect on hearing-impaired learners' achievement in geometry.

Descriptive statistics comprising of the means, standard deviations and gains by respondents in both the pre-tests and post-tests in the Mathematics Achievement Test (MAT) were calculated and displayed as shown in Table 8.

Table 8:

Means, standard deviations (SD) and gains by respondents in both the pre-test and post-test in the Mathematics Achievement Test (MAT)

	GROUP			
	E	C_1	C_2	C_3
Condition	**(Treated)**	**(Treated)**	**(Not Treated)**	**(Not Treated)**
VARIABLE	**(N=15)**	**(N=19)**	**(N=15)**	**(N=17)**
Pre-test	33.6667		11.9667	
S.D.	13.7538		5.7924	
Post-test	49.8333	47.1053	21.0000	43.2647
S.D.	16.7829	18.6202	11.1739	15.9434
Mean Gains	16.1666		9.0333	

The influence of the experimental conditions on the pre-tested group was determined by comparing the post-test means for groups E versus group C_1, group E versus group C_2 and group E versus group C_3, whose results were summarised as indicated in Table 8. A comparison of the post-test means of group E and group C_1 revealed that the post-test mean for group E (49.8333) was more statistically significant than that for C_1 (47.1053) at $p<0.05$, indicative of the fact that group E achieved a higher mean score than group C_1.

On comparing the post-test means of group E and group C_2, results revealed that the post-test mean for E (49.8333) was more statistically significant than that for C_2 (21.0000) at $p<0.05$. This provided evidence of the effectiveness of the CAL experimental treatment. A further comparison of the post-test means of group E and group C_3 revealed that the post-test mean for group E (49.8333) was more statistically significant than that for C_3 (43.2647) at $p<0.05$, indicative of the fact that group E achieved a higher mean score than group C_3.

These results clearly indicated that the post test mean score for group E was greater than that of groups C_1, C_2 and C_3. It was therefore evident from the results above that the experimental conditions positively influenced learning compared to learners who were not subjected to treatment. Thus, this was indicative of the fact that CAL treatment had a positive effect on all learners who were subjected to the treatment.

The effect of the experiment on the unpre-tested groups was found by comparing the post-test means for C_1 (47.1053) and C_3 (43.2647). The unpre-tested control group that was exposed to CAL; C_1 performed better than the unpre-tested control group that was not treated C_3. This further supported the effectiveness of using the CAL treatment. On the basis of this result, the null hypothesis (Ho1) that "the use of the CAL geometry software in the teaching of geometry in Standard Three has no effect on hearing-impaired learners' achievement in geometry" was rejected.

In order to establish the mean score differences, a t-test analysis of sample results of post-test mean scores in the Mathematics Achievement Test (MAT) was conducted. The results are displayed as shown in Table 9.

Table 9:

Sample t-test results of post-test mean scores of groups E versus C_2 and C_1 versus C_3 in the Mathematics Achievement Test (MAT)

GROUPS	df	t-Value	Sig. 2-Tail	C-Value
E versus C_2	14	7.977	0.000	2.145
C_1 versus C_3	16	0.532	0.602	2.120
E - C_2	Mean difference	28.8333		
C_1 - C_3	Mean difference	3.8406		

- Statistically significant at $\alpha = 0.05$

Table 9 reveals that t-values of t (1, 15 = 7.977, $p<0.05$) and t (1, 17 = 0.532, $p<0.05$) were obtained, which indicated that respondents exposed to CAL performed better than those not exposed to it. Table 9 also shows that average differences in means (gains) of the post-test scores between (E - C_2 = 28.8333) and (C_1 - C_3 = 3.8406) are statistically significant at the 0.05 level, in favour of group E and C_1. This is evidence of the effectiveness of CAL. There was therefore sufficient evidence to reject the null hypothesis (Ho1) that "the use of the CAL geometry software in the teaching of geometry in Standard Three has no effect on hearing-impaired learners' achievement in geometry" and uphold the alternative hypothesis that the use of the CAL geometry software in the teaching of geometry in standard three has a significant effect on hearing-impaired learners' achievement in geometry.

Hearing-impaired learners do not have homogeneous characteristics with regard to deformity. Some respondents had residual hearing while others were devoid of any hearing capabilities. It was therefore not easy to rationally analyse their results without considering the lack of homogeneity in their hearing disabilities. Due to this,

an Analysis of Covariance (ANCOVA) for both the experimental E and control group C_2 on post-test mean scores of the respondents in the Mathematics Achievement Test (MAT) had to be done using the pre-test scores as covariates. The results are summarised as shown in Table 10.

Table 10:

Results of the Analysis of Covariance (ANCOVA) of post-test scores in MAT with pre-test mean scores as covariates for the experimental group (E) and control group (C_2)

SOURCE	df	Sum of Squares	Mean Square	F-ratio	Sig.
E (Pre-test for MAT)	1	1601.070	1601.070	8.886	0.011
Post-test for MAT	1	1131.353	1131.353	6.279	0.026
Error	13	2342.262	180.174		
Total	15	41193.750			
Corrected Total	14	3943.333			

*R Squared = 0.406 (Adjusted R Squared = 0.360)

An examination of Table 10 reveals that the effect of the CAL treatment is statistically significant for the two test mean scores at the F value (1, 14 = 8.886, $p<0.05$). It shows that students in the experimental groups had higher scores than those in control groups. Descriptive statistics also show that s the experimental groups scores in MAT were higher than those in control groups. None of the interaction effects are statistically significant. This gives sufficient evidence to reject the null hypothesis (Ho1) that "the use of the CAL geometry software in the teaching of

geometry in Standard Three has no effect on hearing-impaired learners' achievement in geometry" and accept the alternative hypothesis that "the use of the CAL geometry software in the teaching of geometry in Standard Three has a significant effect on hearing-impaired learners' achievement in geometry".

4.3.2 The effects of using the CAL software on learners' perception of their classroom learning environment

The following null hypothesis was tested:

Ho2: The use of CAL software in teaching geometry in standard three has no statistically significant effect on the perception of the classroom environment between hearing-impaired learners exposed to CAL and those not exposed to it.

The results on the effects of the CAL software on learners' perception of their classroom learning environment obtained using the mathematics classroom environment questionnaire (MCEQ) were analysed using Chi-square and tabulated in Table 11 for the experimental group E_1, in Table 12 for the control group C_1, and in Table 13 for both groups.

Table 11:

Chi-squared results of the Mathematics Classroom Environment Questionnaire (MCEQ) for post test scores of experimental group E_1

Score	Observed N	Expected N	Residual
60.00	2	2.3	-0.3
65.00	4	2.3	1.7
70.00	2	2.3	-0.3
75.00	2	2.3	-0.3
80.00	1	2.3	-1.3
85.00	3	2.3	0.7
Total	14		

$\chi^2_{critical} = 2.286$ $\chi^2_{calculated} = 11.070$ $p < 0.05$ $N = 15$

Table 11 shows that six cells (100.0%) have expected frequencies of less than 5. The minimum expected cell frequency is 2.3. The 5% significance level at 14 degrees of freedom indicates the critical values of 11.070. A comparison between the critical value with the calculated chi-squared statistics for groups E_1 indicated that the calculated value was less than the critical values (E_1: $2.286 < 11.070$).

Table 12 shows that nine cells (100.0%) have expected frequencies of less than 5. The minimum expected cell frequency is 2.0. The 5% significance level at 18 degrees of freedom indicates the critical values of 15.507.

Table 12:

Chi-squared results of the Mathematics Classroom Environment Questionnaire (MCEQ) for post test scores of control group C_1

Score	Observed N	Expected N	Residual
30.00	2	2.0	0.0
40.00	1	2.0	-1.0
50.00	2	2.0	0.0
55.00	3	2.0	1.0
60.00	1	2.0	-1.0
65.00	3	2.0	1.0
75.00	1	2.0	-1.0
80.00	3	2.0	1.0
85.00	2	2.0	0.0
Total	**18**		

$\chi^2_{critical} = 3.000$ $\chi^2_{calculated} = 15.507$ $p < 0.05$ $N = 19$

A comparison between the critical value with the calculated chi-squared statistics for group C_1 indicated that the calculated value was less than the critical values (C_1: $3.000 < 15.507$).

Table 13:

A comparison of the Mathematics Classroom Environment Questionnaire (MCEQ) Chi-squared (χ^2) statistic results for the post test scores of experimental group (E_1) and the control group (C_1)

Group	MCEQ (E_1)	MCEQ (C_1)
Chi-Square(E_1, C_1)	2.286	3.000
Df	5	8
Asymp. Sig.	0.808	0.934

A comparison between critical values with the calculated chi-squared statistics for groups E_1 and C_1 in Table 13 indicated that both calculated values were less than the critical values (E_1: 2.286 < 11.070 and C_1: 3.000 < 15.507). On the basis of these statistics, there is no evidence for rejection of the null hypothesis (Ho2) that there is no statistically significant difference in perception of the classroom environment between hearing-impaired learners exposed to CAL and those not exposed to it. Therefore, the null hypothesis was upheld.

4.4 Discussion of the results

4.4.1 The effects of using the CAL software on students' achievement in geometry

The post-test scores for the Mathematics Achievement Test (MAT) were analysed using the t-test. In the t-test analysis of sample results conducted to establish mean score differences of post-test mean scores of respondents in MAT, it was established that learners who were instructed using the Computer-Aided Learning software attained higher scores than those taught in the conventional method of instruction. The average differences in means (gains) of the post-test scores between E - C_2, and C_1 - C_3 were statistically significant at the 0.05 level. This further proved the effectiveness of CAL as an instructional alternative.

An Analysis of Covariance (ANCOVA) for both the experimental E and control group C_2 on post-test mean scores of the respondents in the Mathematics Achievement Test (MAT) was done using the pre-test scores as covariates. This analysis established that the difference between the two groups was statistically significant, leading to the rejection of the null hypothesis (Ho1) that "the use of the CAL geometry software in the teaching of geometry in Standard Three has no effect on hearing-impaired learners' achievement in geometry".

It was also noted that students in the experimental groups had reliably higher scores than control group students in MAT as was also indicated in descriptive statistics. None of the interaction effects were found to be statistically significant. This gave sufficient evidence to reject the null hypothesis (Ho1) that the use of the CAL geometry software in the teaching of geometry in Standard Three has no effect on

hearing-impaired learners' achievement in geometry, and accept the alternative hypothesis that the use of the CAL geometry software in the teaching of geometry in standard three had a significant effect on hearing-impaired learners' achievement in geometry. Supportive findings by Lang (2005) revealed that this technology presents very exciting approaches to visually oriented learners. He also says that it has the potential to meet the needs of bilingual deaf students. He alludes that the highly visual materials stimulate writing, vocabulary enrichment, and independent learning skills in deaf learners. This fits in with other studies suggesting the effectiveness of using the CAL treatment.

The study also supports previous findings by Caccamise and Lang (1996) who established that computers enhance communication in the classroom during the learning of technical concepts. Yushau, Bokhari and Wessels (2004) also established that the use of CAL improves the learning of mathematics and influences the achievements of students in the subject. He however cautions that there is need to evaluate the software packages before use to select those that can aid the student in their learning process.

In his article on Intelligent Tutoring Systems, Noppenberg (2002) supports this aspect of computer-aided learning. He affirms that advances in educational software will only further its role in the classroom. In view of these findings, it may be concluded that the use of Computer-Aided Learning (CAL) is more effective in the attainment of better results than the conventional mode of instruction.

4.4.2 The effects of using the CAL software on learners' perception of their classroom learning environment

Post test scores for MCEQ were analysed using Chi-square (χ^2) where a comparison of critical values with calculated values was made. The comparison between the critical values with the calculated chi-squared statistics for groups E and C_1 indicated that both calculated values were less than the critical values, indicating that there is no evidence for rejecting the null hypothesis (Ho2) that "there is no statistically significant difference in perception of the classroom environment between hearing-impaired learners exposed to CAL and those not exposed to it". This suggested the absence of any significant association between the use of the CAL software and learners' perception of their classroom learning environment (E_1: 2.286 < 11.070 and C_1: 3.000 < 15.507). The researcher therefore established that there was no statistically significant difference in perception of the classroom environment between hearing-impaired pupils exposed to CAL and those not exposed to it, with regard to groups E and C_1.

Despite chi-squared test statistics indicating lack of evidence of any statistically significant difference in perception of the classroom environment between hearing-impaired pupils exposed to CAL and those not exposed to it, gains attained in classroom achievement reflect otherwise. The negative response by some learners towards the use of computers in the classroom was expected considering the fact that these learners were encountering the machines for the first time. Their views on the rude intrusion into their learning environment were a reaction against the shift towards a new technology, which is not always readily accepted.

Studies have revealed that both teachers and students often react negatively towards the computer. This is attributed to a phobia or natural anxiety towards computers, which is usually detected in their responses when asked to comment on their initial experiences with the machine. This negative attitude influences the acceptance of computers in classrooms as learners nostalgically wish back their traditional mode of instruction. Nevertheless, the computer is still a crucial component in education in that it shows promise to meet the needs of hearing-impaired students. Supportive evidence by Atkinson (2003) indicated that treatment under CAL experimental conditions positively influenced learning compared to learners who were not subjected to treatment. Thus, CAL treatment had a positive effect.

The findings in this study also confirm that in the absence of hearing faculties, hearing-impaired learners are expected to maximise learning through visual perception and physical manipulation which account for over 65% of learning (Walklin, 1994). By providing a stimulating visual learning environment, CAL is therefore expected to enhance learning for the hearing-impaired learner. The study supports the argument by Crompton (1989) that a linguistically rich environment should be colourful, stimulating, challenging and full of fun and that the computer offers such an opportunity for visual learning. This study is also supportive of findings by Ray and Davis (1991) that established the ability in a computer to extend the attention span among hyperactive hearing-impaired learners by occupying them through visually colourful, challenging and stimulating learning environment. This frees the teacher thus, enabling him to concentrate on learners' language development, which is of greater concern. This study therefore helps explain the link between perception and achievement with regard to special education by reinforcing Piaget's and Bruner's views on cognitive development which affirmatively stress

learners' abilities to select, extract, maintain and use environmental information as prerequisites to learning.

The use of the CAL software in teaching geometry produced higher scores among hearing-impaired learners who used the software compared to those who were taught using the traditional method of instruction. The results of this study indicate that computer-aided learning not only improves students' perception of their classroom learning environment, but that CAL has a positive effect on learner achievement when used in teaching hearing-impaired pupils. This is in line with recommendations made by the Kenya National Examination Council that there is a need to change teaching strategies in order to improve achievement in mathematics. The use of CAL should therefore be emphasised in classroom instruction with an aim of not only attaining high examination results in geometry, but also speeding up and improving the delivery of concepts and lesson content to learners, apart from providing a more vibrant interesting learning environment.

CHAPTER 5

FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

The study focused on the design and development of the Computer-Aided Learning software, and investigation of its effects on learners' achievement in geometry, and their perception of the enhanced learning environment. The software was administered in special schools for the hearing-impaired at the primary three level of education while controlling for learning using the traditional mode of learning. This chapter presents a summary of findings, conclusions and recommendations accruing from results of the study.

5.2 Findings

On the basis of the data analysis after experimentation, and the fact that this study was conducted successfully, it was established that:

i) The use of the CAL geometry software in the teaching of geometry in Standard Three has a significant effect on hearing-impaired learners' achievement in geometry.

ii) There was no statistically significant difference in perception of the classroom environment between hearing-impaired learners exposed to CAL and those not exposed to it.

5.3 Conclusions

These conclusions are based on the objectives of the study and generalised to all students learning geometry in special primary schools for hearing-impaired learners in Rift Valley Province:

i) Hearing-impaired learners taught using the CAL software do not necessarily have a better perception of their learning environment than those taught using the traditional method of instruction.

ii) When hearing-impaired learners are taught using the CAL software, their achievement in geometry is better than that of those taught using the traditional mode of instruction.

5.4 General implications of the study

The general implications of this study are clearly addressed by answers to the following questions:

i) What value does Computer-Aided Learning (CAL) add to education?

ii) What could stakeholders benefit from CAL as a learning strategy?

iii) What does CAL bring into the academic world?

iv) What is the future of CAL in Kenya's market?

i) This study established that Computer-Aided Learning can make significant contributions to education, which include the following:

- CAL adds a new learning strategy to education for instruction among hearing-impaired learners. This method of instruction can supplement the traditional methods of instruction which are mainly lecture oriented.
- This study established that the method improves learners' achievement when used during classroom instruction. This is significant considering our need to improve learners' achievement in class.
- Computer-Aided Learning eases learning by presenting information in a manner that is more appealing to learners. Concepts are visually presented in text and graphical format to ease encoding, processing, storage and retrieval of information, thereby quickening the learning process.
- Apart from introducing a mode of instruction that is both interesting and motivating to the learner compared to the lecture method preferred in classroom instruction, improved achievement in class through the use of CAL offers hearing-impaired learners a means through which they can attain higher scores and further their education.

ii) The following stake holders are expected to benefit from CAL.

- Learners in special schools for hearing-impaired learners will through this study, acquire a new learning strategy that delivers learning content in a different and possibly more appealing manner. The software allows for interaction between the learner and the computer. It gives a feedback that reflects a learner's level of achievement, including learning through exploration and discovery.

- Teachers in special schools for the hearing-impaired are expected to find in CAL a method that supplements their normal methods of instruction thus ensuring the teacher saves time for lesson planning and preparation. Teachers in regular schools may embrace the use of CAL for instruction to normal learners in other disciplines considering the fact that the use of CAL has proved to be successful among hearing-impaired learners.
- Curriculum developers and planners will find it beneficial to incorporate CAL in the implementation of school curricular to help improve learners' absorption of concepts during instruction while aiming to catch up with international trends in information and communication technology.
- The business world stands to benefit when computer literate school leavers join the work force. This supports current trends of maintaining skilled labour within a nation instead of exporting labour and thereafter, out-sourcing such labour to nations that have a shortage in such skilled labour. The use of CAL in classroom instruction is the initial step towards ensuring a computer literate work force.

iii) CAL introduces a new form of learning into the academic world:

- Computer-Aided Learning introduces virtual learning to hearing-impaired learners who have otherwise been confined to the lecture method of instruction. Virtual learning encompasses the use of digital tools (computers) and digital electronic information to give instruction to the learner with little or limited assistance from the teacher. Instructions are prepared in advance and stored electronically as software on compact discs or installed in a computer for use at ones convenience. This aspect of learning ensures

repetition with guarantee towards better learning of concepts. However, CAL is not aimed at replacing the teacher.

iv)The future of CAL in Kenya's market is very bright when we consider various factors which include the following:

- The introduction of CAL in the classroom is in line with future technological trends exhibited in the developing/developed world where a lot of learning is shifting towards the computer and other digital devices. The government of Kenya seeks to computerise learning in schools by first distributing desktop computers to schools. This implies that computer literacy is being advocated for at the lowest levels of education beginning with nursery schools, which are already familiarising learners with computers at a very young age. It is imperative that teachers introduce learners to virtual learning through Computer-Aided Learning. The introduction of CAL is opportune.
- The government's policy on information and communication technology (ICT) seeks to establish digital villages in Kenya. This calls for computers literacy among learners at all levels of education. The use of CAL therefore prepares learners in their future use of computers.
- Computer literacy is steadily becoming a prerequisite for employment in Kenya. It is considered advantageous when a job seeker is computer literate. The introduction of CAL among hearing-impaired learners places these learners on an equal competitive level with other job seekers who are expected to be proficient in the use of computers.

- The deluge of information makes computerisation necessary for purposes of storing information. New methods of retrieving/acquiring this information are necessary, hence the need to introduce CAL and the use of computers to learners.
- The prominence of the internet in society today seeks to embrace the modern class room as a means of communication. It serves the teacher well to have learners who are literate in computer skills.
- The versatility of computer-based software makes it possible to give instructions via the computer. The linking of the mobile phone to the internet ensures the accessibility of such information on a mobile phone. This will ensure the removal of any hindrances to accessing information by users of mobile phones, which have already become necessary tools among students in both schools and colleges. Computer software like the one used in CAL will soon be accessible on mobile phones.

5.5 Recommendations

The use of computers transfers the focus from the instructor by directly placing the responsibility of learning upon the students such that, instead of the learner passively sitting through a lecture, the computer compels the students to be an active participant in his/her search to not only acquire, but master the lesson's contents. The computer introduces this learner-centred approach towards learning relegating the teachers to the role of facilitation and constructive planning of future learning experiences.

The introduction of computers into the classroom is steadily leading to a shift from the traditional chalk and talk/lecture modes of instruction, towards more need-based

learner-centred/discovery methods of learning. This study established that the use of the computer in classroom instruction carries such a potential considering the fact that it greatly enhances the learning environment. The researcher therefore recommends that:

i. The use of CAL software should be encouraged in other subject areas in order to improve achievement.

ii. Future curriculum designs should incorporate the use of CAL and computer software in instructional processes in both primary and secondary schools.

iii. Learners should be introduced to CAL early in schools to enable them to cope with modern technological trends in both social and academic spheres.

5.6 Suggestions for further research

Results of this study suggested that the use of the computer for instruction enhances the learning environment in the teaching of geometry to the hearing-impaired learner, leading to higher achievement in geometry. Researches in teaching approaches that help to enhance leaning are yet to be delved into exhaustively. There is a lot of ground to be covered in this direction considering our level of technological development in Africa. Further research is still necessary in the following areas:

(i) A replication of this study on the use of Computer-Aided Learning (CAL) in the teaching of Algebra to hearing-impaired learners.

(ii) A replication of this study with a view to using acoustically enhanced Computer-Aided Learning (CAL) in teaching geometry to learners with residual hearing for better integration within the hearing world.

(iii) Research on the efficacy of an electronic sign language dictionary for instructional purposes.

(iv) A study on the effects of CAL based concept maps in the teaching of Geometry in secondary geometry.

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APPENDICES

APPENDIX A

PERMISSION TO CONDUCT RESEARCH

MINISTRY OF EDUCATION

Telegrams: "Schooling", Nakuru
Telephone: Nakuru42955 and 41311
When replying please quote

Ref. No TSC / 204849 / 7

PROVICIAL EDUCATION OFFICE
P.O BOX 259
NAKURU
10TH July, 2003

Mr. Timothy Anjili
TSC/ 204849

Thro!
The Headmaster
Nyangori High School
P.O Box 251
Kisumu

RE: PERMISSION TO CONDUCT RESEARCH

Permission is hereby granted to Mr. Timothy Anjili to conduct research related activities in special schools for the deaf in Rift Valley Province.

Head teachers in these schools are authorized to accord him any assistance he may require. All enquiries should be directed to this office.

F. E.Nyong'a
For:
PROVINCIAL DIRECTOR OF EDUCATION
RIFT VALLEY PROVINCE
C.C
The Secretary
Teachers Service Commission
Private Bag
NAIROBI

APPENDIX B

LETTER OF INTRODUCTION

Timothy Anjili
Egerton University
Curriculum and Instruction Dept.
P.O. Box 536
Njoro
Date:20th July 2003

The Head teacher
……
……
……

Dear Sir/Madam,

RE: PERMISSION TO UNDERTAKE RESEARCH IN YOUR SCHOOL

I am a student in Egerton University, undertaking a research entitled "Effects Of Computer-Aided Learning on Hearing-Impaired Learners' Achievement in Standard Three Geometry and Perception Their Learning Environment in Rift Valley, Kenya"

Your school has been selected to participate in this study. Permission to conduct the study has been granted by the Provincial Director of Education (Rift Valley). Your cooperation will be highly appreciated.

Yours faithfully

Timothy Anjili

APPENDIX C

Units and special education primary schools for the hearing-impaired in Kenya

Name of school	Type	Town	District	Province
Aga Khan	Unit.Pri.	Nairobi	Nairobi	Nairobi
Dagoretti	Unit.Pri.	Nairobi	Nairobi	Nairobi
RaceCource Rd	Unit.Pri.	Nairobi	Nairobi	Nairobi
Kambui	Pri. Sch.	Ruiru	Kiambu	Central
Murang'a	Pri.Sch.	Murang'a	Murang'a	Central
Kerugoya	Pri.Sch.	Kerugoya	Kirinyaga	Central
Tumu tumu	Pri.Sch.	Karatina	Nyeri	Central
Nyandarua	Pri.Sch.	Kinangop	Nyandarua	Central
Kitui	Pri.Sch.	Machakos	Machakos	Eastern
Kaaga	Pri.Sch.	Kaaga	Meru	Eastern
Embu	Unit.	Embu	Embu	Eastern
Aga Khan	Spec. Sch.	Mombasa	Mombasa	Coast
Ziwani	Pri.Sch.	Mombasa	Mombasa	Coast
Kibarani	Pri.Sch.	Kilifi	Kilifi	Coast
Kwale	Pri.Sch.	Kwale	Kwale	Coast
Hola	Pri.Sch.	Hola	Kilifi	Coast
Ngala	Special Sch.	Nakuru	Nakuru	Rift Valley
Kapsabet	Pri.Sch.	Kapsabet	Nandi	Rift Valley
Kabarnet	Pri.Sch.	Kabarnet	Baringo	Rift Valley
St. Kizito	Pri.Boarding	Litein	Buret	Rift Valley
Iten	Pri.Sch.	Iten	Keiyo	Rift Valley
Kedowa	Pri.Sch.	Londiani	Kericho	Rift Valley
Eldoret	Unit.	Eldoret	Uasin Gishu	Rift Valley
Kuja	Pri.Sch.	Homa Bay	Homa Bay	Nyanza
Maseno	Pri.Sch.	Maseno	Kisumu	Nyanza
Nyang'oma	Pri.Sch.	Bondo	Bondo	Nyanza
Mumias	Pri.Sch.	Mumias	Kakamega	Western

Source: Adapted from Ndurumo (1990); Provincial Education Office Records. Rift Valley (2003).

APPENDIX D

Hearing levels, traits and services for the hearing-impaired.

HEARING LOSS(dB) LEVEL		TRAITS	EDUC. SERVICE
	0 – 24	Normal Hearing	Regular Education
	25 – 35	Mild difficulties with speech sounds.	Regular Education, Speech therapy needed
I	36 – 54	Moderate difficulties in hearing distant speech.	Regular Education, Therapy/Amplification needed.
II	55 – 69	Moderately severe difficulties with loud or soft	Regular Educ., Spec. school speech therapy/amplification needed
III	70 – 89	Severe handicap with normal sound levels.	Special School placement and Therapy to curb deterioration.
IV	90 +	Profound difficulties in hearing & speech.	Special Education/Speech Therapy needed

Source: Cartwright, Cartwright & Ward (1984)

APPENDIX E

CAL Instructional manual for hearing-impaired learners

NB: To be used under an instructor's supervision and guidance

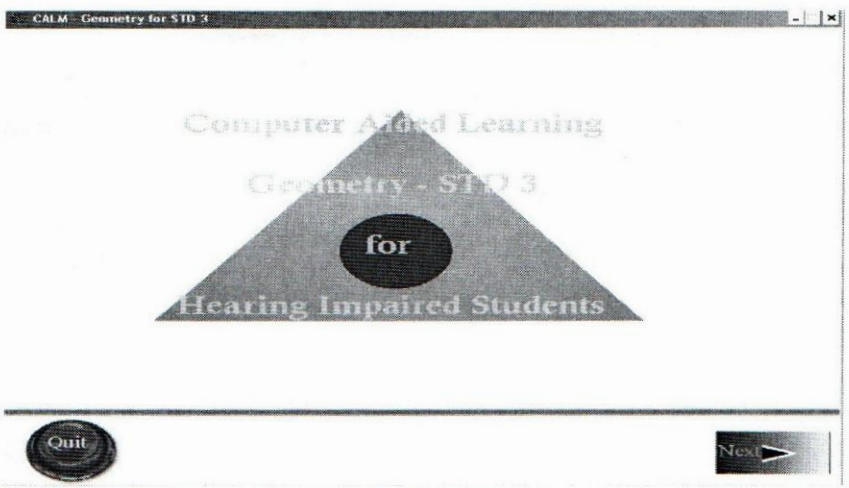
1. Ensure all computer parts are correctly connected i.e. the system unit, the monitor, the keyboard and the mouse.

2. Switch on the power button on the system unit.

3. Wait for the machine to boot (i.e. start, load the operating system until all Visible screen – based activity and beeping stops).

4. Check the screen for a red icon labelled **MMB CAL Geometry**. Use the mouse to double-click the icon and wait until the program loads onto the screen.

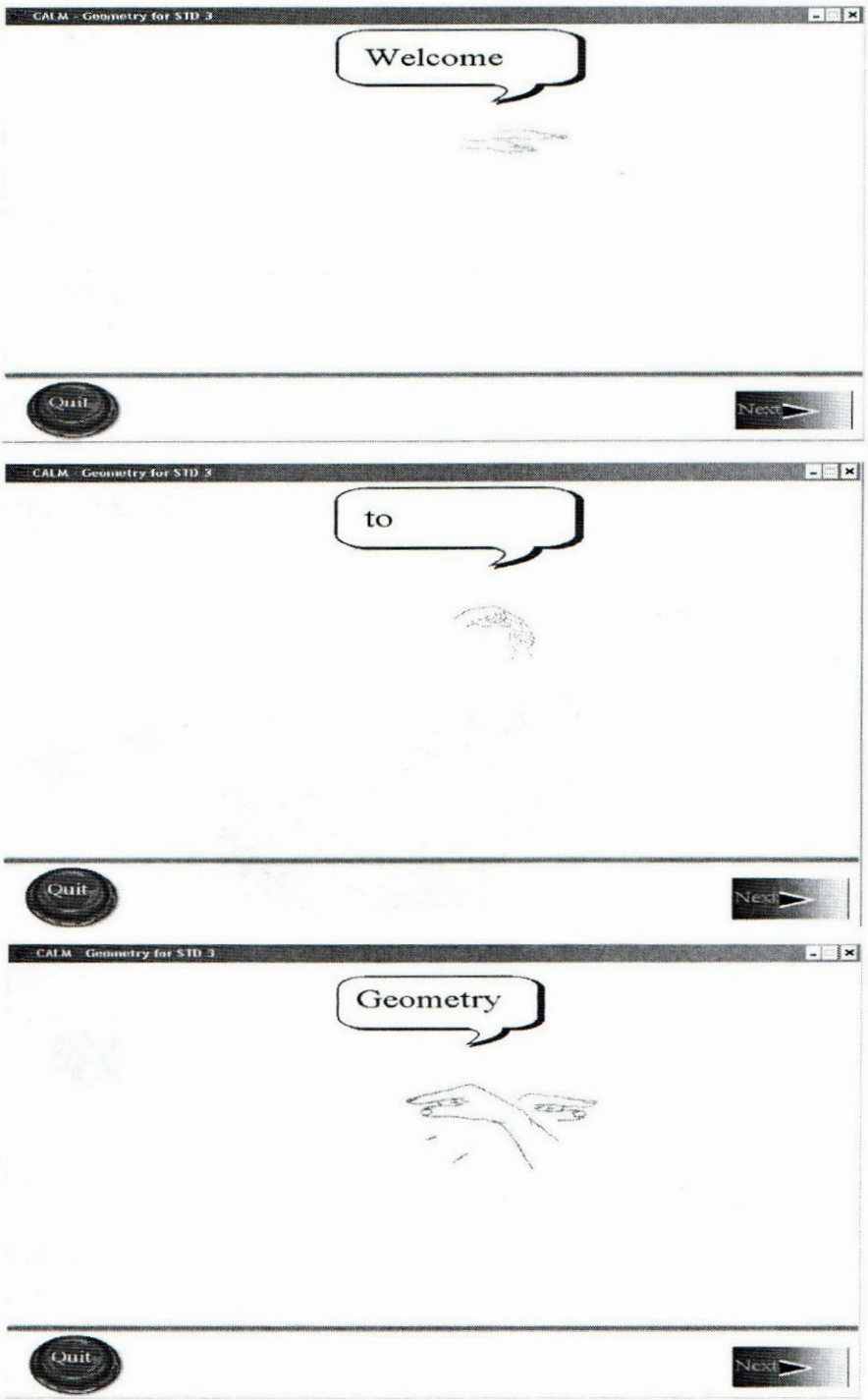
5. The first page displays the title '**Computer-Aided Learning Geometry for hearing-impaired Students**' with a **QUIT** and **NEXT** button in the left and right hand corners respectively as illustrated below.



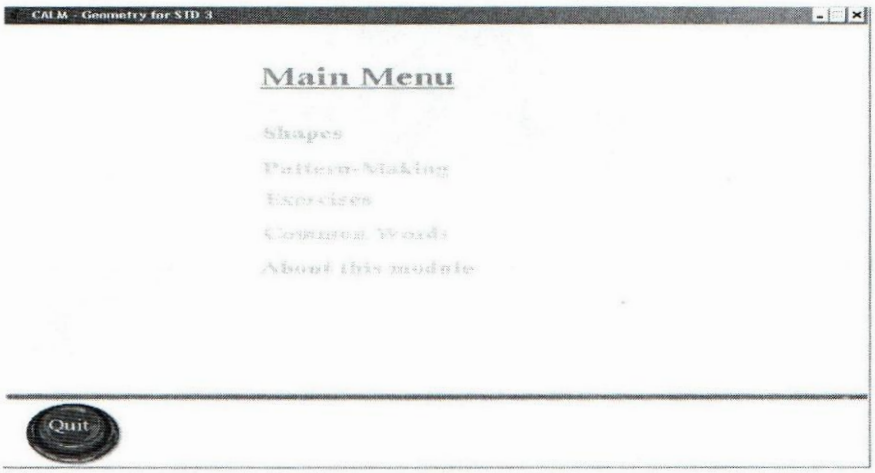
6. Click **NEXT** to continue with the program. (NB: Click **QUIT** only if you want to stop the software. Ensure to click only once for the

program to operate smoothly. If the program crashes, restart the program again).

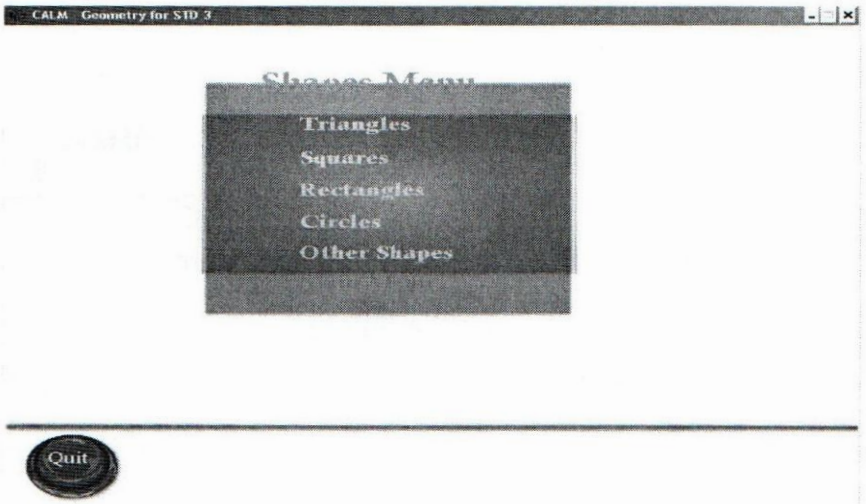
7. Wait for the **Welcome** message then click **NEXT** to continue.



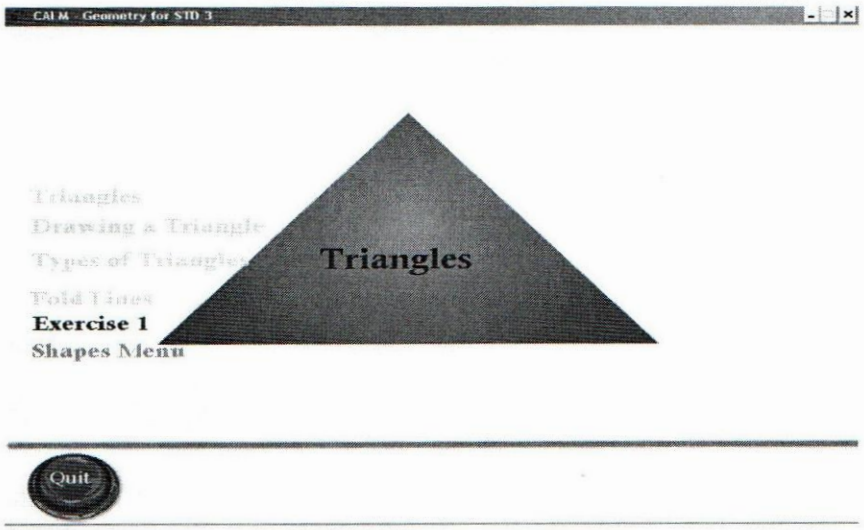
8. This launches a topical menu with the following content:



9. Click on **Shapes** to launch the sub-topical menu for shapes with the following content:



10. Click **Triangles** to launch the menu for triangles with the following content:



11. Click **Triangles** to launch the triangles, or any other item in the menu to launch the concept related to the item. Each page contains a **QUIT, BACK** and **NEXT** button at the bottom of the page.

12. A click on the tab **NEXT** launches contents under the subtitles in the menu. Each page offers an option to **QUIT,** go **BACK** to the menu, to **LEARN** the conceptions in any page, to move **BACK** to the previous page or move to the **NEXT** page. A **STOP** button gives an option to terminate action.

13. Repeat this procedure for each subtopic until all concepts are covered or Learning takes place. In case of any difficulties, consult the teacher.

APPENDIX F

MATHEMATICS ACHIEVEMENT TEST (MAT)

School.....Age.....Sex.....

Instructions:

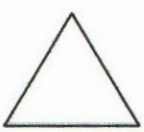
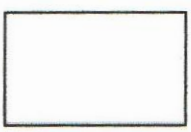
a) Answer **all** the given questions

b) Write your answers in the spaces provided.

c) **Circle** the right choices, for example

The sum of 1, 2 and 3 is (A) 4 (B) 7 (C) (6) (D) 5

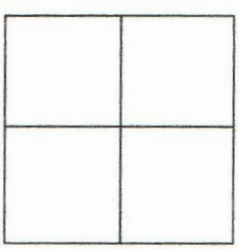
1) Write the correct name under each shape for the given figures.

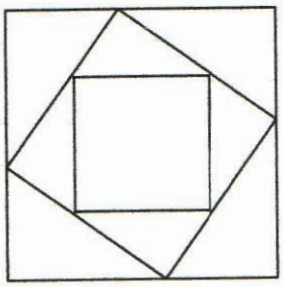

....

2) In the picture below I can see

(A) 2 rectangles (B) 0 rectangles (C) 4 rectangles (D) 5 rectangles



3) (i) In the picture below I can see:



(A) 2 Squares (B) 1 Squares

(C) 3 Squares (D) 4 Squares

(ii) I can also see:

(A) 4 triangles (B) 6 triangles

(C) 7 triangles (D) 8 triangles

4) In the picture below I can see:

(A) 3 circles (B) 4 circles (C) 5 circles (D) 8 circles



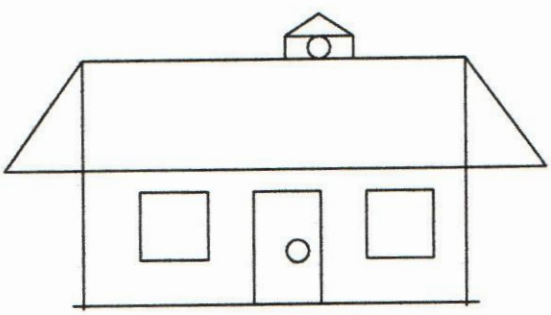
5) Count the shapes in the house below.

(i) Circles .....

(ii) Triangles.....

(iii) Squares.....

(iv) Rectangles.....



6) How many sides does a circle have?

(A) 2 sides (B) 3 sides (C) 1 side (D) 4 sides

7) How many sides does a triangle have?

(A) 2 sides (B) 3 sides (C) 1 side (D) 4 sides

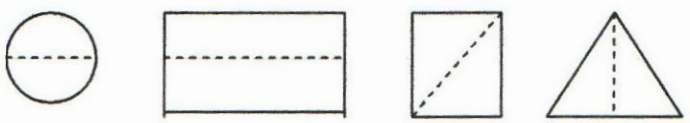
8) How many sides does a rectangle have?

(A) 2 sides (B) 3 sides (C) 4 sides (D) 1 side

9) How many corners are there in a circle?

(A) 0 corners (B) 1 corner (C) 2 corners (D) 3 corners

10) What fraction does the dotted line within the shapes divide each of the figures?

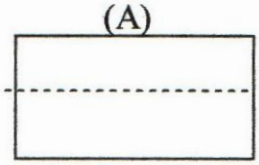


(A) ¼ (B) 1/3

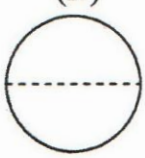
(C) ½ (D) 2/1

11) Which of the following shapes show divisions of 1/4?

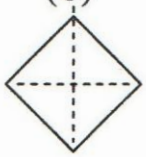
(A)



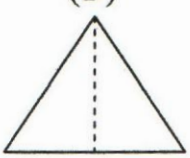
(B)



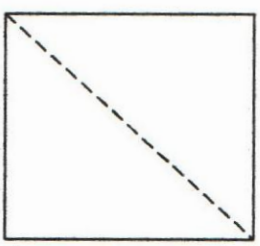
(C)



(D)



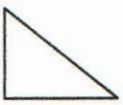
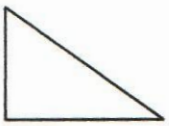
12) What shape do you get when you fold the picture below?



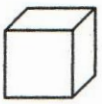
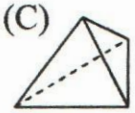
(A) A Square (B) A Rectangle

(C) A Triangle (D) A Circle

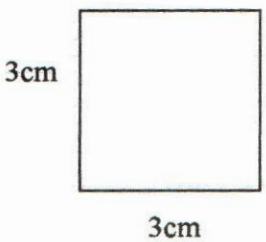
13) Pick the biggest shape among the ones below.

(A)  (B)  (C)  (D) 

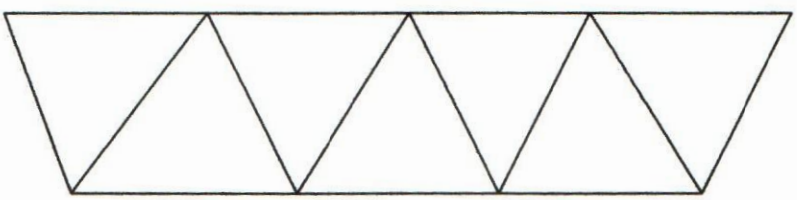
14) In which of these shapes can you see a square?

(A)  (B)  (C)  (D) 

15) Divide the figure below into four equal squares.

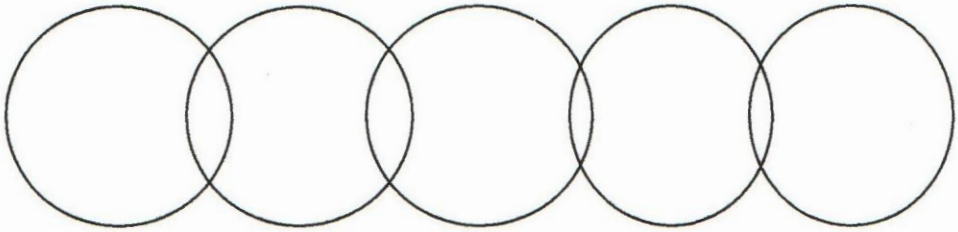


Which shapes can you see below?

16) 

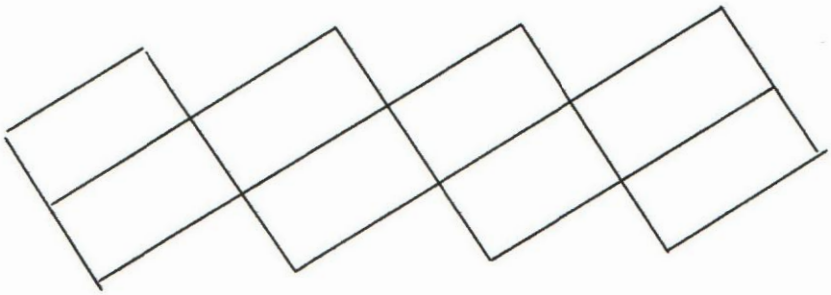
(A) Squares (B) Circles (C) Triangles (D) Rectangles

17)



(A) Squares (B) Circles (C) Triangles (D) Rectangles

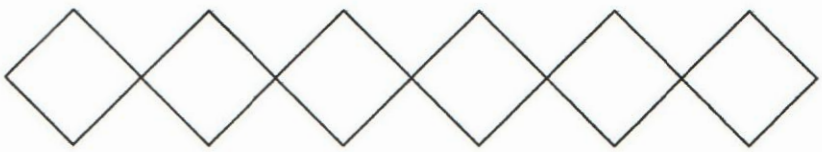
18)



(A) Squares (B) Circles (C) Triangles (D) Rectangles

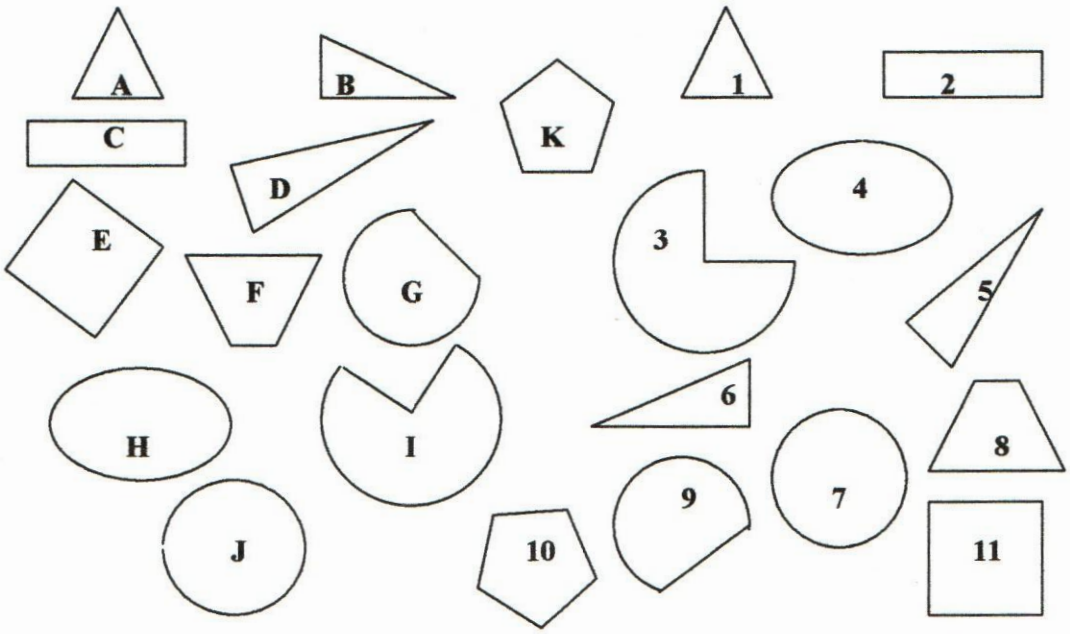
Which shapes can you see below?

19)



(A) Squares (B) Circles (C) Triangles (D) Rectangles

20) Match the shapes that look alike. For example: **A = 1**



A=__, B=__, C=__, D=__, E=__, F=__, G=__, H=__, I=__, J=__, K=__.

APPENDIX G

MATHEMATICS CLASSROOM ENVIRONMENT QUESTIONNAIRE (MCEQ).

School……Class……Sex……Age……

Instructions

a) This is **NOT** a test.

b) **Circle** your answer. The choices are **YES** or **NO**.

Example: Question: The lesson was interesting. (YES) NO

Item	Choice
1) We asked questions in the classroom.	YES NO
2) The teacher said our work was good.	YES NO
3) The teacher showed us how to work.	YES NO
4) Students made noise in class.	YES NO
5) We talked with our friends in class.	YES NO
6) Girls used the computer more than boys.	YES NO
7) Boys used the computer more than girls.	YES NO
8) The computer showed pictures and sentences clearly.	YES NO
9) We had enough time to finish our work.	YES NO
10) We did not have enough pencils and rulers in class.	YES NO
11) We worked together in groups.	YES NO

12) We solved problems alone. YES NO

13) We understood the pictures and words. YES NO

14) We helped each other in class. YES NO

15) Everybody took part in group work. YES NO

16) Boys got more help from the teacher than girls. YES NO

17) We had competitions in class. YES NO

18) We had a lot of time to finish our work. YES NO

19) Typing on the keyboard was not easy. YES NO

20) Pupils were friendly and worked together in class. YES NO

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