EFFECT OF A SOCIALIZED MATHEMATICAL LANGUAGE MODULE ON STUDENTS' UNDERSTANDING OF MATHEMATICS AND THEIR PERCEPTION OF THE LEARNING ENVIRONMENT: A CASE OF FORM TWO STUDENTS OF BUNGOMA DISTRICT, KENYA

BY

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A Thesis Submitted to Graduate School in Partial Fulfilment of the Requirements for the Award of the Degree of Master of Education (Science Education) of Egerton University

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DECLARATION

'I declare that this thesis on *Effect of a Socialised Mathematical Language Module on Students' Understanding of Mathematics and their Perception of the Learning Environment: A Case of Form Two Students of Bungoma District, Kenya* is my original work and has not been presented for a Degree or Diploma in any University or institution of learning.'

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DEDICATION

This thesis is dedicated with love and affection to Mary Viviane and the late Dr. Gideon Webi Wekesa.

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ABSTRACT

The general performance in mathematics among secondary school students in Kenya has over the years been poor. There is evidence that students have problems in understanding and interrelating the symbols and special language structure as used in mathematics. This study was designed to develop and explore the instructional potential of a Socialised Mathematical Language (SML) module in teaching and learning of statistics in mathematics. A quasi-experimental approach adapted from the Solomon Four Group Experimental Design was employed to compare experimental and control groups drawn from Bungoma district. Four different measures namely achievement test, students' questionnaire, teachers' questionnaire and observation schedule were used to collect data from 156 form two students. These students were randomly assigned in their intact classes to four groups namely experimental group one (E_1), experimental group two (E_2), control group one (C_1) and control group two (C_2). All the groups were taught the same content of the topic statistics in mathematics. However, groups E_1 and E_2 were taught by the SML approach while groups C_1 and C_2 were taught the conventional way. Groups E_1 and C_1 received pre-test before the commencement of the actual study. At the end of the topic, all the four groups were post-tested on all the measures.

Both qualitative and quantitative data were generated and hence both descriptive statistics (means, standard deviations, & percentages) and inferential statistics (t-test & the Analysis of Variance) were used for data analysis and hypotheses testing. An analysis of the findings indicate that the SML module resulted in significant learning gains, better perception of the learning environment and provided appropriate opportunities for student participation and interaction. Therefore the SML module was helpful in enhancing the teaching and learning of mathematics, facilitated in making the subject easily understandable to students and improved student performance in the subject.

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CHAPTER ONE

INTRODUCTION

1.1 Background Information

Mathematics plays an important role in scientific progress and development. Cockroft (1982) concurs with Mutunga and Breakel (1992) to state the fundamental role of mathematics as to lie in its everyday application in most social sciences and arts, government and business transactions. Cockroft further states that mathematics is increasingly being used in the study of physical sciences and engineering, biological sciences and medicine, geography, economics, business and management studies, household chores, military and aerodynamic advancements. Scopes (1973) outlined four basic goals of teaching the subject as utilitarian, personal, economic and cultural. Therefore, mathematics in our society is training in itself, where development of new techniques and concepts must have scientific, economic and sociological consequences akin to the development needs of the society. This is partly why mathematics is compulsory in the school curriculum in Kenya (Republic of Kenya, 1999).

It is emphasised that certain content must be covered in the secondary school syllabus and specific concepts and skills mastered by students (Kenya Institute of Education [KIE], 1992). This is because some concepts and skills such as measurement, statistics, scale drawing and calculus are useful and are applied in other subjects like physics, chemistry, biology and geography (Kenya National Examination Council [KNEC], 2000a; 2000b; 2000c).

The subject as is conceived in the world by mathematicians has a subject language of complete abstraction and precision (Costello, 1991; Durkin, 1995). According to African Curriculum Organisation [ACO] (1979), mathematics has no reference to actual phenomena. The subject deals with properties and ideas applicable to phenomena in the actual world, but not connected to them either in feelings, emotions or sensations. Githua (2001) argues that mathematics uses an internationally accepted symbol system that has condensed meaning. These

symbols and terminologies are not familiar and sometimes contradict meanings in ordinary English. For instance, the word 'mode' means style in English while in Mathematics, it is the event, number or value with the highest frequency.

However, language policy in Kenya stipulates that English is the medium of instruction from upper primary school level to University (Bogonko, 1992; Ministry of Education [MOE], 2001; Republic of Kenya, 1964; 1976). The language of the catchment area for the school is used as a medium of instruction for lower primary and pre-school levels. Kiswahili is used as mother tongue in cosmopolitan areas. In secondary schools, Kiswahili is taught as a language while other subjects in the curriculum are taught in English. This means that English is the language for teaching mathematics and other subjects except Kiswahili. Asiachi and Okech (1992) argue that the choice of a particular language for development and implementation of a curriculum is a central issue for education officials to find answers to. They pinpoint that in a multi-cultural society such as Kenya, the greatest problem to a curriculum developer is the choice of the language of instruction.

Despite its importance in the school curriculum and everyday life, mathematics is a subject that seems to be little understood by many secondary school students. This can be inferred from the poor performance levels as depicted by the Kenya Certificate of Secondary Examination (KCSE) results (KNEC, 2000c) shown in Table 1.

Table 1: Summary of KCSE Performance from 1996 to 1999 by %.

Year	Paper	Mean score	Standard deviation
1996	1	17.43	17.09
	2	19.09	16.59
	Overall	36.24	32.99
1997	1	17.44	16.69
	2	15.50	15.49
	Overall	32.62	31.59
1998	1	19.59	18.23
	2	15.64	15.25
	Overall	35.04	32.71
1999	1	13.46	13.85
	2	11.46	11.76
	Overall	24.45	24.94

Source: KNEC (2000b; 2000c) reports.

The mean score figures indicate that on the overall the students scored an average of about 35 marks while the standard deviation figures show that on the overall the students varied by 32 marks above and/or below the mean scores of the years indicated respectively. This implies that the candidates who sat for the examination during these years had mastered less than 35% of the prescribed syllabus (KNEC, 2000c). Further scrutiny of the results shows that the most poorly performed topics in Mathematics were algebra, 3-dimensional geometry and statistics (Kamau, 2000; KNEC, 2000b; 2000c).

An analysis of the KCSE examination question papers indicates that questions on statistics as compared to other topics keep recurring year after year yet no remarkable improvement has been realised in terms of student performance. This suggests that students have a problem in understanding statistics. It is however important that students perform well in this area, since statistics gives useful information used in planning, decision making and research by companies, government departments, scientists and so on (KIE, 1995). Thus, statistics is a useful tool in life.

Allen (1996) has argued that many of the serious problems that face secondary school mathematics instruction today may not be attributed to deficiencies in the curriculum, teaching or

assessment. This is in agreement with scholars who have expressed the view that learning difficulties in mathematics spring from language considerations rather than inherent conceptual difficulties of the subject (Bunyi, 1994; Cleghorn, 1989; Eshiwani, 1983; 1984; Githua, 2001, MOE, 2001). This provides evidence to suggest that there is a language problem in mathematics and students have problems in understanding and interrelating the symbols and the special language structure used in mathematics. Although statistics owes much from the theory of probability, the topic on probability is among the better-performed topics. Indeed, statistics has a lot of symbols and notations of which students may have inadequate understanding.

Githua (2001) and MOE (2001) concur to argue that the specialised language in mathematics tests and examinations is one factor that could contribute to poor performance. The KNEC report (2000b) has advised teachers to break down the complex language contained in mathematical concepts to simple language that students can comprehend. Durkin (1995) supports this point by noting that one of the principle problems of language in mathematics is that meanings to be conveyed are often complex. The reason being, English words take different meanings when used in different contexts.

Further, Dean (1982) pointed out that teachers have difficulty in communicating mathematical ideas or even simple instructions to students because they have difficulty in comprehending the mathematical language. Consequently, in order for the teacher to communicate with the learner well, a good command of language is very important. Students' perception of mathematics and the environment in which it is learnt might be negatively affected by the teacher's approach in presenting the subject matter (Costello, 1991). In addition, Githua (2001) alludes that the sentence structure, length and unfamiliar symbols and terminologies make mathematics textbooks difficult to read and comprehend. Thus, the foregoing discussion suggests that there is an inadequate understanding of both the English language and the mathematical language as used in mathematics instruction. This study sought to develop and investigate the

effect of an integrated mathematical language module herein referred to as a Socialised Mathematical Language (SML) module for teaching and learning statistics.

1.2 Statement of the Problem

The general performance in mathematics among secondary school students in Kenya has been poor for many years (KNEC, 2000a; 2000b). This means that Kenya may not achieve her goal of industrialisation by the year 2020, for which mathematical knowledge is necessary. Studies conducted on students' performance in mathematics reveal that, the language of mathematics is one of the major factors responsible for the poor performance in the subject (Eshiwani, 1983). No specific and precise language of instruction has been developed to facilitate students' understanding of mathematical concepts and skills. It is not clear what language would be appropriate for mathematics instruction in secondary schools. However, it is important to begin somewhere in an attempt to come up with such a language. As already stated, statistics is useful in life and has a lot of mathematical language, which could provide a starting point. As such, it is useful to develop a Socialised Mathematical Language (SML) module to enhance students understanding of mathematical concepts and skills in statistics and perception of their learning environment.

1.3 Purpose of the Study

The purpose of this study was to develop an SML module and investigate its effect on Form Two students' understanding of statistics in mathematics and also on their perception of the mathematics learning environment.

1.4 Objectives of the Study

The following specific objectives guided the study.

1. To develop an SML module for teaching and learning statistics in mathematics

2. To determine the effect of the SML module on students' achievement in statistics.
3. To analyse the effect of the SML module on students' perception of learning environment.
4. To determine the effect of the SML module on students' skill performance in statistics.
5. To examine the effect of the SML module on classroom interaction during mathematics instruction.

1.5 Hypotheses of the Study

The following null hypotheses were statistically tested:-

Ho_1: The SML module has no significant effect on students' achievement in statistics.

Ho_2: The SML module has no significant effect on students' perception of learning environment.

Ho_3: The SML module has no significant effect on students' skill performance in statistics.

Ho_4: The SML module has no significant effect on classroom interaction during mathematics lessons.

1.6 Significance of the Study

This study was prompted by the persistent poor student results in mathematics in KCSE examinations. As already stated, the subject plays a pivotal role in scientific progress and development. There are studies that have been conducted on this issue and several findings, conclusions and recommendations reached. However, there are certain factors that make the present study distinctive and significant.

To begin with, this study is probably the first of the kind in Kenya to systematically develop and examine the effect of the SML on students' understanding of mathematics and

perception of learning environment. In this regard, it is envisaged that it would trigger further research into the development and use of the SML in other topics and classes during mathematics instruction in particular and science instruction in general. So far, very little has been done or otherwise known about what language would be appropriate for mathematics instruction in secondary schools.

The development and implementation of the SML module conformed to the approved content and objectives given in the KIE syllabus, textbooks for students and teachers guides. This means that the module followed closely the requisite curriculum content and materials stipulated in the science education syllabus. In other words the module developed and used in the present study was curriculum-based and content-specific tailored to meet the instructional and learning needs of the form two students.

In contrast to the previous studies that focused on gathering data on students' performance, perception of the learning environment and/or science, and teaching of mathematics in local languages, the present study has shown that the SML could become an integral part of instruction in Kenyan classrooms. This conforms to the language policy in Kenya. Hence it is hoped that policy makers, mathematics textbook authors and publishers, teachers, students and all those concerned with the role of language and education may find this approach useful in the instructional process. All the stakeholders will thus benefit from the results of this study by using appropriate language that will make the instructional process easily understandable by teachers and form two students in secondary schools especially in statistics. This might improve the instructional process and students' performance at the secondary school level.

1.7 Scope of the Study

The proposed study involved Form Two students selected randomly from Bungoma district. The district has provincial, district and private categories of schools. The district was

selected because students' performance in mathematics has been poor (District Education Office Bungoma, 2001). Available statistics show a performance mean score of 2.580, 3.125, 3.028, 3.485 and 3.640 for 1996,1997,1998,1999 and 2000 KCSE examination respectively. Although these figures indicate an improving trend, they represent less than a third of the maximum aggregate score of twelve points. Furthermore, Bungoma district was selected because of its familiarity to the researcher and good transport network that facilitated accessibility to schools and respondents.

The study focused on public secondary schools in the district category. This is because there are more district secondary schools as compared to provincial and private schools, hence, availability of respondents for the study. Besides, students admitted into these schools have almost the same qualification based on their Kenya Certificate of Primary Education (KCPE) examination performance. This would provide a basis for generalisation of the results. Form two students were chosen because the area of statistics chosen for study is taught at this level (KIE, 1992). Statistics was selected because students' performance in this area is relatively poor in KCSE examinations and hence the topic is rated among the most difficult in mathematics (Kamau, 2000; KNEC, 2000b). In addition, statistics has a lot of mathematical symbols and terminology of which students seem to hold an inadequate understanding of.

The SML module that was developed for this study consisted of concepts and skills in the topic statistics. The specific content centred on concepts and skills on data collection and organisation, measures of central tendency and methods of data representation as outlined in the syllabus and teachers guide. Thus, the module concentrated on student understanding of mathematical language in statistics lessons rather than the whole mathematics syllabus.

It is difficult for a researcher to manipulate more than four independent variables in a single study using an experimental design (Borg, 1987). As such only identified variables namely achievement, skill performance, perception and interaction were included in the study. Although

several factors may affect the teaching and learning of mathematics, this study focused on language only.

1.8 Limitations of the Study

There are individual differences in any mathematics classroom (Mondoh, 2000b). This may contribute to behavioural phenomenon observed in a given setting. Therefore data obtained from this study may not be valid for other groups and settings. In addition, this study was conducted within a specified timeframe and resources available to the researcher. As such only identified variables and sampled schools were studied.

Another limitation of the present study was the difficulty to reconstitute classes. This arose because school authorities could not allow already constituted classes to be reconstituted. This therefore did not allow individual random selection of subjects. As such, the researcher used intact classes of students. However, the research design adapted in this study and the statistical tests applied in data analysis are robust enough to counter any confounding factors that may affect the validity of the present study in this regard.

There are criticisms leveled against multiple-choice items as stated by Gronlund et al (1988). As such the use of such items in Section A of the Mathematics Achievement Test{MAT} measuring instrument is worthy justification. A total of 15-multiple choice questions were used in Section A of the MAT because of the economic and resource constraints on the part of the researcher. Specifically, the implementation of this study was limited to the time made available by the school authorities. Due to these reasons, it would be inappropriate to compare the results of this study to those that were sufficient in themselves. Hence generalization of the results of this study has been done with caution.

1.9 Assumptions of the Study

This study was carried out under the following assumptions:

1. That all mathematics teachers were trained and qualified to teach the subject matter effectively and that they had the same experience in teaching the subject. Therefore, the difference in students' understanding and perception was only attributed to the treatment given.
2. That language was the main factor affecting students' performance in mathematics and confounding factors were taken care of by the research design and statistical tools that were applied.

1.10 Definition of Terms

Language- Refers to the system of words and symbols used by a particular group for indicating meaning of ideas and/or feelings (Longman, 1992). In this study, language referred to words and symbols as used in English and mathematics during formal instruction.

Mathematical language- in this study, it referred to specific words, symbols, signs, notations and formulae used by mathematicians to express ideas, concepts and skills in the topic statistics in mathematics.

Skill performance- is the psychomotor manifestation of acquired knowledge. In this study, this involved logical working and correct computation of a mathematical problem and drawing of statistical diagrams.

Classroom interaction-is the interaction between the student-teacher-student and materials during mathematics instruction (Kirembu, 1991). This included interpersonal communication,

discussions, questioning and references to, or use of instructional materials in the learning process by teachers and students during lessons in the topic statistics.

Socialised mathematical language- Simplified language that explains and expresses mathematical concepts. In this study, the language integrated ordinary English language and Mathematical language in teaching and learning of statistics. Statistical terms and symbols were explained in both the English and Mathematical contexts.

Perception- is a personal view about a phenomenon (Longman, 1992). In this study a score was obtained on students' views about their learning environment as measured on a five point Likert scale.

Understanding- it is the knowledge of meaning of something (Longman, 1992). In this study, it was taken to mean the score obtained in relation to successful mathematical operations as measured by students' knowledge and skill performance in the achievement test.

Mathematics Learning environment- is all that entails teaching and learning of mathematics in a normal classroom setting. In this study, this included teacher and student activities, discussion, time, language and instructional materials used during statistics lessons.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

In the past two decades, language proficiency has been identified as an important determinant of students' performance in science and mathematics. Studies in Mathematics Education in Kenya seem to have dealt more with student -teacher factors and instructional materials in the school curriculum than the use of language in instruction (Mondoh, 1986; Munguti, 1984; Ondu, 1986; Wanyonyi, 1987). As such, there seems to be lack of research specifically focusing on the use of language in classroom discourse in mathematics among Kenyan secondary schools. This chapter is concerned with a review of related literature in regard to language in mathematics instruction and relates it to the conditions found in Kenyan secondary schools.

2.2 Secondary School Mathematics in Kenya

2.2.1 Objectives of Teaching Mathematics in Secondary Schools

According to the secondary school mathematics syllabus, mathematics is a distinct subject of study in the curriculum. The main objective of teaching this subject at the secondary school level is to assist in the process of producing a person who will be numerate, orderly, logical, accurate and precise in thought (KIE, 1992; KNEC, 2000a). Moreover, the person should be competent in appraising and utilising the mathematical skills in playing a positive role in the development of a modern society. This implies that a person will make precise and logical use of mathematical language to concretise problems from everyday situations, comprehend, analyse, synthesise and evaluate a set of numerical data to both familiar and unfamiliar situations.

2.2.2 Learning and Teaching Mathematics in Secondary Schools

Learning has been defined as an active process in which learners actively construct meaning of their own experiences (Driver & Bell, 1986; Mursel, 1954). Mursel further argues that a good context for learning must be that in which the learner interacts with and concepts to be acquired are simplified. Mondoh (2000b) notes that in the process of learning mathematics learners should be actively involved so as to construct meaning from experiences provided in the mathematics lesson and in some cases lessons outside the classroom that are mathematical in nature.

Teaching involves students organising their learning experiences successfully in a way that makes sense to them (Driver & Bell, 1986; Mursel, 1954). Mursel further claims that it is teaching that brings about effective learning. The decisive question in this case is not methods or procedures but results that should be applied in other areas. Thus, teaching involves teacher activities that are aimed at assisting the learner to learn. Effective teaching takes place if there is meaningful learning as an outcome.

However a suitable method of teaching in the hands of one teacher may be quite unsuitable for another. Similarly, a successful method for teaching one class under certain conditions may prove inappropriate for teaching the same class under different conditions (Ayot & Patel, 1987). This means that the method adopted depends on the teachers' interest and abilities, intelligence and interest of pupils and availability of facilities for effective and efficient teaching. However, Njeremani (2001) alludes that teachers might be unqualified because they lack training on how to teach certain levels like Forms one and two where according to Piaget, pupils are at concrete operational stage. Lecture method is largely used because it is what most graduate teachers are familiar with, having been exposed to it for all their studying time during their training. Several authors have argued that quantitative concepts and skills in science cannot be easily realised in classrooms that employ expository teaching (Ayot & Patel, 1987; Kiboss, 1997; KIE, 1992;

KNEC, 2000a). This is because understanding of such concepts is both time-related, task oriented and tends to emerge from the process of quantifying a phenomena. In addition, activities associated with expository teaching are weak since they do not give enough opportunities to students to exercise certain behaviours that may help them gain necessary knowledge and skills.

Njeremani (2001) further explains that textbooks on the other hand might be inappropriate due to irrelevance in relation to course objectives. Sometime textbooks might use advanced language, quite inappropriate for certain lower levels. Since it is important for teachers to inculcate adequate content knowledge to guide learners to quantify a phenomenon, this study attempted to restructure the teaching and learning of a mathematics topic on statistics by developing and exploring the instructional potential of the SML module.

2.2.3 Concept Development in Mathematics

Mathematical concept formation is related to, and dependent upon language development (Bell, et al. 1983). This includes the development of adequate terminology as pre-requisite for cognitive growth. In his earliest studies of intellectual development, Piaget stated that language and thought are in a genetic circle where each leans on the other in independent formation and continuous reciprocal action (Austin & Howson, 1978).

Language seems to play an essential role in the development of higher order concepts. Both Piaget and Vygosky provide evidence that the development of linguistic structure in some cases precedes the appreciation of the corresponding relationship. Vygosky (1962) in an experimental study of concept formation probed more deeply into the dependence of understanding concepts on the language that describes them. He found that children do not make the separation between linguistic forms and meaning. In this regard both Piaget and Vygosky conceded that language is a major influence on individuals thinking. This is because language and thought are so inseparable that words and symbols take the characteristic features with them. As

such language provides verbal symbols that represent concepts and can be used as stimuli for the internalised manipulation of these concepts.

Nevertheless, research in psychology of learning by Piaget and Brunner ushered in new knowledge regarding how children learn complex mathematical ideas (Shiundu & Omulando, 1992). They say pupils can learn any complex concept provided it is presented in a honest manner whereby appropriate opportunity is provided for pupils to participate actively in the learning activity. Eshiwani (1984) argues that concepts in mathematics exist in hierarchies. There are simple concepts that lead to complex concepts. Therefore mathematics is best taught using the known to unknown approach. Eshiwani further distinguished between relational and instrumental understanding as far as mathematics is concerned. He explains relational understanding as to include all descriptions, classifications and understanding of relationships, which help explain the social phenomenon. In this view, the development of terminology appears to be important for concept formation in mathematics. The general description of language in the development of mathematical concepts is difficult to provide, but the language, especially oral dialogue is an essential part of this process that needs to be well established. This may depend on how learners understand the language used in presenting mathematical concepts.

Since independence, several changes have been effected in the mathematics curriculum in Kenya. Most of the changes have been towards realising mathematics as a practical subject and a tool for other subjects (ACO, 1979; Mutunga & Breakel, 1992). Asiachi and Okech (1992) explain that the essence of some programmes was that the old concept of the child receiving instructions from the teacher made learning passive. Further, they concur with Shiundu and Omulando (1992) and Eshiwani (1984) in arguing that syllabuses and the textbooks used were far difficult for an average learner and the content was extremely demanding to both students and teachers. The texts were best suited for top students who were to continue with mathematics beyond high school because the language used in the textbooks was generally difficult for most learners. This implies

that little attention was devoted to average and below average learners whom primary and/or secondary school education is terminal and also form the majority of the Kenyan school population. Since Kenya is striving for industrialisation, it is these graduates who are expected to develop and raise the standards of living especially in the rural areas. As such, a good understanding of mathematics would be necessary.

Mathematics education in Kenya involves the learning of concepts, skills and procedures. It is generally accepted that concept development in mathematics as is the case in other subjects derives from verbal discussions between the teacher and the learner (Bunyi, 1994; Eshiwani, 1984). As stated earlier (see1.1), the concepts and skills in the topic statistics are useful and applicable in life. An understanding of these concepts and skills involves the ability to abstract the mathematical relationship in a mathematical notation. To teach this understanding effectively, simplicity and clarity of the concepts, skills and procedures is essential to both the teacher and the learner. They both need to verbalise the mathematical language in order to internalise the concepts, skills and procedures. This study sought to express such mathematical operations simply and clearly through the SML module.

2.3 Language and Mathematics

Arguably, the nature of mathematical language poses many challenges to students and teachers. According to Durkin and Shire (1995), mathematical knowledge is transmitted, explored and advanced via language: face-to-face, in printed texts, and other media. Students and teachers write, talk and listen mathematics. However, in the diverse contexts of mathematical communication and instruction, language can help the learner to gain insights, yet it can serve also to obscure and impede the learning process. Such an observation is relevant to the Kenyan mathematics curriculum, but the relationship between mathematics and language is intricate. However, studies carried out concerns student-teacher factors in relation to teaching, learning,

achievement and attitudes as regards mathematics (Mondoh, 1986; Munguti, 1984; Ondu, 1986; Wanyonyi, 1987).

An important area that is not reflected by these studies is the use of language in classroom discourse. This oversight might have occurred probably because in Kenyan secondary schools, English is the accepted standard medium of instruction for all subjects except Kiswahili. As such, teachers and students alike must communicate in English. Seldom do they communicate in their home language in the classroom discourse. Language is however important because the sole use of a second language may interfere with science learning and also, using a shared language in classroom discourse may facilitate the understanding of science (Ramorogo & Kiboss, 1997; Thijs & Van den Berg, 1995; Tobin, 1997). The main focus of this study is on the use of language in mathematics instruction in Kenyan secondary schools.

2.3.1 Language Situation in Kenya

The language situation in Kenya is very complex. It is estimated that there are about forty indigenous languages in this country (Bogonko, 1992; Bunyi, 1994). Besides, there is Kiswahili that was declared the national language in 1974 and English, that is a colonial legacy, that is also the official language. As stated earlier, the language policy in Kenya states that English is the official language of instruction for all subjects except Kiswahili from upper primary level to university. However, the medium of education has received criticisms for not being based on systematic classroom research to explore the effects of the use of various languages in teaching and learning (Bunyi, 1994; Cleghorn, 1989). This means that the policy is not of educational considerations.

Tied up with the question of teaching and learning is the issue of cultural transmission. The school in Kenya is major socialising agent and language is seen to be part of culture and the vehicle through which culture is transmitted. Some scholars have argued that vernacular is the

only qualified language to do this (Bogonko, 1992; Bunyi, 1994; Cleghorn, 1989; Costello, 1991). In multicultural and multilingual contexts such as in Kenya, the question of what language to use as a medium of instruction therefore arises. Although there are indications that the policy regarding the medium of instruction is not strictly adhered to (Bunyi, 1994; Cleghorn, 1989), the actual situation in the classroom has not been adequately investigated. This study was specifically designed to develop a socialised language and investigate its effect in a normal classroom setting among Kenyan secondary schools in an attempt to open up this important area of study and begin filling the gaps that may exist.

2.3.2 Language of Instruction

Literature is replete with studies indicating that language interferes with science learning especially when English is used as a medium of instruction to second language users. Thijs and Van den Berg (1995) and, Ramorogo and Kiboss (1997) have argued that cases where English has been used in teaching science, teachers and learners need to have a good command of the English language for meaningful learning to take place. This is in agreement with Tobin (1995) who says that learners with limited proficiency in the use of English often face an enormous challenge of making sense of instruction while at the same time building an understanding of science. He further alludes that science is a form of discourse that incorporates a language characterised by concepts and facts, ways of providing knowledge claims and ways of communicating what is known among participants in a community. This suggests that ordinary English may not be the best medium for science instruction. This is because English words take different meanings when used in different contexts.

In their investigation on pupils' meaning of words commonly used in science lessons, Freyberg and Bell (1990) found that pupils' meaning of some words are different from those of scientists. In some cases, pupil's meanings are narrower and confined to meanings often used in

their everyday language. Gramley and Patzold (1996) report Chesire's findings of a study in reading that boys are firmly embedded in local vernacular culture to use non standard forms of language than girls. This means the problem pupils' face in science and mathematics lessons is to identify the meaning intended in any particular case.

Elsewhere, studies show that any language could be used for instruction. Rutherfold and Nkopodi (1990) report that the use of English enhanced the recognition of science concepts. Conversely, Rolnick (1990) reports that the use of mother tongue (Siswati) rather than English facilitated the learning and expression of science concepts among Swazi students. In Kenya, studies reveal that the use of vernacular for teaching and learning mathematics has a positive effect on enhancing students' acquisition of concepts and performance (Bunyi, 1994). However, based on the language policy on education, such findings are inapplicable at the secondary school level. Indeed, learners tend to construct their knowledge by observing others and co-participation in a community (Roth, 1995). Given the multilingual and multicultural classrooms currently characterising most schools in Kenya, language is a formidable constraint if learners who do not understand the English language are expected to construct and participate in the classroom mathematics activities. Perhaps a socialised mathematical language could enhance student understanding of mathematics in Kenya.

2.3.3 Language of Mathematics

Mathematical language appears to pose problem to students and teachers in the process of teaching and learning. Durkin and Shire (1995) observe that the vocabulary of mathematics includes words and symbols that have multiple meanings. Consequently, pupils often fail to interpret these words and symbols as teachers intend them. Therefore understanding of mathematical words in prose seems to be the major problem. Lawing (1983) however asserts that, in order to translate a sentence into a mathematics problem, one needs to know what the words in

the sentences mean. He alludes that most problems are not difficult to solve when written in mathematical terms but the difficulty arises when the problem is stated in prose.

Copeland (1984) claims that whatever you say to mathematicians, they translate it into their own language and forthwith it becomes something different. He argues that the transfer of what has been learnt in one problem situation to another is important and necessary in understanding mathematics because such cognitive structures as seriation, conservation, commutativity and transitivity are basic parts of many mathematics problems. This means that words are probably not a shortcut to understanding because when a student comes across word problems in textbooks and examinations, which test application and generalisation, the stimuli is not readily apparent. Hence finding the appropriate response of the problem becomes difficult to some students while others who have developed some working procedures and processes on their own, tackle them with success.

2.4 Students' Achievement in Mathematics

Analysis of KCSE results show that boys perform better in science and mathematics than girls while girls outdo boys in art based subjects and languages. For instance, during the 1999 KCSE examination, boys scored a mean score of 19.96 as compared to 12.28 for girls in mathematics while in Kiswahili, the mean scores for boys and girls was 80.47 and 82.04 respectively. This implies that girls have more interest in language-oriented subjects and the arts. Several arguements have been put forward to explain the difference.

Bryden, cited in Mondoh (2001), attempted an explanation on differences in spatial ability by using cerebral organisation of men and women. Bryden argued that there exists a dichotomy between linguistic and spatial skills in the hemispheres of the brain. The left hemisphere controls the linguistic skills while the right, the spatial skills. Accordingly the left hemisphere of the brain develops earlier in girls giving them relative linguistic superiority whereas boys develop the right

hemisphere earlier, giving them greater competence in spatial related activities. Although the difference in information processing may pass as a cause for gender differences in mathematics achievement, there are boys who perform equally better than girls in language and girls who perform better than boys in spatial activities.

Children differ considerably in their potential for learning mathematics (Mondoh, 2000b). She says, perhaps the disparity is that some children who appear articulate and intelligent in their conversation and everyday behaviours do not perform well in mathematics. She argues that significant differences in learning mathematics include knowledge of mathematical concepts, structures and special talents. She therefore suggests that for improvement in mathematics performance, students should be encouraged to engage in activities that would render relevant experiences for future learning of mathematical concepts and skills. These were embedded in the SML module.

2.5 Students' Perceptions of Mathematics Learning Environment

Effective learning environment is one in which the teaching-learning process varies according to such factors as the role of the teacher, the role of the learner, and the nature of instructional activities (Kiboss, 2000). However, these may be influenced by the teacher and learner roles during instruction although the nature of learning activities is largely dependent on the learners' participation. Kiboss further argued that student perceptions about science and mathematics might be negatively affected by the way the teacher presents the subject matter. As such, the knowledge and understanding of the psychological aspects of the learner in the classroom situation were important for this study.

Most secondary school students especially girls perceive mathematics as a "hard" subject (Mondoh, 2000a; 2000b). Dean (1982) and Copeland (1984) argue that, the subsequent use of examinations as incentives for study depends to a large extent on the motivational effects of the

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previous examination results. If these are poor, students might be discouraged and give up whereas if they were good, they might be tempted to take it easy afterwards. This scenario probably makes mathematics "hard" to students.

Scholars note that students have taken little interest in science subjects because they do not enjoy the wonderment of learning science through experiments due to lack of facilities. Ndirangu (2000) asserts that teaching and learning materials are inadequate especially for science subjects. Due to this, teachers have resorted to theoretical approaches. These approaches as he argues have contributed to negative perceptions by learners who view some science subjects as irrelevant and strenuous to learn.

The influence of adults is unquestionably great on student perception (Changeiywo, 2000; Okebukola & Jegede, 1990). Adults act as role models that have traditionally been considered to vary by gender. Boys are known to imitate male forms while girls imitate female patterns. Changeiywo (2000) found that traditional beliefs seem to have an effect on students' images of scientists and science. This shows not only how unerringly students imitate models but also how susceptible they are to gender stereotypes. Since only one factor was considered in this case, there is need for further investigation on other factors like the class level.

Cognitive theorists agree that all learning is dependent on the learner attending to stimuli and correctly perceiving and processing them. The arousal and maintenance of attention during instruction process may be achieved by embedding the proper perception of the lesson elements (Kiboss, 1997; 2000). Kiboss (2000) adds that attention is influenced by a variety of factors e.g. the level of student involvement, personal interests and prior knowledge, lesson difficulty, novelty and familiarity and pacing. All these were considered when designing the SML module whereby the learning of the topic statistics depended on the teacher and each individual students contribution and participation in the group. The teacher was responsible for restructuring and

controlling the classroom environment in order to allow the students to work interactively in collaborative group(s).

2.6 Classroom Interaction

The Kenya Government has placed a high premium on education. Because of this, it is very important that the teaching and learning process in the classroom be conducted as efficiently as possible. However, Bunyi (1994) views the linguistic medium in which the instructional process take place to be critical. The reason being the dearth of instructional materials coupled with inadequate understanding of the linguistic medium by both teachers and students. Tobin (1997) asserts that all learners in a science classroom should be accorded opportunities to engage in science like activities and give feedback on the adequacy of their performance. He adds that learning involves the interaction between individuals that centres on explaining, clarifying, elaborating, justifying, querying and evaluating of concepts and skills. This seems to imply that language is a shared commodity in that participants use it to interpret texts of the community and their own contexts. Therefore, to completely engage in learning, both the teacher and student need to develop a certain vocabulary that they must use to communicate meaning.

Studies have shown that classroom interaction is an important determinant of student achievement in mathematics. Kirembu (1991) found that the nature and quality of classroom interaction is vital for good performance. He argues that the quality of classroom interaction should exist in contexts of social interaction. This involves reciprocal contacts between the teacher and the learner whose interchange leads to meaningful teaching and learning. The teacher acts as a mediator between the student and the body of knowledge and this may vary from one teacher to another depending upon his/her knowledge, experience and attitudes.

Sanga (1982) established that in Kenyan classes, some students have greater interaction with their teachers than others do. This interaction is accelerated by criticisms or praises during

instruction. Evans (1980) supports this argument by noting that teachers interact more with their most creative students whilst the least creative students receive few and usually discouraging interactions. Although Kirembu (1991) found that the more interactive students and teachers are, the better the student performance, Sanga (1982) recommends further research concerning classroom interaction in an effort to obtain more comprehensive picture on the same.

Interaction in the classroom seems to be a complex and difficult process. Considering that the group that makes the classroom community establishes the classroom climate, the nature of their interactions is crucial (Costello, 1991; Kiboss, 1997; 2000). The relational quality of these interactions is channelled through verbal and non-verbal interactions in the classroom. Examples include classroom talks, facial expressions and inference to learning materials. It has been established that classroom environments that provide opportunities for such interactions often result into meaningful learning (Ramorogo & Kiboss, 1997). Therefore, this study looked into the frequency of student-teacher-student and material interaction during the instructional lessons in the topic statistics.

2.7 Skill Performance in Mathematics

The process of teaching is not only transmitting knowledge but rather negotiation of meanings (Boyle, 1997). Emphasis is on the skills and processes that require students to become expert in the domain of facts and knowledge. There are a total of 15 science process skills that have been identified in science (Okere, 1996). The need for students to develop statistical skills is critical if they have to apply them in life (KIE, 1988; 1992; 1995; KNEC, 2000a). Specifically, the secondary school mathematics teachers guide emphasises the following: collecting and organising raw data by the use of frequency tables, represent data in bar charts, histograms and/or frequency polygons and calculations involving the measures of central tendency. These skills should be taught based on the notion of transferability whereby once a skill has been acquired, it may be

transferred to new areas of application. However, the assessment of such process skills in mathematics is of concern.

Studies reveal that students score differently on different examination items. Some do well on relatively easy items while others score highly on difficult ones (Kakonge, 1980; Wamani, 1980). This in a way suggests that some students are less or more impulsive than others, hence a difference in process skills. Mondoh (1986) found that there is an overall significant difference between boys and girls on mathematical abilities in arithmetic reasoning and computational skills. This however seem to contradict with Wanyonyi (1987) who found girls to perform equally well as boys in arithmetics. Hence, it is necessary to find out more on students' skill performance in mathematics.

The trend in the 8-4-4 system of education is towards including a skill-oriented education (Bunyi, 1994; Republic of Kenya, 1984). The argument behind this is that a vocational oriented curriculum enables graduates of the various educational levels earn a living as either paid workers or self employed and hence contribute towards national development as well as individual development. By emphasising project work, it is expected that skills acquired will enable learners in the informal sector that absorbs majority of them after school (Bosire; 2000a; 2000b; Republic of Kenya, 1984). The conceptual emphasis of the 8-4-4 mathematics syllabus is so great that process skills like computation, drawing and interpretation are neglected. Hence, the public outcry about the incompetence of school graduates in performing simple skills like computational operations. Such basic skills are needed by any school leaver joining the society who otherwise will be ill equipped to face the grilling of life out of school (Wanyonyi, 1987). This study sought to inculcate in students appropriate skills in the topic statistics.

2.8 Summary

From the foregoing discussion, it is clear that the understanding of mathematics concepts and skills can be influenced by language. The learning process embodies the development of language on the concept held by the individual learner. It is also clear from literature that pupils come to mathematics lessons with their own language conceptions about mathematical ideas, concepts and skills that may greatly influence their learning and understanding as they try to interpret the new language and experiences in terms of what they already know. Therefore, for effective teaching and learning of science in general and mathematics in particular, students' understanding of mathematics and perception of their learning environment needs to be established. Once this is done, it may possibly provide appropriate remediation to modify the language of instruction thus enhancing meaningful learning and student interest in mathematics.

2.9 Theoretical Framework

Mathematics has logical processes based on psychological structures available to the child. These structures change as the child matures psychologically and neurologically and as the child has the necessary experience in the physical world. These experiences involve actions performed on symbols and words of communication with other people. The current study was based on two theories namely the cognitive structural view of learning and the constructivist view of learning.

According to the cognitive structural theory, learning involves active cognitive processing of information rather than mere stimulus-response association (Okere, 1996). The items of information acquired through learning mathematics are stored, filed and cross-indexed rather than stored in isolation from one another. This theory asserts that mathematical knowledge is organised into categories that simplify the task of processing and retaining information by allowing the individual to interpret the new input with reference to the familiar. Thus learning mathematics is

an ongoing process of developing an increasingly sophisticated cognitive structure for representing and interacting with the world.

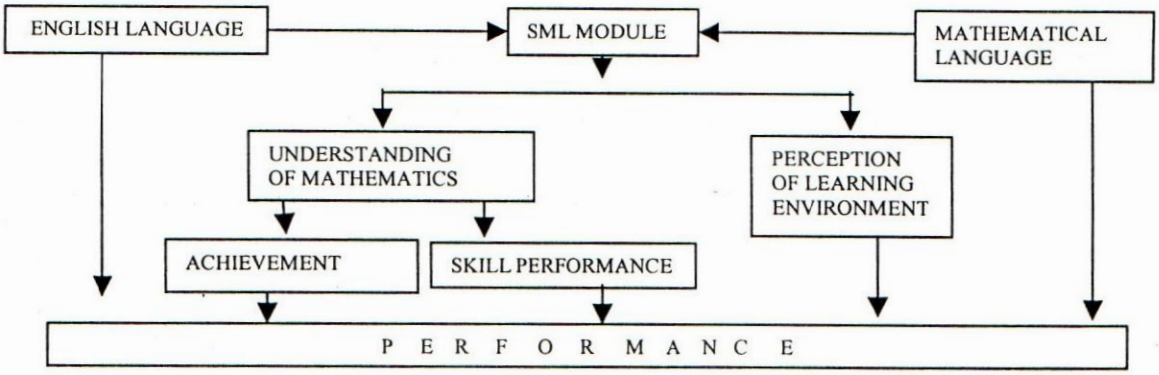
However, Okere (1996) argues that recent research has led to the development of constructivist theories in which learners are seen constructing meaning from input but processing it through existing cognitive structures. Constructivists assert that we learn through a continual process of constructing, interpreting, and modifying our own representations of reality based on our experiences with reality (Jonassen, 1994). This is done in ways that leave the input open to further processing and possible reconstruction. Thus, constructivists view learning as depending on the degree to which learners can activate existing cognitive structures to subsume the new input or construct new ones. Applied to the present study, learning mathematics is viewed as an activity, which involves constructing meaning through social processes whereby learners interact with each other and the environment. In this context, the notion that children are capable of constructing their own knowledge of mathematics in their own unique ways is acceptable as the best way of acquiring mathematical knowledge (Costello, 1991). This perspective gives credence to the view that effective learning is better promoted by giving learners some opportunity to negotiate their own understanding through participation.

The mathematics curriculum is organised hierarchically and spirally (Eshiwani, 1984; KIE, 1992; KNEC, 2000a). Topics are organised such that the earlier topics in the syllabus act as pre-requisites to those that come later. This makes learners to process and reconstruct new learning experiences as they ascend the academic ladder. In addition, mathematics instruction does not mean that the learner only attends to information presented but must interpret and integrate it into the existing knowledge base. To acquire knowledge, the learner must perceive, classify, apply, evaluate and manipulate the information presented. This underlies two principles: the concept of acquisition and the rule of application (Kiboss, 1997). Depending on the type of activities

embedded in the SML module, these principles revolve around the use of prior knowledge, defining, exemplifying and application of concepts.

The variables explained in the literature can be presented in a conceptual form as shown.

Fig. 1: Conceptual Presentation of the Variables



This framework shows that both the English and mathematical languages influence students performance. These two languages influence the students' understanding of mathematics and their subsequent performance in the subject and hence were integrated to constitute the SML module. Students are to construct meaning of the language as used in statistics. This is expected to enhance students understanding of statistics as measured by their achievement and skill performance, the perception of the mathematics learning environment and consequently improve their performance in mathematics.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This study developed an SML module and investigated its effect on Form Two students' understanding of mathematics and perception of the learning environment. To achieve this aim, data from selected secondary schools in Bungoma district was collected. Chapters one and two provided the needed context to situate the study. This third chapter offers details of the methodology that was used to investigate the problem in question.

3.2 Research Design

A quasi-experimental approach adapted from the Solomon Four-Group Experimental design was employed for this study. This design is considered appropriate for quasi-experimental studies because it provides the most effective and efficient tools available for determining cause and effect relationship (Ary, et al, 1972; Borg, 1987; Koul, 1992; Ogunniyi, 1992). Besides, the design provides adequate control of other variables that may contaminate the validity of the study. The design involves a random assignment of intact classes of subjects to four groups with two groups being experimental and the other two as controls. Table 2 illustrates this study design.

Table 2: Solomon Four - Group Experimental Design

Group	Pre-test	Treatment	Post-test
E_1	O_1	X	O_2
E_2		X	O_3
C_1	O_4		O_5
C_2			O_6

Source: Ary et al (1972) p. 247

As shown in Table 2, four groups of subjects: the Experimental Group One (E_1), the Experimental Group Two (E_2), the Control Group One (C_1) and the Control Group Two (C_2) were used. Groups E_1 and E_2 formed the experimental group while C_1 and C_2 were the control groups. Groups E_1 and C_1 received a pre-test (O_1 & O_4) to ascertain whether or not the groups under study had comparable characteristics while E_1 and E_2 got treatment (X) that was an exposure to the SML module (see 3.3 & Appendix A). All groups in this study received a post-test that facilitated comparisons between the groups. However, to avoid interaction of subjects from different groups one class from a school constituted one group of subjects, hence four schools were required for this study. Therefore, there was random assignment of selected classes to both groups because schools chosen for the study did not allow intact classes to be split (Kathuri & Pals, 1993).

3.3 The Experimental Treatment

As already stated above, the aim of this study was to develop a Socialised Mathematical Language module herein referred to as the SML. The module was to serve as an instructional material for both the experimental and treatment groups in this study. This section provides a detailed account of this instructional material in terms of its design, validation, pilot and implementation.

3.3.1 The Design of the SML Module

The development of the SML module for this study took four weeks. The module was developed for teaching and learning the topic statistics in mathematics. The content of the module was based on the KIE approved syllabus, the teachers' guide and students' textbooks. The main concerns of the SML was to simplify the language used in presenting the concepts and skills in statistics in three areas namely data collection and organisation, measures of central tendency and data representation. These content areas were presented in twelve lessons (two double lessons of

80 minutes each and eight singles of 40 minutes each) and taught to form two students for over a period of two weeks. The language used in this module integrated the ordinary English language and the mathematical language in the context of teaching and learning the topic statistics in mathematics (see Appendix A).

3.3.2 Validity and Reliability of the SML Module

During the initial development, the SML module was reviewed twice. The first review involved a specialist in statistics and two other experts in mathematics education. The purpose of this review was to assess the overall design, subject content, offline materials and the adequacy of the language used. The second version was however reviewed by nine reviewers (five lecturers drawn from the Faculty of Education, one statistics lecturer in the department of mathematics and three secondary school mathematics teachers with at least ten years of teaching experience). The purpose of the second review was to solicit comments on the suitability of the module, quality of the design, surface features and pedagogical issues. The comments and/or suggestions from the second review were incorporated just as it was the case for the first review before piloting.

After the modifications from the second review, the SML module was tried on 20 form two students in a school in Bungoma, which did not take part in the actual study. On overall, these students involved in the pilot study felt that the SML lessons were self explanatory, interesting, understandable, enjoyable and important. The teacher involved in the piloting on the other hand found the SML module to have clear lesson notes that were simplified for student understanding. Certainly, the pilot testing of the SML module provided valuable information that was necessary for appropriate revision of the final version that was used in the actual study.

3.3.3 Implementation of the SML Module

Prior to the commencement of the actual study, the teachers for the experimental groups were inducted for a period of one week. One week was deemed sufficient for the researcher to familiarize teachers with the requirements and the approach of the SML module. This included the presentation and explanation of concepts, notations and group activiries.

3.4 Population

The target population consisted of form two students from public schools in Bungoma district. The district has 128 schools: 93 district schools, 25 provincial schools and 7 private schools (District Education Office Bungoma, 2001). For reasons stated earlier (see 1.7), the district category of schools were selected. However, to guard against gender bias, co-education boarding and/or day schools with at least two non-segregated by gender streams per class were selected. There were 30 such schools hence, an estimated accessible population of about 2,400 students. The list of schools was obtained from the Bungoma District Education Office.

3.5 Sampling Procedures

Purposive sampling was used to identify the secondary school category and the class level that formed the study population. However simple random sampling technique was used to draw the required four classes in four schools out of the accessible thirty schools for this study (see 3.2 & 3.4 respectively). This technique was considered appropriate because it ensured that all schools had an equal chance of being included in the study sample. Besides, simple random sampling gives random samples, which yield data that can be generalised within margins of error that can be determined statistically (Borg, 1987; Kathuri & Pals, 1993; Mugenda & Mugenda; 1999). Due to the small number of schools to sample from, this study employed balloting method. This involved assigning a numeral to each of the thirty schools, placing the numbers in a container and then

picking a number at random with replacement. Schools corresponding to the numbers picked were included in the study sample. Balloting was again used to select one stream from each of the sampled four schools that participated in the study. All the students in the selected classes participated.

3.5.1 Sample Size

Generally, a sample size is determined by the number of variables in the study, type of research design, method of data analysis and the size of accessible population (Ary, et al 1972; Borg, 1987). However, according to Mugenda and Mugenda (1999), at least 30 cases per group are required for experimental research. From above (see 3.2 3.4 & 3.5), four schools were sampled and one stream from each school included in the study sample. Although it was assumed that the average enrolment was forty students per stream, giving the approximate sample size of the study as 160 students, the actual sample size that participated was 166 students. However during data coding and roostering, it was found that ten students had either incomplete data and/or missed some test hence reduced the sample size for data analysis to 156 students. These subjects were used in their four intact classes in the four schools that were randomly assigned to experimental groups (E_1 = 37 students & E_2 = 40 students) and control groups (C_1 = 35 students & C_2 = 44 students).

3.6 Variables of the Study

In this study, the independent variable was the SML module while understanding of mathematics and student perception of their learning environment were the dependent variables. The module integrated the mathematical language and the language of instruction as used in the teaching learning process. Understanding was taken as an umbrella embodying two correlates namely student achievement and skill performance. A score obtained from the mathematics

achievement test (see 3.7.5 & Appendix E) represented these. Student perception of their learning environment was on the other hand taken to mean students views about their learning environment during lessons in the topic statistics. It was represented by the score obtained on the student questionnaire as measured on a five point Likert scale (see 3.7.2 & Appendix B).

3.7 Instrumentation

Okuni and Tembe (1997) argue that no single method of obtaining data is perfect. Using more than one method of collecting data is recommended. As such, four instruments were used to collect data to meet the objectives of the study. These were the students' questionnaire, teachers' questionnaire, observation schedule and achievement tests.

3.7.1 Validity and Reliability of the Instruments

Research instruments must measure exactly and precisely what they are out to measure. According to Gronlund et al (1988), an instrument will produce good results if it has been validated by at least five experts. As such, seven lecturers from Egerton University validated all the measurement tools employed in this study. In addition, the consistency levels of the research instruments are vital in determining whether the data to be generated from the instruments is to be reliable. A reliability coefficient of not less than 0.7 is recommended for consistency levels (Gronlund et al, 1988). In this regard, the reliability of the instruments was ascertained using the Kuder-Richardson formula 21 (K-R 21). Specifically, a reliability of over 0.75 was obtained on all the instruments. This formula is considered appropriate because it can determine the reliability of an instrument using a single administration (Kathuri & Palls, 1993). Also, this formula can assess multiple response items that were mainly used in the study. Prior to establishing the consistency levels, the instruments used in the study were pilot tested on twenty students in one school that

was not part of the study sample. Details on the validity and reliability of the research instruments are presented in the following sub-sections.

3.7.2 Students' Questionnaire

One students' questionnaire called the Student Perception Questionnaire (SPQ) was adapted from Kiboss (1997) and modified to suit the current study. Kiboss developed an instrument to measure the students' perception of the classroom environment in physics. This questionnaire had 20 structured items that solicited students' views about their learning environment during lessons on the topic statistics. This instrument was based on the language used during instruction, time adequacy, instructional materials and students' and teachers' activities as measured on a five point Likert scale (see Appendix B). A team of seven experts from the Faculty of Education in Egerton University validated the SPQ instrument before it was pilot tested. Although Kiboss had pilot tested this instrument in Nakuru and found it to have a reliability coefficient of 0.75 using K-R 21 formula, the SPQ adapted for use in this study was pilot tested again for reliability and found to have a reliability coefficient of 0.77 using K-R 21 formula, before it was used in the actual study.

3.7.3 Teachers' Questionnaire

There was need to get teachers reactions to the SML module as compared to other methods of teaching. This provided additional data that supplemented and backed up the collected data. As such, the researcher developed one teacher's questionnaire known as the Teacher Evaluation Questionnaire (TEQ). The questionnaire contained 25 structured items that solicited teachers' views, feelings and opinions about the SML module. The items related to adequacy of the content, instructional activities and simplicity of the language used to explain statistical concepts and skills. These dimensions were measured on a five point Likert scale (see Appendix C). Six lecturers from

the Faculty of Education in Egerton University validated TEQ. However before it was used in the actual study, TEQ was tried on five secondary school mathematics teachers. A reliability coefficient of 0.79 was obtained when the teacher's responses were scored and analysed using the K-R 21 formula.

3.7.4 Observation Schedule

A Mathematics Classroom Observation Schedule (MACOS) was adapted from the ten Flander's Interaction Analysis Categories (FIAC) and Kiboss (2000) by the researcher. MACOS was used to observe some lessons in statistics for purposes of providing data on student-teacher-student and material interaction during the instruction process. This was reviewed by seven lecturers from the Faculty of Education of Egerton University for validity before pilot testing for reliability. Although the validated MACOS instrument contained seven teacher activity related items and eight student activity related items on reinforcement, teaching style, questioning, responding, talk-initiation and silence, it was however established during the pilot stage that two teacher activity items were collecting information on the same activity. As such, one teacher activity was struck out reducing the teacher activity related items to six (see Appendix D). Scores obtained from the pilot test observations were used to ascertain the reliability of the MACOS. On analysis of these scores using K-R 21 formula, a reliability coefficient of 0.78 was obtained.

3.7.5 Achievement Test

A Mathematics Achievement Test (MAT) was developed by the researcher to assess students' knowledge and skill performance. This instrument contained items on data collection and organisation, the measures of central tendency and data presentation. A total of 25 items were developed based on the table of specification designed for the topic statistics on the above dimensions against the first three cognitive levels as stated in the Blooms taxonomy as shown in

Table 3. . Each of the 25 items was analysed for difficulty level and discrimination indices. It was found after the item analysis that all the MAT items had a difficulty level of between 0.42 and 0.65 and a discrimination index of between 0.21 and 0.35. These indices are acceptable because according to Gronlund et al (1988), an item of a difficulty level and discrimination index within the range 0.3 – 0.7and 0.2 – 0.5 respectively is recommended.

Table 3. Table of Specification for MAT Items

	Knowledge	Comprehension	Application	TOTAL
Data collection and organisation	3	2	1	6
Measures of central tendency	6	3	2	11
Data representation	3	3	2	8
TOTAL	12	8	5	25

At this juncture, it is worthy to note that the MAT instrument had two sections: A and B. Section A assessed students understanding of mathematical terminology and symbols. This section consisted of fifteen multiple-choice items. Section B on the other hand assessed students' skill performance in computation, interpretation and drawing of statistical diagrams and consisted of five unstructured questions (see Appendix E). On the whole, six experts knowledgeable in mathematics and mathematics education from Egerton University validated the MAT instrument. However, the reliability of the two sections of the MAT was ascertained separately using K-R 21 before the commencement of the actual study. Specifically, a reliability coefficient of 0.75 and 0.76 was obtained for sections A and B respectively.

3.8 Data Collection

To generate data required for this study, teachers involved in teaching the experimental group were inserviced for a period of one week by the researcher as pertaining to the implementation of the SML module. MAT and SPQ were first administered to students in groups

E_1 and C_1 for purposes of ascertaining their entry level and homogeneity. Groups E_1 and E_2 were then exposed to a series of 12 lessons in statistics using the SML approach, whilst groups C_1 and C_2 were exposed to the same content using normal approaches. In the process, the researcher observed some lessons and tallied the observations in MACOS. After all the students in this study had completed the topic, SPQ and an equivalent form of MAT were administered to all the students in the groups. It is noteworthy that each of the instruments was administered at the same time in all the schools and followed the rules governing examination in Kenya. At the time SPQ was administered, TEQ was also administered to teachers involved in the experimental groups. Finally, the researcher scored and coded collected data for analysis.

3.9 Data Analysis

This study generated both qualitative and quantitative data that was analyzed both descriptively and inferentially. Raw data were summarized in form of tables using means, standard deviations and percentages. Statistical tests of significance were analyzed using the one-way Analysis of Variance (ANOVA). In order to establish exactly where the mean differences may lie and the direction of the difference, an independent samples t-test was performed. This was further confirmed by the Tukey's Honest Significant Difference test. These tests were chosen because they provide simple and accurate results. All tests of significance were conducted at $\propto = 0.05$ level.

Specifically, all the hypotheses were analyzed using the ANOVA and t-test In addition, brief presentations in tabular form and narrations of the qualitative data collected were analyzed for hypothesis four. Also, the analysis of the teachers' evaluation of the SML module was analyzed qualitatively. Details on how the data collected was analyzed in terms of quantitative and qualitative descriptions are presented in the next chapter.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Introduction

This study developed an SML module and investigated its effect on Form Two students' understanding of mathematics and perception of their learning environment. This chapter presents the results and discussions of the study. The chapter describes the data generated from the study using descriptive and/or inferential statistics while the results are discussed thereafter. The results of analysis are presented in the form of tables or excerpts followed by interpretations.

4.2 Pre – Tests Analysis

The aim for pre-testing was to ascertain whether or not the students' selected to participate in this study had comparable characteristics before presenting the topic statistics. To achieve this aim, the students in groups E_1 and C_1 were pre-tested on MAT and SPQ. The Pre-test results obtained by the groups are presented in tables 4 and 5.

Table 4. Comparisons of Mean Scores and Standard Deviation of the Pre-test Scores of the MAT and SPQ

TEST		GROUP E_1 (N=37)		GROUP C_1 (N=35)	
		Mean	SD	Mean	SD
MAT	A	38.93[a]	9.45	38.49[a]	8.53
	B	22.38[b]	15.59	21.27[b]	14.72
SPQ		56.78[c]	8.74	55.95[c]	10.48

[a b c] denote identical mean scores

As shown in Table 4, the mean scores of both groups (E_1 & C_1) obtained were similar on SPQ and the two sections of the MAT measures. However, a further analysis of these results was necessary in order to establish whether the mean scores were significantly different at 0.05 level. A one way Analysis of variance (ANOVA) gave the following results.

Table 5 An ANOVA of the Pre-test Scores of the MAT and SPQ

TEST		F-ratio	P-value
MAT	A	0.12	0.28
	B	0.33	0.57
SPQ		0.19	0.25

An examination of the results in Table 5 indicates that the mean scores for both E_1 and C_1 groups on the two sections of MAT and SPQ test measures are not statistically different. In all cases, the F- ratios are less than unity and the tabulated value. Therefore, there is no significant difference on all the pre-test measures between the two groups. This is an indication that the groups in question were comparable, had similar entry behaviour, and hence homogenous. This made them suitable for the study.

4.3 Results and Interpretation

This section presents the results and their interpretations based on the objectives, hypotheses and variables of the study (see 1.4, 1.5, 3.6 respectively).

4.3.1 The Effect of the SML Module on Students' Achievement

The main objective of the Mathematics Achievement Test (MAT) was to ascertain whether or not there was a significant difference between the students' understanding as measured by their knowledge and skill performance (see 3.6). Section A was concerned with assessing students' knowledge in statistics. The hypothesis tested was whether the SML module had no significant effect on students' achievement in statistics. The results obtained are summarized in Table 6.

Table 6 Comparison of the Mean Pre-test and Post-test scores and Standard Deviations obtained by students on Section A of the MAT

SCALE	OVERALL	GROUP			
		E1	E2	C1	C2
PRE-TEST	38.71	38.93[a]	-	38.49[a]	-
SD	8.99	9.45	-	8.53	-
POST-TEST	71.73	77.80[b]	77.10[b]	65.30[c]	66.70[c]
SD	11.35	10.84	11.32	11.40	11.84
MEAN GAIN	33.02	38.87	-	26.81	-

[a, b, c] denotes similar mean scores.

Results in Table 6 show that the post-test mean scores for groups E_1 and E_2 and that of C_1 and C_2 respectively, are quite similar. On overall, the groups mean gain on student's achievement in knowledge of statistical concepts was 33.54. However, the mean gains for group E_1 (38.87) was significantly higher (by12.06) than that of group C_1 (26.81). This suggests that the experimental group gained more than the control group. In order to determine whether the difference in mean scores was significant, a one way ANOVA was performed. Table 7 summarizes the results of the ANOVA test.

Table 7 An ANOVA of the Post- test scores of the Groups on Section A of the MAT

SOURCE	D.F	SS	MS	F-ratio	P-value
BETWEEN GROUPS	3	623.88	207.96	7.46*	0.00
WITHIN GROUPS	153	4265.16	27.88		
TOTAL	156	4889.04			

* Denotes significant mean differences at $P<0.05$ ($F_{tabulated}$ 3, 153 = 2.67; $F_{computed}$ = 7.46)

The results in Table 7 reveal that the differences between the section A of the MAT post-test mean scores are statistically significant. However this analysis does not show the direction of the difference. In order to determine where the mean score difference lie and the direction of the difference, a post hoc multiple comparison test for an independent sample t-test was performed and the results obtained are reported in Table 8.

Table 8 Independent Samples t-test of Post-test Mean Scores obtained by the Groups

GROUPS	DF	t-VALUE	2- TAIL	C-VALUE
E1,Vs,E2	69	0.12	0.27	1.99
E1,Vs,C1	72	2.74*	0.86	1.99
E1,Vs,C2	85	3.54*	0.01	1.99
C1,Vs, C2	83	0.45	0.66	1.99
C1,Vs,E2	67	2.32*	0.00	1.99
E2,Vs,C2	82	3.93*	0.26	1.99

* Denotes significant at $p<0.05$

The t-test analysis reported in Table 8 above reveals that the mean scores obtained by the students within the treatment groups (E_1 & E_2) and control groups (C_1 & C_2) respectively were not statistically different. However, there were significant differences between the mean scores of the experimental groups and the control groups i.e. the mean scores obtained by the treatment groups were significantly higher than those in the control groups. A comparison of the post-test mean scores yielded t-values of t (1,73=2.74), t (1,86=3.54), t (1,68=2.32) and t (1,83=3.93) at $p<0.05$. A further analysis of the differences using Tukey's-Honest Significant Difference (THSD) test also revealed the following trend: $E_1=E_2>C_1=C_2$. This suggests that the students who were exposed to the SML module out-performed those who were not exposed to it in section A of the MAT.

Considering the results presented in Tables 6,7 and 8, it was found that the post-test mean scores obtained by students in groups E_1 (77.80) and E_2 (77.10) were not significantly different at $p=0.05$. Also, the mean scores of groups C_1 (65.30) and C_2 (66.70) are not different. However, the mean scores obtained by the students in groups E_1 and C_1, E_1 and C_2, E_2 and C_1 and, E_2 and C_2 are significantly different at $p<0.05$. In addition, the t-values confirm that the difference between the means obtained by the students in the treatment groups and those in the control groups on section A of the MAT is statistically significant. In view of these findings the null hypothesis suggesting that the SML module has no significant effect on students achievement in statistics is rejected.

4.3.2 The Effect of the SML Module on Students' Skill Performance.

Section B of the MAT was developed to ascertain whether or not there was a significant difference between the students' skill performance before and after the commencement of the topic statistics between the students exposed to the SML module and those not exposed. This was meant to test the hypothesis that the SML module has no significant effect on students' skill performance in statistics. The results on students' skill performance are reported in the subsequent tables and interpreted in the paragraphs that follow.

Table 9 Comparison of the Mean Pre-test and Post-test Scores and Standard Deviations obtained by students on Section B of the MAT.

SCALE	OVERALL	GROUP			
		E 1	E2	C1	C2
PRE-TEST	21.80	22.38[a]	-	21.27[a]	-
S.D	2.78	2.77	-	2.45	-
POST-TEST	73.48	78.65[b]	77.28[b]	69.22[c]	68.75[c]
S.D	6.15	3.95	3.25	4.32	4.17
MEAN GAIN	51.62	56.27	-	48.00	-

[a,b,c] denotes similar mean scores.

A perusal of the results in Table 9 show that the pre-test mean scores obtained by the students' in group E_1 (22.38) and C_1 (21.27) were similar before teaching the mathematics topic on statistics. After the exposure to the topic, the students in the experimental group scored a higher mean score E_1 (78.65) than those in group C_1 (69.22) and C_2 (68.75). Similarly, group E_2 scored a higher mean score (77.28) than those in groups C_1 and C_2. The mean gain of statistical skills for group E_1 (56.27) and for the whole group (51.75) were both higher than that of group C_1 (48.00). This suggests that there were differences in the mean scores obtained between the experimental groups (E_1 & E_2) and control groups (C_1 & C_2). This implies that the skill performance of the students in the SML treatment groups was better than those in the control groups. In order to

establish whether the differences were significant, an ANOVA test was done and the results as summarized in Table 10 obtained.

Table 10 ANOVA of the Post-test scores of students on Skill Performance.

SOURCE	DF	SS	MS	F-value	P-Value
BETWEEN GROUPS	3	1065.36	355.12	9.11*	0.05
WITHIN GROUPS	153	5966.07	38.99		
TOTAL	156	7031.43			

* Means significant at $p<0.05$

From the results in Table 4.7, the F-value ($F\ 3, 153 = 9.11$, $p<0.05$) indicates that the mean scores of the groups were significantly different. However, this analysis does not show the direction of the difference. In order to determine the direction of the difference, the independent samples t-test was performed and results obtained are reported in Table 11.

Table 11 Independent Sample t-test of Post-test Mean scores on Students' Skill Performance

GROUPS	DF	t-VALUE	2-TAIL SIG	C-VALUE
E1 vs E2	69	0.33	0.75	1.99
E1 vs C1	72	3.58*	0.86	1.99
E1 vs C2	85	3.06*	0.96	1.99
C1 vs C1	83	0.12	0.15	1.99
C1 vs E2	67	3.54 *	0.77	1.99
E1 vs C2	82	3.80 *	0.67	1.99

* Significant at $p< O.05$

The t-test analysis reported in Table 11 reveals that the mean scores obtained by the students in the experimental groups were significantly different from and higher than those in the control groups. A comparison of the post-test t-values of $t\ (1,73 = 3.58)$, $t\ (1,86 = 3.06)$, $t\ (1,67 = 3.54)$ and $t\ (1,83 = 3.80)$ at $p< 0.05$ level were obtained. A further analysis of the difference using THSD test also confirmed the trend $E_1 = E_2 > C_1 = C_2$ at 0.05 level. This implies that the students

who were exposed to the SML module performed better in section B of the MAT than those not exposed.

From the results presented in Tables 9,10 and 11 it suffices that the post-test mean scores of experimental groups ($E_1 = 78.65$ & $E_2 = 77.28$) are not statistically different at $p = 0.05$. Also, the mean scores of the control groups ($C_1 = 69.22$ & $C_2 = 68.75$) are not statistically different at the same level. However, there is a statistically significant difference between the experimental groups and the control groups at $p = 0.05$ level, where the former scored significantly higher values than the latter. In addition, the t-values confirm that the difference between the mean scores obtained by the students in the experimental and control groups on skill performance are statistically significant at 0.05 level. In view of the foregoing presentation and interpretation of the results on skill performance, the null hypothesis indicating that the SML module has no significant effect on students' skill performance in statistics is rejected.

4.3.3 The Effect of the SML Module on Students' Perception of their Mathematics Learning Environment

The aim of the Students' Perception Questionnaire (SPQ) was to ascertain whether or not there was a significant difference between the mathematics learning environment before and after the topic statistics between the students exposed to the SML module and those not exposed. The null hypothesis tested was that the SML module has no significant effect on students' perception of their learning environment. Table 12 shows the mean scores on students' perceptions as measured on a five point Likert scale.

Table 12 Comparison of the Mean Pre-test and Post- test Scores and Standard Deviations obtained by the students on the SPQ

SCALE	OVERALL	GROUPS			
		E_1	E_2	C_1	C_2
PRE-TEST	56.36	56.78[a]	-	55.94[a]	-
SD	9.61	8.74	-	10.48	-
POST-TEST	74.18	78.49[b]	76.41[b]	70.31[c]	71.52[c]
SD	8.43	8.09	8.12	8.38	9.13
MEAN GAIN	17.82	21.71	-	14.37	-

[a, bc], Denotes similar mean scores.

An analysis of the results in Table 12 reveals that the pre-test mean scores of E_1 and C_1 and the post-test mean scores of groups E_1 and E_2, and, C_1 and C_2 respectively are quite similar. However, the mean gain for group E_1 (21.71) was higher by 7.34 points than that of group C_1 (14.37). Overall, the mean gain on the SPQ was 17.82. Hence the former group is closer to the overall mean gain for the whole group than the latter. The results suggest that the perception of the students in the treatment groups on the SPQ was different from those in the control groups ($E_1 = E_2 > C_1 = C_2$). A further analysis of the posttest mean scores using the ANOVA gave the following results.

Table 13 An ANOVA of the Post-test Scores on the SPQ

SOURCE	D.F	SS	MS	F-ratio	P-value
BETWEEN GROUPS	3	1806.11	602,04	5.90*	0.001
WITHIN GROUPS	153	15503.50	102.10		
TOTAL	156	17309.61			

*Means significant at $p<0.05$

The result in Table 13 confirms that the mean scores between the groups on the SPQ differ significantly at 0.05 level. However, this analysis does not show the direction of the difference. In order to determine the direction of the difference, an independent samples t-test was performed. Table 14 suggests the possible the difference and direction of the difference.

Table 14 Independent Samples t-test for by the subjects in the groups on the SPQ

GROUPS	D.F	t-VALUE	2 TAIL SIG.
E1 Vs E2	69	0.32	0.42
E1 Vs C1	72	4.38*	0.00
E1 vs C2	85	4.77*	0.00
C1 vs C2	83	0.56	0.12
C1 vs E2	67	2.47*	0.75
E2 vs C2	83	2.48*	0.45

***Means significant at p<0.05.**

An examination of the results in Table 14 reveals that the t-values of E_1 and E_2 (t=0.32) and that of C_1 and C_2 (t=0.56) are not statistically different. But the t-values of groups E_1 and C_1 (t=4.38), E_1 and C_2 (t=4.77), C_1 and E_2 (t=2.47) and E_2 and C_2 (t=4.38) indicate statistically significant differences in the post-test mean scores on SPQ in favour of the treatment groups. A further analysis of the difference using the THSD test also confirmed that $E_1 = E_2 > C_1 = C_2$ at 0.05 level.

From the foregoing presentation, it can be noted that although E_1 and C_1 groups were pre-tested, their post-test mean scores are not significantly different from those of E_2 and C_2 respectively. This means that the pre-test did not exert any impact on the post-test mean scores of the SPQ. Therefore, the significantly higher mean scores obtained by the treatment groups compared to the control groups were due to the SML module rather than chance. Therefore, the null hypothesis indicating that the SML module had no significant effect on the students' perception of their learning environment is rejected.

4.3.4 The Effect of the SML Module on Classroom Interaction During Mathematics Lessons

The purpose of the Mathematics Classroom Observation Schedule (MACOS) was to assess whether there was a significant difference between the classroom interactions in the mathematics lessons of the experimental and control groups during class instruction on the topic statistics. Data on student-teacher-student and material interaction were collected from at least three lessons taken

from each of the SML and regular classrooms respectively. The hypothesis tested was that the SML module has no significant effect on classroom interaction during mathematics lessons. The frequency of the classroom activities observed in this study was calculated as a percentage and the results are reported in Table 15.

Table 15 Comparison of Teachers' and Students Activities during Mathematics Lessons in Statistics by Percentage

CATEGORY	GROUP			
	E_1	E_2	C_1	C_2
TEACHER ACTIVITY				
Reinforcing behaviour	9.9	10.8	5.8	5.4
Giving directions	6.3	6.2	11.3	10.2
Supervises activities	9.6	9.4	6.9	5.8
Asks questions	6.4	6.6	6.8	6.9
Guides/demonstrates skills	4.8	4.2	9.9	8.4
Explains concepts and skills	3.1	3.6	10.8	9.2
TOTAL	40.1	40.8	45.5	44.9
STUDENT ACTIVITY				
Responds to questions	9.5	9.2	7.6	6.9
Follow instructions	8.4	8.7	11.8	10.9
Initiates classroom talk	7.2	8.4	4.7	4.6
Asks questions	12.7	10.6	3.2	3.4
Writes or copies notes	7.1	7.4	7.2	7.7
Expresses agreement	9.1	8.8	12.4	11.8
Periods of silence inactivity	1.6	1.3	5.8	5.9
Consults other students	4.2	4.8	1.8	2.9
TOTAL	59.9	59.2	54.5	56.9

A perusal of the results in Table 15 show the classroom activities observed during the class instructions. The table suggests possible similarities and differences between the teachers' and students' activities in the experimental and control groups. It indicates that on overall, the teacher in groups E_1 and E_2 did less of the class activity as compared to groups C_1 and C_2. On the other hand, the students in E_1 and E_2 as compared to C_1 and C_2 dominated the classroom activities.

However, in order to ascertain whether there were differences in interaction patterns during the mathematics activities observed in the lessons, the frequencies obtained were transcribed into a score. The scores for each classroom lesson observed in each group were then used to determine whether the SML augmented classes differed from the regular classes in the way teachers and

students interacted in a normal classroom setting. Table 16 shows the respective means for the groups.

Table 16 Means and Standard Deviations obtained by Groups on MACOS

SCALE	GROUP E_1	E_2	C_1	C_2
MEAN	76.75[a]	75.04[a]	61.88[b]	61.38[b]
S.D	11.07	10.78	9.30	8.28

[a b] denote similar mean scores

Table 16 compares the mean scores obtained by the groups on MACOS. A close examination of these results indicates higher mean scores for treatment groups than for control groups. Also, the mean scores between the treatment groups (E_1 = 76.75 & E_2 =75.04) and the control groups (C_1 = 61.88 & C_2 = 61.38) are not similar unlike within the groups. The treatment groups have similar results due to the same SML treatment to which they were exposed. In order to ascertain the significance of the difference between the groups, a one way ANOVA test yielded the results summarized in Table 17.

Table 17 ANOVA of the MACOS Mean scores

SOURCE	DF	SS	MS	F-RATIO	P-VALUE
BETWEEN GROUPS	3	63.15	21.05	5.95 *	0.00
WITHIN GROUPS	14	49.59	3.54		
TOTAL	17	112.74			

*Significant at 0.05 level.

Results of the ANOVA indicate the F-value to be significant at $p<0.05$. This means that the mean scores obtained by the SML treatment and control groups were statistically different. However, the ANOVA test does not show the direction of the difference. As such, an independent samples t-test was performed and the results reported in Table18.

Table 18 Independent Samples t-test of Post-test Mean Scores obtained on MACOS

GROUP	DF	t-value	SIG

E1vs E2	69	0.34	0.50
E1 vs C1	72	7.43*	0.00
E1 vs C2	85	9.76*	0.03
E2 vs C2	82	8.62*	0.00
C1 vs C2	83	0.51	0.76
C1 vs E2	67	6.54	0.00

* Denote Significant at $p<0.05$

Table 18 confirms where possible differences and the direction of the differences are. It shows that there are differences between the experimental and control groups which are significant. There are however no significant differences within the experimental and control groups. Similar results were obtained using the THSD that revealed the following trend: $C_1 = C_2 < E_1 = E_2$ at 0.05 level. This suggests that the SML programme had similar effects on both experimental groups.

From the foregoing presentation and interpretation, the significantly higher mean scores obtained by the treatment groups as compared to the control groups was due to the SML treatment. Therefore, the null hypothesis indicating that the SML module has no significant effect on classroom interaction during the mathematics lessons is rejected.

4.3.5 Qualitative Descriptions of the Mathematics Classroom Interactions

The quantitative descriptions presented above suggest patterns and variations characteristic of the student-teacher-student and material interactions observed in the mathematics lessons in this study. However, it was necessary to make personal observations so as to determine what exactly transpired during classroom instruction. This was to cater for certain qualitative aspects that provided additional information, which support the quantitative results obtained.

4.3.5.1 Student – Teacher Interaction

Students acquire knowledge, certain cognitive, affective, social and psychomotor skills during instructional lessons. This depends on the content presented to them and how it is presented by means of language (Kiboss, 1997). This implies that learning is influenced by many factors such as reading ability and the interpersonal communication expended by students and teachers during the instructional process. Costello (1991) asserts that the way to improve the interpersonal communication during instructional process is to provide opportunities whereby the teachers have little to talk as students have more to talk in mathematics activities. The following excerpt is indicative of how the teacher in the SML classroom attempted to provide opportunities to enhance student-teacher interaction.

Excerpt 1

Teacher: [On noticing the student's raised hand] Yes Wafula, you have a question?

Wafula: Yes sir. Sir, I don't understand when to use the formula ½ (n+1) and the average of ½ n and ½(n+2).

Teacher: Wafula, you mean you don't understand when to apply the formulas.

Wafula: Yes sir. [Another student raised her hand].

Teacher: Jane, you want to explain to Wafula? Go ahead...

Jane: Sir, unlike in our mathematics textbooks, the manual you gave us has explained clearly and in detail situations to apply the formulas. The manual explains that when the total observations are an even number, then the median is found using the formula average of ½ n^{th} and ½ $(n+2)^{th}$ items while if the total observations are an odd number, we use ½ $(n+1)^{th}$ item where n is the total number of observations.

Teacher: Excellent! When n (total number of observations) is odd we find the ½ $(n+1)^{th}$ item as the median while if n is even then we find the average of ½ n^{th} and ½$(n+2)^{th}$ items as the median. Is that clear to you Wafula and the whole class?

Class: Yes *[Observation Notes, School B: Group E2, 4/3/02]*.

4.3.5.2 Student-Student Interaction

Talking plays a dominant part in the process of learning mathematics. Infact, the teaching of mathematics is mostly about talking whereby the teacher expounds a concept and/or skill, questioning students and eliciting responses on how much students do or do not understand during the lesson (Costello, 1991). In such lessons, conversations amongst students are likely to be peripheral to the mathematical activity. Under such circumstances, it is hardly surprising that conversations and discussions amongst students in mathematics lessons have not been regarded as legitimate or valuable. The classroom styles most commonly adopted in mathematics do not accommodate such talk, nor do they appear to promote any improvement in students' participation. This was employed throughout the mathematics lessons in the SML treatment classrooms. Excerpt 2 and 3 below are indicative of students-student participation in the lessons to engender a form of self-actualization and co-operation in the SML classrooms.

Excerpt 2

Odhiambo: Peter, what have you got as the mean age?

Peter: 16 years.

Odhiambo: No. I have gotten 14 years.

Peter: Ask Maina what he has got.

Odhiambo: Maina, what have you got as the mean age?

Maina: 16 years.

Odhiambo: Oh no! Where have I gone wrong? [Peter and Maina peruse through Odhiambo's working].

Maina: The sum of fx.

Peter: Oh yeah! The sum of fx is 240 and not 210.

Maina: Your addition is wrong. Please repeat. [Odhiambo repeats adding fx column values].

Odhiambo: Mmm. The sum of fx is 240. I had added wrongly. Thank you so much. [*Observation Notes School A: Group E1, 6/3/02*].

Excerpt 3

Teacher: [After writing a problem for example 2 on the chalk board] Yes Catherine, come and guide the class to work out the problem on the board.

Catherine: The question requires us to calculate the mean score of the test. Class, what is the formula for calculating the mean?

Class: Total sum of observation…[the teacher intervened].

Teacher: Hey, quiet. Be orderly. You respond if and only if you've been chosen. O.K?

Class: Yes sir.

Teacher: Go on Catherine.

Catherine: What is the formula? Yes Juma.

Juma: Total sum of observations in the set of data divide by the total number of observations.

Catherine: [She writes the formula on the board] What is the sum of the observations? Yes Linet.

Linet: Five hundred and seventy six.

Catherine: What is the total number of observations? Denis.

Denis: They are twelve.

Catherine: Therefore the mean is [She writes the figures] 576/12 . What do you get if you simplify this? Akinyi.

Akinyi: 49.

Catherine: Eeh…. Is it correct? Wanjala.

Wanjala: No. The answer is 48. [Catherine writes 48 and goes to sit down].

Teacher: Very good Catherine. Remember to be very careful with the mathematical operations. O.K.

Class: Yes sir. [*Observation Notes School B: Group E2, 1/3/02*].

4.3.5.3 Teacher-Student Interaction

As already stated, much of the mathematics teaching involves the teacher expounding on a topic, questioning and eliciting students responses. However, when mathematics teaching is based on an individualized learning scheme, teachers have little opportunity to talk to and with the whole class. Instead, teachers talk with individual students prompting them, offering help and advice and encouraging suggestions (Costello, 1991). The following anecdotes are indicative of the parallelism in the treatment and control groups observed in this study on teacher-student interactions. Specifically, excerpt 4 and 5 indicate how the teacher in the experimental and control groups respectively provided for teacher- student interactions during the lessons.

Excerpt 4

Teacher: Yesterday, we learnt about how to find the median of an ungrouped data. What were the three main steps to follow in determining the median? Nekesa, what is the first step?

Nekesa: finding the ½ $(n+1)^{th}$ item when n is even and the average of ½ n and ½ (n+1) item when n is odd .

Teacher: Um uh ..... what about you Oluoch?

Oluoch: The first step is arranging the observations in order of sizes i.e. in ascending or descending order.

Teacher: Good. What is the second step? Njoroge.

Njoroge Establish the total number of observation to see whether there are an even or odd number.

Teacher: OK. The final step...Imeldah.

Imeldah: If n is odd, you find the ½ $(n+1)^{th}$ item while if n is even, you find the average of ½ n and ½ $(n+2)^{th}$ items as the median.

Teacher: All right. Nekesa can you now tell us the three steps in their order?

Nekesa: Yes sir. The first step is to arrange the observations in ascending or descending order. Then you find the number of observations in the distribution to establish whether they are even or odd. Finally, you find the $\frac{1}{2}(n+1)^{th}$ item if the number of observations is odd or the average of $\frac{1}{2}\, n^{th}$ and $\frac{1}{2}(n+2)^{th}$ items if the number of observations is even as the median.

Teacher: Very good...Now today, we'll learn about finding the measures of central tendency for grouped data [*Observation Notes, School B: Group E2, 5/3/02*].

Excerpt 5

Teacher: Today we are going to learn about calculating the mean from a grouped frequency distribution table. Now to find the mean from a grouped frequency table, we need to get the sum of the products of the mid points (X) and the frequencies (f) and then divide by the sum of frequencies. This is summarised in the formula $\bar{x} = \sum fx / \sum f$ where $\bar{x}$ = mean, $\sum fx$... Let us use this formula in our examples today. [The teacher guides students to find the mid points and the products of mid points and frequencies]. Now, what do you get when you add the values in the f column? Yes John?

John: Forty. [The teacher writes $\sum f = 40$ in last row of the frequency column].

Teacher: What about the $\sum fx$ column? Mark.

Mark: Nine hundred and sixty. [The teacher writes $\sum fx = 960$ in the same row as $\sum f$ in the $\sum fx$ column].

Teacher: Substituting $\sum fx$ and $\sum f$ in the formula we have $\bar{x} = 960/40$. This gives us... Mark.

Mark: 24.

Teacher: OK the mean therefore is 24. Any question upto that point? [The class kept quiet]. Silence means no question. [After writing example 2 question on the chalkboard] What are the mid points of the given interval? John.

John: 3, 8, 13, 18, 23, and 28

Teacher: What are the products of x and f?

Class: [in chorus] 24, 56, 39, ...

Teacher: now, what is $\sum f$ and $\sum fx$? Mercy, sigma f is?
Mercy: sigma f equals 45.
Teacher: John, what is sigma fx?

John: Sigma fx equals to 801

Teacher: What will be the mean be then? Nekoye.

Nekoye: Eight hundred and one over forty five.

Teacher: What does that give us? Mark.

Mark: Seventeen point eight.

Teacher: Good. The mean mark is 17.8. [*Observation Notes, School C, Group C1, 6/03/02*].

From, this excerpts (Excerpts 4 & 5) there was difference in the questioning strategies and students participation. Excerpt 4 suggests that the teacher's questioning strategies were varied between questions that relate students' content knowledge and those used to link the previous lesson with the new. Moreover, the teacher attempted to create a cordial relationship with the learners by involving most of them in answering questions. Although Costello (1991) contends that teachers often use questions and students' engagement as measures to maintain their supremacy in the classroom especially when teaching an unfamiliar subject-matter, Excerpt 5 indicates that the teacher centred around two students (John and Mark). This denied other students a chance to fully participate in the lesson and hence they were passive. This perhaps explains why the students in the treatment groups out performed those in the control groups.

4.3.5.4 Student-Material Interaction

The principal problem of language in mathematics is that the meanings to be conveyed are often complex (Durkin, 1995). The reason being that English words take different meaning when used in different contexts. Githua (2001) supports this point by alluding that the sentence structure, sentence length and unfamiliar symbols and terminologies make mathematics textbooks difficult to read and comprehend on the part of students. Interestingly, the strong interpersonal relationship observed in the SML treatment groups engaged all students in stimulating learning experiences. Excerpt 6 depicts an interaction between students and materials observed in one of the SML classrooms in this regard.

Excerpt 6

Ken: Oh no...

Peter: What is it, Ken?

Ken: I have failed this exercise again.

Peter: Let me see... Here is where you went wrong. Look at the question in the book. The key word is 'at least 54.5' which means all those students who scored 54.5 marks and above.

Ken: Oh oh!...

Peter: Try it again. You will get it right this time.

Ken: [Repeats the exercise and takes the book for marking]. Yeah, I have now got it. I think, I now understand the meaning of at least. Thank you Peter [*Observation Notes, School A: Group E1, 8/03/02*].

From this anecdote, it appears that the student (Ken) had not only identified where he erred but also understood the phrase at least. This finding suggests that students may fail to solve correctly a given problem due to inadequate understanding of the language used in the question. In view of the foregoing, it suffices that the SML module may have provided a conducive environment that enhanced students' participation and self-actualization during the teaching and

learning process. Perhaps this is the reason why the SML treatment groups out-performed the control groups who were denied the treatment on all the dependent measures.

4.3.6 Teachers' Evaluation of the SML Module

A good context for teaching and learning is that in which the teacher and the learner freely interact with, and the concepts to be acquired are simplified (Driver & Bell, 1986; Kiboss, 2000). The SML module developed in this study provided such an environment. However in order to ascertain whether the SML module developed met this aim, one Teacher Evaluation Questionnaire (TEQ) was administered so as to solicit teachers' views, feelings and opinions about the SML module in terms of adequacy of the content, instructional activities and simplicity of the language used. These were measured on a five point Likert scale and the results recorded as summarized in Table 19.

An examination of Table 19 indicates that the teachers involved in teaching the treatment groups strongly agreed to statements in favour of the SML module. They strongly agreed that the SML module was understandable, friendly, useful, important and adequate in content. Also, students actively participated during the lessons and the mathematical concepts, symbols, terminologies and skills were clearly, adequately and simply explained. On the whole, the teachers would like mathematics to be taught using the new approach in which neither boys nor girls receive more individual help, compete against one another and both sexes actively participate during the lesson. This once again suggests that the SML module was adequate in content, instructional activities and the language used was simple for students to understand the mathematical concepts, symbols, terminologies and skills in the topic statistics. In addition the SML module provided adequate opportunities for student participation and that it fostered the spirit of co-operation. Perhaps this is another reason why the students in the SML treatment groups

performed better on all the dependant measures than their colleagues in the control groups as seen in the previous sections.

Table 19 Teachers' Evaluation of the SML Module

STATEMENT	GROUP E_1	E_2
1.The SML lessons were understandable	SA	SA
2. The SML lessons were dull	SD	SD
3. The SML lessons were friendly	SA	SA
4. The SML lessons were useful	SA	SA
5. The SML lessons were meaningless	SD	SD
6. The SML lessons were unimportant	SD	SD
7. The SML lessons were difficult	SD	D
8. The SML lessons were useless	SD	SD
9. The SML lessons were important	SA	SA
10. I was uncomfortable with the SML lessons	SD	D
11. I like the mathematics lessons taught without the use of the new approach	SD	SD
12 Mathematics symbols and terminologies discussed were clear	SA	SA
13. Students actively participated during the SML lessons	SA	SA
14. Girls received more individual help than boys	D	D
15. I like the mathematics lessons taught with the use of the new approach	SA	SA
16. Students actively participated during the SML lessons	SA	SA
17. Sufficient exercises were given the SML lessons	A	A
18. Students could solve problems from textbooks and past papers	SA	SA
19. Students worked in groups	A	A
20. The SML lessons were adequate in content	SA	SA
21. Boys were more active than girls	SD	D
22. Students competed against each other in class	SD	D
23. Students had enough time to finish the exercises	A	A
24. Concepts were adequately explained in the SML lessons	SA	SA
25. Students were motivated to ask questions and/or answer questions in class.	A	SA

SA = Strongly Agree, SD = Strongly Disagree, A = Agree, D = Disagree and U = Uncertain.

On the basis of the teachers' evaluation, the SML enhanced the students' cognitive, social and psychomotor domains. The extent of student participation in the learning process, the simplicity and clarity of the language used and appropriate learning environment observed in the SML classes emerges in support of the SML's strength in improving students understanding of the topic statistics. In this regard it is evident that the SML program alone could not have been responsible for the student gains in achievement observed in the mathematics topic on statistics. Rather it was the collaboration of the students in the SML treatment groups, the teachers

facilitative role and the student reciprocal relationship that were responsible for the statistical knowledge gains, skill performance and perception of the mathematics learning environment observed in this study.

4.4 Discussions

The teacher's role in the lesson is a major determining factor of the classroom environment. According to Ramorogo and Kiboss (1997), meaningful learning often develops best in classroom environments that give students more opportunities for more participatory interaction. Perhaps, this is the reason why the teacher in the SML treatment groups provided more student participation opportunities as seen in Table 16 and the subsequent narration in the excerpts. This is in agreement with Kiboss (1997; 2000) who found a strong relationship between the nature of the conducive classroom environment and the acquisition of the necessary knowledge and skills.

This study has shown the interactiveness of the lesson components. Contrary to earlier studies in Kenya which indicate that some students have greater interaction with their teachers than others do (Sanga, 1982), the findings of this study have placed all the students on the same level i.e. all the students in the classroom (irrespective of their gender) have equal opportunities to interact and participate fully in the lesson(s). In addition, the results have shown that teachers have to explain terminologies and phrases used in the subject. The KNEC reports (2000b; 2000c) and MOE (2001) have made similar views whereby they advise teachers to break down the complex language contained in mathematical concepts to simple language that students can comprehend easily. Indeed, studies have shown that collaborative socialisation during the teaching and learning process is critically important in students' performance (Johnson & Johnson, 1991; Kiboss, 1997; 2000; Kirembu, 1991).

4.5 Summary

This chapter has made an attempt to present and discuss the data collected in order to accept or reject the hypotheses posited for testing with regard to the effect of a Socialised Mathematical Language (SML) module on a mathematics topic of statistics. The findings of this study have shown that the use of the SML module can be effective in enhancing student understanding of statistics in mathematics as well as fostering their perception of the mathematics learning environment. In addition the qualitative findings have demonstrated that the use of the SML enhanced group or otherwise co-operative learning that enhances student-teacher-student and material interaction by providing appropriate opportunities for meaningful learning.

Also this study has demonstrated that the use of SML can provide a starting point of departure to move away from the predominantly expository teaching that gives the teacher greater opportunities to dominate mathematical activities during the lesson(s). Both the quantitative and qualitative data have shown that the use of the SML gave the students more opportunities to develop socialisation skills that were necessary for them to negotiate meanings and to effectively co-participate in the learning environment. It is noteworthy that the SML successfully succeeded in making the teacher a facilitator in the teaching-learning process.

On the whole, the qualitative findings agree with the quantitative results presented in this study. Considering the significant learning gains and the qualitative data cited, there is evidence to suggest that the SML module was effective in influencing the student understanding of the mathematics topic on statistics. Moreover looking at the qualitative evidence, the simplicity and clarity of the SML module and the conducive classroom learning environment that allowed mutual student-teacher-student and material interactions must have exerted a positive influence on the outcomes reported in this study. However, future studies should make attempts to ascertain whether or not the present findings are genuine or incidental.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

The present study entailed the development and implementation of the SML module in a normal classroom setting. The main focus of the study was to determine and analyse the effect of the SML module on students' understanding of mathematics and their perception of the learning environment. Chapter one provided the background information to the study while chapter two presented a review of related literature and the theoretical framework of the study. Chapters three and four were concerned with the research methodology and the analysis of the results respectively. This chapter is to present the summary of the findings, the conclusions reached and provide some recommendations and suggestions for further research.

5.2 Summary of the Major Findings

There were four hypotheses set for this study. On all the hypotheses, the findings of this study are in the affirmative of a significant effect of the SML module. The findings are in favour of the students exposed to the SML module. The inferential statistics have revealed that there were differences between the mean scores obtained by the students in the SML treatment groups (E_1 & E_2) and those of the control groups (C_1 & C_2) that were statistically significant. Therefore the results show the effect of the SML in engendering cognitive, affective and psychomotor gains. On the whole, the SML module has to a large extent been successful in attaining the objectives of the study.

The SML module developed for teaching and learning the topic statistics in mathematics was found to be readable, understandable, clear and simple in presenting statistical concepts and skills on the part of students. Teachers on the other hand found the module to have clear and

elaborate lesson notes that were simplified for students understanding even on their own. This implies that the module succeeded in simplifying the language used in presenting mathematical concepts and skills in the topic statistics.

It was further established that students exposed to this module acquired the needed knowledge, concepts and skills. This can be inferred from the higher mean gains obtained on all the dependent measures by students exposed to it as compared to those not so exposed. On achievement, the results show a positive influence on students' knowledge and skill performance in favour of the module. This is an indication that the SML module had an effect on students' understanding of the topic statistics.

Nonetheless, results indicate that the SML learning environment was conducive for meaningful learning. The students' perceptions show a significant difference between the SML and regular learning environments. This is the reason why students in the treatment groups had significant learning gains unlike those in the control groups. The higher mean scores in the students' perception scores in favour of the treatment groups confirms that the SML module had an effect on students' perceptions of their learning environment.

The conducive learning environment seen in the SML classrooms facilitated mutual interactions during the lessons in the topic statistics. This follows from the tabulated results and narrations reported earlier. Specifically, the SML module provided appropriate opportunities for interpersonal communication and relationship. Both the quantitative and qualitative results ascribe the effect of the SML module on classroom interactions during mathematics instruction.

From the teachers' evaluation of the module, there is no gender bias in treatment groups. Both boys and girls had equal opportunities to participate in the lesson activities. On the whole, the forgoing suggests an effect of the SML module on students understanding of mathematics and perception of their learning environment.

5.3 Conclusions

The following conclusions have been reached from the analysis of the data presented in the previous chapter. First and foremost, the pre-test mean scores of E_1 and C_1 were identical while their post-test mean scores with respect to MAT, SPQ and MACOS were statistically different. However the post-test scores within the experimental groups (E_1 & E_2) and control groups (C_1 & C_2) respectively regarding the same variables were quite similar. Although E_1 and C_1 had an increase in the posttest mean scores, there were higher increases realized in E_1 that were similar to E_2 denied the pre-test. The increase in the mean score of the C_1 that was similar to C_2 was as a result of exposure to the content. Therefore, the pre-test did not have any effect on the posttest. Hence, the difference in the posttest mean scores of the treatment and control groups is attributed to the SML treatment.

Secondly, there were significant learning gains obtained by the students exposed to the SML module on both sections of the MAT instrument as compared to the low learning gains obtained by those students not exposed to the SML treatment. Unlike the mean scores of the two treatment groups E_1 and E_2, the mean scores of the control groups C_1 and C_2 were similar and significantly different from those of the former with respect to MAT, SPQ and MACOS measures.

In contrast to the subjects in control groups (C_1 & C_2), the students' perception of their learning environment as measured by SPQ in the treatment groups (E_1 & E_2) was quite encouraging. Similar conclusions are reached regarding the students' participation as observed during the lessons. It has been concluded that the teacher in the regular classroom tends to dominate the classroom activities and talks whereas in the SML augmented classes, the students tend to dominate both the classroom activities and talks. In addition the SML module affected the students' understanding of mathematics and their perception of the learning environment by engaging them in interactive endeavours that resulted in their self-actualisation and subsequent

ownership of the lessons. Indeed both quantitative and qualitative data have shown that the SML enhanced the students' interpersonal communication and interaction.

Furthermore, the effect of gender and age did not seem to exert any significant influence on the students' knowledge, perception and interaction in the topic statistics. An analysis of the TEQ suggests that the SML provided equal opportunities for both boys and girls to collaborate, support and interact together. The teachers' role was shifted from the role of transmitter of knowledge to that of a facilitator in the teaching-learning process.

5.4 Implication of the Findings

There are a number of implications that can be inferred from the findings of this study. The SML module used in this study has demonstrated a great potential in promoting certain cognitive, affective and psychomotor skills of form two students in mathematics. Based on the findings of this study, the problem of students having problems in reading and understanding mathematics textbooks may be resolved by the use of the SML. Additionally, the students' difficulty in understanding the mathematical language may be resolved by using the SML. In this view, the poor performance of students in mathematics in general and statistics in particular may be solved using the SML approach. With the recent call for teachers to simplify the language contained in mathematical concepts and skills (KNEC, 2000b; MOE 2001), the findings of the present study might become useful in providing a starting point and part of the database in this direction. Although it would be naïve to generalize the findings of this study in one district for prescribing an instructional model, more investigations covering a large scope would be necessary for meaningful conclusions about the SML.

The performance levels of the control groups have demonstrated the weaknesses of the regular instructional practices. In contrast to this, the SML module proved to be effective in promoting co-operative learning, which forms part of the solution to large classes in the context of

inadequate human and material resources. The findings have shown that the SML approach has the potential of encouraging high student participation in mathematics lessons and activities. The SML method engendered social interactions that foster a sense of self-actualization among students' than the regular method used in this study. In general, a well-designed SML module could promote a conducive learning environment that enhances the development and acquisition of concepts and skills and active student participation. The potential of the SML in maintaining such comparable abilities may be an area of interest to the stakeholders.

5.5 Recommendation and Suggestions for Further Research

Based on the findings and conclusions made in this study, it is recommended that the SML approach be adopted for mathematics instruction in Kenyan secondary schools. This follows from the significant learning gains obtained by students exposed to the SML module. Teachers should explain the terminologies and symbols in mathematics as opposed to their ordinary usage in English.

Although the Ministry of Education (MOE) and the Kenya National Examination Council (KNEC) has formally recognised that there is a language problem in mathematics education, there is need to familiarise teachers, students, mathematics textbook authors and publishers on the use of a socialised language. Given the harsh economic constraints currently facing this country, the use of the SML module as a teaching-learning strategy may be useful since the SML learning environment can militate against the teaching-learning needs of both the teacher and the student.

There is a need however to know more about how and in what way(s) the SML can influence cognitive abilities and process skills during the teaching –learning process. Areas in need for further investigations include the following.

1. Studies involving larger sample sizes in terms of the number of participating students, teachers and schools to confirm whether or not the present findings hold. Such studies should aim at

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uncovering fully how the variables function in the context of the SML learning environment to bring about meaningful learning.

2. Systematic studies involving more variables. The investigations should consider variables like the effect of the SML module on students' motivation, interest and attitudes among others. In addition, systematic studies should be done to determine in detail if there would be any differential effect of gender and age on the subjects' achievement, skill performance, perception of the classroom environment and other variables as a result of the SML. Such studies will provide additional database that will recommend the SML approach to be a full classroom method of instruction.
3. The use of in-depth naturalistic inquiries to gain further insights into the students' understanding and subsequent use of a socialised language to negotiate meanings during the classroom discourse.
4. A long-term study of the use of the SML in different secondary school categories need to be undertaken in order to understand whether or not there is a strong novelty effect. Such studies should be extensive enough so as to help ascertain the duration of the effect of the SML.
5. The measurement instruments developed and validated specifically for this study should be used in other studies on language and education to further test their validity, reliability and usefulness.

In view of the foregoing, the present study has explored the effect of the SML module for teaching a mathematics topic on statistics. The suggestions for further research presented above are intended to widen the database and enable educators and policy makers make more eneralizations to different student populations and instructional settings.

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APPENDIX A

A SOCIALISED MATHEMATICAL LANGUAGE MODULE FOR TEACHING AND LEARNING STATISTICS

PART 1

TEACHERS MANUAL FOR TEACHING THE TOPIC STATISTICS IN FORM TWO MATHEMATICS

BY

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INTRODUCTION TO TEACHERS

The following is a mathematics module on concepts and skills in the topic statistics developed for Form Two teachers and students. Although statistics is a topic for mathematics, it is meant to introduce students to statistical concepts and skills related to other subjects and fields of application that they will be learning in the course of their secondary education and thereafter.

The design and development of this module is to assist teachers in producing a person who will be numerate, orderly, logical, accurate and precise in thought (Kenya Institute of Education [KIE], 1992; Kenya National Examinations Council [KNEC], 2000a). In addition the person should be competent in appraising and utilising statistical concepts and skills in playing a positive role in the development of a modern society. As such a person will make precise and logical use of mathematical language to concretise problems from everyday situations, comprehend, analyse, synthesise and evaluate a set of numerical data to both familiar and unfamiliar situations.

The purpose and objective of the Socialised Mathematical Language (SML) module revolves around the methodology, delivery and evaluation of mathematical concepts and skills. SML is a simplified language that explains and expresses mathematical concepts and skills by integrating ordinary English language and mathematical language in teaching and learning of statistics. This provides a frame of reference upon which clues regarding the content, methodology, and reinforcement of group learning are embedded. This framework helps in the development of functions considered necessary to generate student interest, understanding and exercise of some control over their learning environment.

The content of this module is based on the KIE secondary school mathematics syllabus, teachers guide and approved textbooks for Form Two students. The areas covered are data collection and organization, the measures of central tendency and data presentation. Emphasis is given to students' understanding of mathematical symbols, notation, formulae, terminologies and drawing of diagrams and graphs.

The course will entail co-operative or otherwise group learning. This is the learning in which students work together in structured groups towards achieving a common goal. The users of the SML module are therefore expected to interact through class instruction, instructional materials and group discussions. To arrive at some agreement with regard to the content areas on which the SML module is developed, the following issues will be considered: the number of students in the class, their relative performance differences, the number of lessons to be taught, the current approach to the topic and other problems being experienced in teaching and learning this topic. Therefore teachers should place their students into groups consisting of 5 – 10 students that will be used in performing group activities given after every lesson.

The module will revolve around the following specific objectives:-

1. Definition of statistics.
2. Data collection and organization.
3. Frequency distribution tables.
4. Measures of central tendency.
5. Graphical presentation of data.
6. Data interpretation and application of the knowledge gained to both familiar and unfamiliar situations.

THE SML LESSONS

The KIE mathematics syllabus, teachers guide and text books indicate that the teaching of mathematics is influenced by such factors as the teachers' quality and competence, the topic to be covered, facilities available, the age and aptitude of learners, and the class size. As such, the teaching methods applied include lecture, discussion, teaching by examples and project work stipulated in the KIE approved mathematics syllabus for secondary schools. However, such expository methods are teacher dominated and may not be appropriate for quantitative concepts and skills as those in the topic statistics. It is against this background that the SML lessons seek to provide opportunities for students to exercise some control over their learning environment.

The SML module shall be set as a centre stage for Form Two classroom interaction engaging the factors mentioned above in a normal classroom setting. The topic 'statistics' shall be broken down into sub-topics to be followed in the lessons. These shall be restructured in this module and a socialised language used to explain each section. Some examples and exercises similar to those that appear in mathematics texts shall be used. As already stated the aim of mathematics education is to enable learners to make precise and logical use of mathematical language to concretize and solve problems from everyday situations that will enable them to play a positive role in the development of modern society. Hence precise knowledge, skills and interest as regards mathematics become essential assets because students need understanding of mathematical language.

In order to achieve this aim, the following aspects of statistics will be considered pertinent: data collection and organization, statistical symbols, notations and formulas, the measures of central tendency and data representation and interpretation. A description of each topic area and the respective objectives are specified below. It is believed that by the end of this topic, students should be able to understand and apply correctly the mathematical language used in the topic statistics.

(a) Data Collection and Organisation

More often than not students may come up with data concerning their marks in a term, age and height of their friends in class, number of family members etc. Sometimes, such data can be too large that writing and presenting it is tidious. As such the students should be familiar with the method used to collect and simplify large data to make it understandable and easy to work with. Therefore students should be guided to:-

1. Collect data of various kinds
2. Make a frequency distribution table for collected data
3. Group data into appropriate classes

(b) Statistical Notation and Formulas

In statistics, numbers describes data. Sometimes the numbers can be obtained directly from a given set of data or by applying a formula. Therefore the students should be familiar with how to get the required values from a given set of data. They should be guided to:-

1. Use correctly the notation of different aspects in statistics
2. Apply the formulae used for calculating different statistics
3. Explain the symbols used to denote different meanings
4. Distinguish the difference between terms as used in statistics

(c) Measures of Central Tendency

Students are familiar with the average and the most common item in a given set of data. However, they may get a feeling that this is not part of statistics. The students are also familiar with ways or methods of finding the average. Therefore when calculating the mean, mode and median, students should be familiar with basic formulas and/or methods of calculating these measures of central tendency. Thus students through instruction should be taught how to:-

1. Calculate the mean of a given set of data
2. State the mode of a given set of data
3. Compute the median of a given set of data

(d) Data Representation

Data can be represented in various forms such as tables, charts and graphs. The best way to represent data is to present it in the most understandable method and as accurately as possible. For instance if a farmer has maize, beans and sugarcane in his farm, the percentage proportion of each crop can best be shown on a pie chart.

Although students may understand how to present data graphically, they may confuse between different graphs such as the line graph, bar graph, histogram and the polygon. The confusion may arise from lack of understanding between plotting frequencies against class limits, class boundaries or class mid points. The abiscissor (x-axis) may vary but the ordinate (y-axis) is the same. Therefore students should be taught to be able to:-

1. Label the diagram and axes and plot points correctly on a Cartesian plane
2. Draw a pie-chart to represent a given set of data
3. Plot a bar chart of a given set of data
4. Represent a set of data on a histogram
5. Plot a frequency polygon for a given set of data
6. Represent a histogram and a frequency polygon of a given set of data on the same set of axes.

LESSON PLANS

Statistics in mathematics is a wide topic that can be taught under several sub-topics and lesson objectives. The SML module consists of twelve lessons taken from the topic statistics 1 under the Form Two mathematics curriculum.

LESSON 1

Topic area: Data collection and organization
Sub-topic: Data collection
Lesson Objectives: At the end of the lesson, the learner should be able to:-

1. Define the term statistics
2. Give examples of data used in statistics
3. Make a frequency distribution table

Lesson Development.

Step I: The teacher shall define the term statistics and give its importance as a topic of study.
Step II: By discussion, learners shall come up with examples of data used in statistics.
Step III: Through illustration by some examples, the teacher shall guide learners in making a frequency distribution table. The learners (as a class) should make a frequency table of one example on the chalkboard. The learners shall further make a frequency distribution table individually as the teacher supervises the students' work.
Step IV: The lesson is summarized by questions and answers on the key points covered in the lesson. Finally the teacher organizes students for group activities that will come after each lesson and gives the group activity of the lesson.

Teacher's Activities

1. Explains what is required of students to do
2. Gives brief notes on the content required
3. Organizes students for group activities and gives the group activity of the lesson
4. Supervises students' work

Students' Activities

1. Attend to the teacher and take notes
2. Respond to questions asked by the teacher or ask questions
3. Work individually to perform the class exercise
4. Participate in class discussions.

Group Activity I

Each member of the group should collect and record data concerning the following situations.
1. Age of their family members .
2. The marks obtained during their previous end term tests
3. Crops planted at their home and their acreage

Record the collected data from each member to form group data. This means that each group must have 3 sets of data: (i) the age of family members (ii) marks obtained during the previous end term tests and (iii) crops planted at home and the acreage of each. Then make an ungrouped frequency distribution tables for the first two sets of data.

NOTE: Keep this data well for later use in group activities that will follow.

LESSON 2

Sub-topic: Data organization
Lesson Objectives: At the end of this lesson, the learner should be able to:-
1. Define various terms used to describe grouped data
2. Group data into appropriate classes

Lesson Development

Step I: The learners and the teacher briefly review the previous lesson on data collection.
Step II: The teacher first introduces the lesson by asking the learners to suggest what they understand by various terms used to describe grouped data such as class size, class limits and class boundary.
Step III: By using examples the teacher shall guide learners to group data into appropriate classes. Further the teacher shall guide students to group one set of data on the chalkboard.
Step IV: The teacher shall give a class exercise to be done individually by students as she/he goes round to check on students progress in the exercise.
Step V The lesson is concluded by the teacher asking questions to recapitulate the main points in the lesson.

Teacher's Activities

1. Guides learners to define various terms used to describe grouped data
2. Explains what is required of learners to do
3. Helps learners carry out the class exercise
4. Supervises and assesses the learners work

Students' Activities

1. Attends to the teachers instructions and takes notes
2. Responds to questions asked by the teacher or asks questions
3. Follow steps required to group data
4. Participates in class discussion
5. Work individually during class exercise.

Group Activity 2

For the raw data recorded in activity 1 on age of family members and marks obtained in the previous end term tests, make a grouped frequency table with classes ranging between 10 and 15.

LESSON 3

Topic area: Measures of central tendency
Sub-topic: The mean of ungrouped data
Lesson Objectives: By the end of the lesson, the learner should be able to:-
1. Find the mean of ungrouped data
2. State and explain the formula for finding the mean of ungrouped data
3. Explain the symbols and notations concerning the mean
4. Apply the formula to find the mean of ungrouped data.

Lesson Development

Step I: The teacher leads the learners to discuss the mean as a measure of central tendency. The learners shall be introduced to the formula for finding the mean of ungrouped data.

Step II: Through examples, the teacher shall guide students to find the mean from a frequency distribution table for ungrouped data

Step III: The teacher shall give a class exercise for students to do individually as he/she goes round to supervise the work

Step IV: The lesson is concluded by the teacher giving students several problems on finding the mean of ungrouped data and the group activity.

Teacher's Activities

1. Explains the formula for finding the mean of ungrouped data
2. Supervises the learners' classroom activities
3. Gives homework and group activity

Students' Activities

1. Attend to the teacher and take notes
2. Participate in class discussion
3. Organize data and/or calculate the mean of the given data using the mean.

Group Activity 3

Using the ungrouped frequency tables developed in activity 1, calculate the mean of each set.

LESSON 4

Sub-topic: The mode and median of ungrouped data

Lesson Objectives: At the end of the lesson, the learner should be able to:-

1. State the mode of ungrouped data
2. Find the median of ungrouped data when n is odd
3. Find the median of ungrouped data when n is even
4. Explain the notation of the mode and the median.

Lesson Development

Step I: The teacher and learners shall discuss briefly the meaning of mode and median as measures of central tendency.

Step II: The teacher shall lead learners in finding the mode and median of ungrouped data. The learners' attention is drawn to steps followed in finding the mode and the formulae applied when determining the median of ungrouped data. The teacher shall provide an exercise to be done by students (as a group) on the mode and median of ungrouped data.

Step III The learners shall individually do an exercise given in class as the teacher moves round the class supervising this exercise.

Step IV The teacher shall conclude the lesson by giving group activity for the lesson and a take-away exercise to be done individually at home.

Teacher's Activities

1. Supervises class exercises
2. Provides class exercise, home work and gives group activity
3. Leads students in class discussion.

Students' Activities

1. Attend to the teacher
2. Organize and calculate the mode and median
3. Participation in class/group discussion
4. Ask questions and/or responds to questions asked in class

Group Activity 4

For each ungrouped frequency table recorded in activity 1, find the mode and the median.

LESSON 5 AND 6

Sub-topic – The mean of grouped data.
Lesson Objectives: At the end of the lesson, the learner should be able to:-

1. Explain the various terms used to in grouped data
2. State and explain the formula for finding the mean of grouped data
3. Apply the formulae to find the mean of a grouped data
4. Explain the symbols and notation concerning the formulae for the mean

Lesson Development

Step I The learners and the teacher shall review briefly the grouping of data discussed in lesson two of this module. Further they will revisit the formula for finding the mean of an ungrouped data whereby the teacher shall explain it to suit grouped data.

Step II The teacher shall lead learners and draw their attention to the process of calculating the mean of grouped data using the formulae. The learners (as a class) shall then calculate the mean of grouped data using the formula.

Step III The teacher shall supervise a class exercise done individually by learners.

Step IV The lesson shall be concluded by the teacher giving several problems on finding the mean of grouped data and group activity.

Teacher's Activities

1. Explaining the process and formula for finding the mean of grouped data
2. Supervises the classroom activities
3. Gives homework and group activity

Students' Activities

1. Attend to the teacher and takes notes
2. Participation in class discussion

3. Organizes data and/or calculate the mean of the grouped data by applying the formula.

Group Activity 5

From the grouped data obtained in activity 2, calculate the mean of each set of data. Compare this means with those obtained in activity 3 and comment.

LESSON 7

Sub-topic: The mode and median of grouped data
Lesson Objectives;- By the end of the lesson, the learner should be able to:-
1. Identify the modal class of a grouped data
2. State and explain the formula for finding the median of a grouped data
3. Apply the formula to find the median of a grouped data

Lesson Development

Step I The learners and the teacher shall review briefly the mode and the median of an ungrouped data discussed during lesson 4 of this module.
Step II The learners' attention shall be drawn to the mode and median of a grouped data. The teacher will lead learners to identify the modal class and further state and explain the formula for calculating the median of a grouped data.
Step III The teacher shall provide problems and let learners to identify the modal class and apply the formula to calculate the median. Then, a supervised class exercise will be given to students to do individually.
Step V The lesson is concluded by the teacher asking questions on the key points in the lesson and finally give homework and group activity

Teacher's Activities

1. States and explains the formula for calculating the median of a grouped data
2. Guides learners to identify the modal class of a grouped data
3. Provide and supervises class exercises
4. Gives homework and group activity

Students' Activities

1. Attends to the teacher and takes notes
2. Participates in group/class activities
3. Apply the formula to calculate the median of given sets of data
4. Identify and state the modal class in a grouped data

Group Activity 6

Find the mode and the median of the grouped data obtained in activity 2. Compare this modes and medians with those obtained in activity 3 and comment.

LESSON 8

Topic Area: Data representation
Sub-topic: Pie chart
Lesson Objectives: By the end of the lesson, the learner should be able to:-
1. State the various ways/methods of representing data
2. Represent data on a pie chart.

Lesson Development

Step I The learners and the teacher shall discuss the various ways of data presentation.
Step II The teacher shall introduce learners to the pie chart and by using examples lead learners to represent given data on it.
Step III Individually, the learners shall represent given data on a pie-chart as a class exercise. The teacher shall go round the class to supervise the exercise.
Step IV The teacher summarizes the lesson and finally gives an assignment and group activity.

Teacher's Activities

1. Explains what is required for students to do
2. Supervises students work
3. Gives assignment and group activity.

Students Activities

1. Attends to the teacher and takes notes
2. Participation in class discussion
3. Work individually in the class exercise.

Group Activity 7

Using the data obtained in activity 1 on crops planted at home and their acreage, find the totals of each crop and record it down. Then represent the obtained total acreage of each crop on a pie chart.

LESSON 9

Sub-topic: A bar chart
Lesson Objectives: By the end of the lesson, the learner should be able to:-
1. Label clearly the Cartesian plane
2. Represent data on a bar chart

Lesson Development

Step I The teacher and the learners shall review the previous lesson. The teacher will then introduce the lesson by asking learner's to suggest the graphical methods for data representation.
Step II The teacher shall centre on bar graph and guide learners on how to draw a labeled bar chart to represent the given data. Using an example given, the teacher will guide learners to draw a well-labeled bar chart on the chalkboard.

Step III The learners shall attempt a class exercise supervised by the teacher
Step IVThe teacher concludes the lesson by asking students to explain the key points in the lesson. Then, one exercise is given to be done at home by students and another as group activity.

Teacher's Activities

1. Guide students in class discussion
2. Supervise class exercises
3. Gives homework and group activity

Students' Activities

1. Attend to the teacher and takes notes
2. Participates in class/group discussion
3. Attempts class exercises
4. Responds to questions asked by the teacher and/or asks questions.

Group Activity 8
From the totals obtained for each crop in activity 7. Represent it on a bar chart.

LESSON 10

Sub-topic: Histogram
Lesson Objectives: By the end of the lesson, the learner should be able to:-
1. Distinguish between a bar chart and a histogram
2. Represent data on a histogram

Lesson Development

Step I The learner and the teacher briefly reviews the previous lesson on representing data on a bar chart.
Step II The teacher shall first introduce the lesson by drawing and labelling the Cartesian plane. The learners shall be guided on how to plot given data on a histogram. The learners shall then use this knowledge to represent other sets of data on a histogram.
Step III The teacher shall give a class exercise to be individually by students as s/he goes round supervising the activity.
Step IV Using questioning as a technique, the teacher shall ask students to recapitulate the main points in the lesson. Then, the teacher gives students some exercise on representing data on a histogram and the group activity.

Teachers' Activities

1. Demonstrates and explains what is required for students to do.
2. Supervise students work
3. Give exercises

Students' Activities

1. Attends to the teacher
2. Participates in class/group activities
3. Present data on a histogram

Group Activity 9

Represent the grouped data obtained in activity 2 on a histogram.

LESSON 11 AND 12

Sub-topic: Frequency polygon
Lesson Objective: By the end of the lesson, the learner should be able to:-
1. Differentiate between a bar chart, histogram and a frequency polygon
2. Represent data on a frequency polygon

Lesson Development

Step I The teacher and the learners shall review the previous two lessons (8 & 9) of this module on a bar chart and histogram respectively.
Step II The teacher shall centre on a frequency polygon and guide learners to represent data on a correctly labelled frequency polygon. The learners shall then (as a class) make a frequency polygon on one set of data given by the teacher.
Step IIIThe teacher shall supervise a class exercise given to students to do individually.
Step IVThe teacher shall conclude the lesson by asking students to distinguishing between the three graphical methods of data presentation. Finally the teacher shall give a take-away exercise and group activity.

Teacher's Activities

1. Explains what is required for students to know
2. Supervise classroom activities
3. Summarises graphical methods of data presentation
4. Give exercises

Students' Activities

1. Attends to the teacher and takes notes
2. Work individually during the class exercise
3. Participates in class activities

Group Activity 10

Represent the grouped data obtained in activity 2 on a frequency polygon. What do you notice about the histogram and the frequency polygon drawn for grouped data obtained in activity 2.

PART 2

STUDENTS MANUAL FOR LEARNING THE TOPIC STATISTICS IN FORM TWO

MATHEMATICS

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INTRODUCTION TO STUDENTS

This manual describes a Socialised Mathematical Language (SML) which shall be used to introduce you t concepts and skills in statistics. The SML is a simplified language that explains and expresses mathematica concepts by integrating the ordinary English language and mathematical language in teaching and leaning o statistics. Statistics is important in that it is related to other subjects and fields of application that you will b learning in secondary education and thereafter. Some basic operation skills that you will require ar described in the course content.

The content for this topic is clarified in this manual. You should however familiarize yourself with the content in your approved mathematics textbooks for Form II. As such try to solve problems given in these books and past papers. An effort shall be made to structure the topic and indicate what your contribution will be in meeting the following objectives:-

(a) Defining statistics
(b) Collecting and organizing data
(c) Presenting data in a meaningful way
(d) Computing measures of central tendency
(e) Interpreting data and applying the knowledge gained to both familiar and unfamiliar situations.

During this topic, you will be required to participate fully with other members of you class. Due to scarcity of materials, you are required to share resources amicably. Thus you will be working as a group and not individually. You are to make contribution to the class and the discussion group. No one individual should monopolize the discussion, teaching and leaning activities. Take turns, make your contribution and feel part of the group and/or class.

CONTENT

Introduction

To most people, statistics deals with numbers and effective ways of summarizing information, which describes some situation. However this is only part of the theory of statistics. *Statistics* can be defined as a scientific method concerned with collection, organization, analysis, summary, presentation, and interpretation of information that describes a situation. This information that describes a situation is referred to as *data*. Thus statistics is the whole process of collecting, organizing, presenting and analyzing data as well as drawing conclusions and making reasonable decisions on the basis of such analysis. In this view, statistics has a number of skills that you need to master. These include how to collect, organize and represent data in a meaningful way. In addition to calculating the mean, the mode and the median will also be considered as the measures of central tendency.

Statistics gives meaningful information that is useful in planning, decision making, education and research just but to name a few. Such information is needed by companies, government departments, scientists, educators, scholars and the general public. For instance, researchers use statistics to describe, summarize, interpret and test the significance of their observations. In education, statistical knowledge gained from this topic is essential to students since it is applied in other subjects like geography and business studies. It is also desirable that educators keep abreast with statistical procedures so that they can understand and evaluate new findings in their respective disciplines. Specifically, statistical procedures are helpful to teachers in evaluating their students' abilities and achievements. Basically, the topic statistics can be studied in three

major topic areas namely data collection and organization, the measures of central tendency and data representation. Each of these topic areas is discussed here below.

DATA COLLECTION AND ORGANISATION

Data collection

This involves gathering information relevant to a specific situation. Possible approaches of gathering such information are by observation, interview or questionnaires. There are various sources of such data. These include data obtained from agricultural production, research, printed materials and personal information such as marks obtained in class tests, height and weight gains etc. Data obtained from printed materials and research of other people is referred to as *secondary data* while that data obtained by individual effort and has never been used before by anybody is called *primary data*. For instance, if you record the age and height of your classmates, then you generate primary data. Also, suppose you record the amount of milk (in litres) produced by a freshian cow you have at home (if any) for one week as 10, 8, 11, 9, 8, 9, and 9, then you come up with primary data. Such data that is collected, recorded as it occurs and has not been organized in any way is called *raw data*.

Data Organisation

This is the process of arranging raw data to make it more meaningful. This makes it easy to make an interpretation of data collected. Although different professionals prefer different methods of organizing and presenting data, we shall first discuss the simplest way of organizing data which is the construction of frequency distribution tables for both ungrouped and grouped data.

Frequency distribution table for ungrouped data

This is a table showing the number of times an item, number or value occurs. Usually, the table has three columns namely item, value or number column, tally column and the number of times an item, number or value occurs (frequency) column. When constructing a frequency distribution table, usually the first step is to arrange the numbers, values or items in order, from highest to lowest in the first column or vice versa. Then a tally mark commonly known as the stroke (/) is made next to each number, item or value whenever it appears/occurs. The tallies appear in the middle column while the last column summarizes the total number of tallies for each value, item or number indicting the number of times of occurrence.

To understand this, let us use the raw data on the amount of milk produced by a freshian cow given above as 10, 8, 11, 9, 8, 9 and 9. These data can be represented in a frequency distribution table as below

Table 1.1 Ungrouped frequency distribution for the amount of milk produced by a freshian cow for one week.

Amount of milk (in litres)	Tally mark	Number of days (frequency)
11	/	1
10	/	1
9	///	3
8	//	2
		Total = 7

Before we interpret the table, let us first define the term frequency. *Frequency* means the number of times an item or value occurs. For example, in the raw data, 8 appears 2 times that is for 2 days in that week, the

freshian cow produced 8 litres of milk each day. Thus in table 1.1, the frequency of 8 is 2 and the frequency of 9 is 3. What is the frequency of 10 and 11 from the table?

Notation: Generally in mathematics and statistics in particular, frequency is denoted by the first letter of the word in small letter, that is lowercase f. However, the total frequency is symbolized as $\sum f$. The symbol $\sum$ is a Greek capital letter which is read as 'sigma'. This symbol stands for 'sum of' implying the total. From the above table, the total frequency is 7 which we can symbolically denote as $\sum f = 7$. Let us use the notation in our next example.

Example

Construct a frequency distribution table to represent the following scores that were recorded from a Statistics Continuous Assessment Test (CAT) given to 42 students

22	16	28	22	26	22	14	20	25	27	25	28	24	23
18	20	19	25	23	33	24	16	31	26	19	23	21	30
32	26	31	34	30	27	21	23	15	17	15	17	25	23

Table 1.2 Frequency Distribution Table for Statistics CAT Scores

Score	Tally	Frequency(f)
34	/	1
33	/	1
32	/	1
31	//	2
30	//	1
29		0
28	//	2
27	///	2
26	////	3
25	//	4
24	/////	2
23	///	5
22	//	3
21	//	2
20	//	2
19	/	2
18	//	1
17	//	2
16	//	2
15	//	2
14	/	1
		$\sum f = 42$

Grouped Data

When dealing with large numbers of raw data, it is desirable to carry out the summarization of data one step further. This can be done by lumping a number of data together into groups thereby reducing the number by putting them into intervals. This process retains the information about frequency and produces a more manageable set of data. The procedure yields grouped data that can also be represented in a frequency distribution table. Unlike in ungrouped data, here the data are grouped to form intervals of data called *class*

intervals. It should be noted that although there is no fixed rule for the number of class intervals, it is usually best to make a minimum of 6 classes and a maximum of about 12. This is because less than 6 classes may distort the results while more than 12 classes may be inconvenient to handle. In addition, having fewer class intervals loses much of the information in the data whereas having more class intervals could bring problems of being unable to understand the data at a glance.

There are four steps in arranging data for the grouped frequency distribution. First and foremost is to determine the range of the raw data. The *range* is the difference between the lowest and highest values in the set of data. Using the raw data on scores obtained from the statistics CAT as our reference, the highest score is 34 while the lowest score is 14. Then the range is 34 – 14 = 20.

Secondly determine the *class size* of the classes into which scores are to be classified. Usually, odd numbered interval sizes such as 3, 5 ... are preferred to even numbered interval sizes such as 2, 4, 6... The reason being, it is easier to get the centre of the interval (class midpoint). Therefore, with odd numbered class sizes, choose that size which will yield between 6 and 12 classes. To find the number of classes, we divide the range by the class size. For example referring to the raw data on scores obtained from the statistics CAT, we can have class sizes of 3 and 5. This will yield the following classes.

(i) A class size of 3 will give $\frac{20}{3} = 7$ classes

(ii) A class size of 5 will give $\frac{20}{5} = 4$ classes

Then choose a class size of 3 to yield 7 classes.

Thirdly, determine the class width of the classes. Note that the number of classes must include the highest and the lowest score. To achieve this, start each class width with a multiple of the class interval. For example, to have smallest data (14) included, the lowest class width start with 12, which is a multiple of 3 and will accommodate the score of 14 such that the lowest class will be 12 – 14. Each succeeding class lower score should then be three points above the one just below it. Therefore in our case, the next class starts at 15, the next at 18 and so on until the highest score of 34 is achieved in the class 33 – 35. Furthermore, note that the 12 – 14 class includes all values equal to or greater than 11.5 but less than 14.5. In statistics, values **12** and **14** are called *class limits* while **11.5** and **14.5** are called *class boundaries*. Similarly, the class 33 – 35 includes all values equal to or greater than 32.5 but less than 35.5. Hence the class limits for a class of 33 – 35 are 33 and 35 and whereas **32.5** and **35.5** are the *class boundaries*. Moreover in the class limits of 32 and 35 for a class of 33 – 35, **33** is called the *lower class limit* while **35** is the *upper class limit*. However, to obtain *class widths* get the difference between the class boundaries. As in the case of 33 - 35 class, the class boundaries are 32.5 and 35.5 whose difference gives the class interval (width) as 35.5 – 32.5 = 3. This in essence equals the class size.

Finally make the tabulation containing four columns – class interval, tally, frequency and mid points. A tally is made for each score opposite the class that it falls. Unlike in ungrouped data you will realise that some tallies will be bunched together in groups of five to facilitate easier counting. The tallies for each class interval are then summed to obtain the respective class frequencies (the number of scores in each class). Class frequencies appear in the third column. The *mid point* is the average of the lower and upper class limits. For example, the midpoint of a class interval of 12 – 14 is (12 + 14)/2 = 26/2 = 13. Similarly, for class interval 32 – 35, the mid point is 33. Mid points are recorded in the last column of the grouped frequency distribution. The above four steps can now be used to make a grouped frequency distribution table for scores from the statistics CAT a shown in the table below.

Table 1.3 Grouped Frequency distribution table for statistics CAT scores

Class interval	Tally	Frequency (f)	Mid points
33 – 35	//	2	34
30 – 32	~~////~~	5	31
27 – 29	////	4	28
24 – 26	~~////~~ ////	9	25
21 – 23	~~////~~ ~~////~~	10	22
18 – 20	~~////~~	5	19
15 – 17	~~////~~ /	6	16
12 – 14	/	1	13
		$\Sigma f = 42$	

Example

The weights (in kgs) of 50 form two students in Kibabii Boys High School were recorded a follows:-

63.7	50.0	58.0	73.4	76.3	42.3	58.0	45.0	62.1	78.0
58.0	59.5	45.2	79.6	69.1	4.8	49.8	84.2	54.9	52.6
52.1	63.5	58.0	45.5	58.7	73.4	53.3	67.3	77.7	59.7
72.9	49.2	74.2	60.2	43.9	73.4	53.3	67.3	77.7	63.5
62.3	46.8	66.2	52.1	59.7	60.5	60.3	69.6	80.2	54.4

Make a grouped frequency distribution table for the above information.

Solution

The weights vary from 40.6 kg to 84.2kg. Therefore range = 84.2 – 40.6 = 43.6. A class size of 3 will give 43.6/3 = 15 classes, a class of size of 5 will give 43.6/5 = 9 classes while a class size of 7 will give 43.6/7 = 7classes. Now, choosing a class size of 5, then the data can be re-arranged in a frequency table as below:-

Class	Tally	Frequency (f)	Midpoint
80 – 84	///	3	82
75 - 79	///	3	77
70 – 74	~~////~~	5	72
65 – 69	///	3	67
60 – 64	~~////~~ ~~////~~///	13	62
55 – 59	~~////~~//	7	57
50 – 54	~~////~~/	6	52
45 – 49	~~////~~	5	47
40 – 44	~~////~~	5	42
		$\Sigma f = 50$	

Note: With practice, you will realise that the tally column and frequency column are the same. Therefore we can delete the tally column so that the frequency distribution table looks as the one shown below.

Class	Frequency (f)	Midpoint
80 – 84	3	82
75 -- 79	3	77
70 – 74	5	72
65 – 69	3	67
60 – 64	13	62
55 – 59	7	57
50 – 54	6	52
45 – 49	5	47
40 – 44	5	42
	$\Sigma f = 50$	

MEASURES OF CENTRAL TENDENCY

Examine the ungrouped and the grouped frequency distribution tables constructed earlier on scores obtained in a statistics CAT. What do you notice about the distribution of the scores in the two frequency tables? You may notice that in the ungrouped and grouped frequency distribution table, there are values in the set of data where the scores tend to cluster around and they spread around that value in a specific way. The value around which other values spread from or cluster around is called a *measure of central tendency*. This measure gives some idea of the average or representative score in the distribution. At this level, there are three ways in which we can describe the measures of central tendency. These are by finding the mean, the mode and the median. The three are what we call measures of central tendency. Details of each measure of central tendency are described below.

However before discussing the respective measures of central tendency, let us look at the importance of these measures. Some situations in which these measures may be useful are:-

1. The mean monthly rainfall of a particular region may determine the type of crops that can be grown.
2. The mean age of a population in a particular country may help the government to plan for provision of certain necessities such a schools, etc.
3. In a production company like shoe company, it is important to know the most frequently required shoe size for men and women so as to plan for production.
4. In business like that of running a hotel, the favourite dish for customers will be important in preparing a menu.

Measures of central tendency for ungrouped data

(a) The mean

In ordinary usage, *mean* refers to the average. It also used to express meaning and some times to refer to ungenerous behaviour. However, in mathematics *mean* refers to the value calculated by adding together several quantities and then dividing by the number of quantities. This measure of central tendency is also referred to as the arithmetic mean. The mean is the most preferred measure because in its computation, each value in the distribution is considered unlike for the mode and median. This measure is found by adding all the values or items in the distribution and dividing by the total number of values or items i.e.

$$\text{Mean} = \frac{\text{Total of values/items}}{\text{Total number of values/items}}$$

For example, given the total amount of milk (in litres) produced by a freshian cow for one week as 10, 8, 11, 9, 8, 9 and 9, the mean can be computed as follows:-

First find the total amount of milk produced i.e. 10 + 8 + 11 + 9 + 8 + 9 + 9 = 54. Then find the total number of items (days) by counting the given values. This gives 7 days. Finally evaluate the mean as:-

Mean = $\frac{\text{Total quantity of milk}}{\text{Total number of days}} = \frac{54}{7} = 7\frac{5}{7}$ litres.

This means that on average, this freshian cow produced $7\frac{5}{7}$ litres of milk per day for that week.

Notation

The mean is usually denoted by a capital letter of the alphabet with a bar (-) over the letter. Thus if we have observation A, B, C, D, X or Y, the mean of A is denoted as A, read as 'A bar', the mean of B is B, red as 'B bar' while the mean of X is denoted as X, read as 'X bar' and that of D is $\bar{D}$ read as D bar'. However, the letters commonly used are the capital X and Y although you can use any letter. The values or items in the data are denoted by capital letters of the alphabet. This means that the capital letter represents all the observations in the data set. For instance we can represent the amount of milk in the above example by capital X or Y or A or B or any letter of the alphabet.

Let us use the capital X in the mean time. The total amount of milk is obtained by summing all the observation i.e. we sum all the observation of X. This can be denoted by ΣX as seen earlier. The total number of observations is usually denoted by N. Hence using the notations the mean amount of milk produced by the freshian cow is calculated as:

$\bar{X} = \Sigma X/N$ where $\bar{X}$= the mean, ΣX= total amount of milk, N= total number of days

Hence, $\bar{X} = 54/7 = 7.72$

Example

Find the mean of 3,3,4,5,6,6,8,9 and 10.

Solution

Suppose we denote the observations by X, then the sum of observations is:

$\Sigma X = 3 + 3 + 4 + 5 + 6 + 6 + 8 + 9 + 10 = 54$ while the total number of observations, N= 9.

Hence, $\bar{X} = \Sigma X/N = 54/9 = 6$

Finding the mean from ungrouped frequency distribution table

Consider the ungrouped frequency distribution table constructed for statistics CAT scores earlier. We can denote the scores by capital X. From the raw data given earlier, the total number of students (N) is 42. This equals total frequency i.e. $\Sigma f = 42$. In order to find the total of scores, we need to get the sum of products of the scores and their respective frequencies i.e. multiply each score with its frequency and then add up all the results. For instance, we multiply 34 by 1, 33 by 1, 32 by 1, 31 by 2 and so on and then add all that we get after the multiplication. We can do this multiplication and addition easily by creating another column after the frequency column to represent the products of the scores (X) and the frequencies (f). This column is denoted as Xf. Then we sum all the values in this column to get the sum of products of the scores and their respective frequencies. It should be noted that this sum is the same as that which is obtained by adding all the raw scores. In statistics, the sum of products of the scores and their respective frequencies is written as ΣXf.

In this view, the mean is obtained by dividing the sum of products of X and f (ΣXf) by the total sum of frequencies (Σf). Thus, mean is sum of products of x and f / sum of frequencies. Symbolically, this is represented as $X = \Sigma Xf/ \Sigma f$ where X = mean, ΣXf = sum of products of X and f, Σf = sum of frequencies. Using this formula, we can evaluate the mean of the statistics CAT scores as shown below.

Score (X)	Frequency(f)	Xf
34	1	34
33	1	33
32	1	31
31	2	62
30	1	30
29	0	0
28	2	56
27	2	54
26	3	78
25	4	100
24	2	48
23	5	115
22	3	66
21	2	42
20	2	40
19	2	38
18	1	18
17	2	34
16	2	32
15	2	30
14	1	14
	$\sum f = 42$	$\sum Xf = 977$

$\bar{X} = \sum Xf / \sum f = 977/42 = 23.26$

(b) The Mode

The mode refers to the way or style of doing something in ordinary English language. However in mathematics, it refers to the most frequent appearing value or item in a distribution. It is the value with the highest frequency in a set of observations. We should note that the mode is a value that occurs most frequently and it is one of the values in the distribution. However, the value may exist or not in the distribution because it can be estimated. Let us illustrate this by the following examples.

1. When we have all the observations in the distribution having the same frequency, no mode exists. For example, no mode exists for the following set of numbers: 4, 8, 11, 10, 3, 9, 5, 7, 15, 14, 13.
2. When we have one value, number or item with the highest frequency than others in a set of data, then that value, number or item is the mode. For example, 13, 15, 22, 16, 7, 14, 15, 17, 11, 5, 8, 23, the mode is 15. In such cases where there is only one value with the highest frequency is referred to as unimodal.
3. When two adjacent values, numbers or items have the same frequency and this frequency is highest in the distribution, the mode is the average of the two modes. For instance, in the distribution consisting of 1, 3, 4, 4, 6, 6, 8, 9, the mode is the average of the two modes 4, and 6 which is obtained by adding 4, to 6 and dividing by 2. This gives 5 as the mode. Note that 5 is not in the distribution hence it is estimated.
4. If the modes are not adjacent, then we have multiple modes. The two or more modes are reported without finding their average. If there are two modes that are non-adjacent, the distribution is said to be bimodal. For example consider the data set 1, 3, 3, 4, 6, 6, 8, 9 the non-adjacent modes 3 and 6 are said to be bimodal.

Notation: The mode is generally denoted by **Mo** or just the word mode.

(c) The Median

Ordinarily, median refers to a line passing through the middle or the centre of an object. In statistics, when any collection of data is arranged in order of size, that is either in ascending or descending order, the value that falls in the middle is called the *median*. Thus, the median is a value in a distribution above which 50% of the values or items are located and the other 50% below it. The median gives information about the value in the middle position in the distribution and is denoted as **Md.**

However, if there are odd number of values or items in the distribution, the median takes the middle value or item when they are ranked from highest to lowest or vice versa. For example, consider the distribution of 15,16,19, 10 and 11. This can be rearranged or ranked as 10,11,15,16,19 or 19,16, 15, 11,10. In either case, the middle value takes the 3^{rd} position and is 15. This becomes the median. However, if there is an even number of values or items, the median is the point halfway between the two middle values or items when they are ranked. In other words, the average of the two middle values is taken as the median. For example, suppose there are six pupils in a class whose ages are 16,18,17,14,16, and 19. Then ranking this ages we have 14,16,16,17,18,19 or 19,18,17,16,16,14. This means that the median age lies between the 3^{rd} and 4^{th} age 16 and 17. Hence, the median is the average of this two values and is estimated as (16 + 17)/2 = 16.5 years.

In general, if we have n values or items arranged in order of sizes, the median is

1. $\frac{1}{2}(n+1)^{th}$ item or value when n is odd
2. the average of $\frac{1}{2}n^{th}$ and $\frac{1}{2}(n+2)^{th}$ item when n is even.

Example
Consider the ungrouped frequency distribution table for statistics CAT scores constructed earlier. From it find the mode and the median.

Solution
(i) mode
From the frequency distribution table, the highest frequency is 5 and the value corresponding to the highest frequency is 23. Hence, the mode is 23.

(ii) median
From the table, the total number of observations is given by $\sum f = 42$. Therefore n = 42 which is even. Now, $\frac{1}{2}n^{th}$ item is $\frac{1}{2} \times 42 = 21$, while $\frac{1}{2}(n+2)^{th}$ item is $\frac{1}{2}(42+2) = \frac{1}{2} \times 44 = 22$.
By adding the frequencies, the $\frac{1}{2}n^{th}$ item takes the 21^{st} position, which is 23. Similarly, the $\frac{1}{2}(n+2)^{th}$ item takes the 22^{nd} position which is also 23. Hence the median, Md = (23 + 23)/2 = 23.

Measures of Central Tendency for Grouped Data

(a) The Mean

For a grouped frequency distribution, the mean is obtained as follows, find the midpoints of class interval by getting the average of the upper and the lower class limits. Usually, the midpoints are denoted by X. Then multiply each midpoint by its corresponding frequency (f). The products are finally summed and divided by the total frequency to give the mean. This can be summarised as

$$\text{Mean} = \frac{\text{sum of products between midpoints and corresponding frequencies}}{\text{Total frequency}}$$

This can be rewritten symbolically as $\overline{X} = \Sigma Xf / \Sigma f$ where X is the midpoints, f is the frequencies, ΣXf is the sum of products of midpoints and frequency and Σf is the total frequency. Using the grouped frequency

distribution table on statistics CAT scores, the calculation of the mean of these scores by applying the above formula is illustrated below.

Class interval	Frequency (f)	Mid points (X)	Xf
33 – 35	2	34	68
30 – 32	5	31	155
27 – 29	4	28	112
24 – 26	9	25	225
21 – 23	10	22	220
18 – 20	5	19	95
15 – 17	6	16	96
12 – 14	1	13	13
	$\Sigma f = 42$		$\Sigma Xf = 984$

$\bar{X} = \Sigma Xf/\Sigma f = 984/42 = 23.43$

Compare this mean with that calculated for the ungrouped frequency table calculated earlier. What can you say about them?

Example

Find the mean of the following data discussed earlier and interpret your result

Class	80- 84	75- 79	70- 74	65- 69	60- 64	55- 59	50- 54	45- 49	40- 44
frequency	3	3	5	3	13	7	6	5	5

Solution

Class	Frequency (f)	Midpoints (X)	Xf
80 – 84	3	82	246
75 - 79	3	77	231
70 – 74	5	72	360
65 – 69	3	67	201
60 – 64	13	62	806
55 – 59	7	57	399
50 – 54	6	52	312
45 – 49	5	47	235
40 – 44	5	42	210
	$\Sigma f = 50$		$\Sigma Xf = 3000$

The mean, $\bar{X} = \Sigma Xf/\Sigma f = 3000/50 = 60$

This means that the average weight of students in this class is 60 Kgs.

(b) The Mode

In grouped data, the class with the highest frequency is called the *modal class*. For example, in our example on statistics CAT scores, the highest frequency is 10 and the class corresponding to the highest frequency is 21 – 23. Hence the modal class is 21 – 23 and the modal frequency is 10. Similarly the modal class for the grouped data on the weight of students given earlier is 60 – 64 with a modal frequency of 13.

(c) The Median

To get the median for the grouped data, some interpolation has to be performed. Consider the grouped data on statistics CAT scores that illustrated how to calculate of the mean earlier. From the data, we found that the mean was 23.43 while the modal class was 21-23. To find the median, first determine the number of observations in the distribution by computing the total frequencies i.e. $\Sigma f = 42$. Then establish the half waypoint of the distribution by dividing total frequencies by 2 i.e. $\Sigma f/2 = 42/2 = 21$. Next identify the median interval in which the middle score falls and determine its class limits. In this case, the median class in which the middle score (21^{st} score) falls is 21-23. The class limits of this class are 20 and 23 while the class boundaries are 20.5 and 23.5.

To find the median we interpolate between the class limits to find a score above and below which 21 cases fall. Notice that the class size is 3 and 10 scores fall within the median class. This means that each of the 10 scores occupies 3/10 = 0.3 of the interval. Since 12 scores fall below the median class, to obtain the median, we require 9 of the 10 scores to reach the middle value (12 + 9 = 21). The proportion of the interval needed to account for 9 scores is (3/10) x 9 = 2.7 units. We add this to the lower limit of the median class to obtain the median as 20.5 + 2.7 = 23.2. This procedure for finding the median of a grouped data is summarised in the formula.

Median, $M_d = L + \frac{(N/2 - Cf_b)i}{fw}$ Where N is the total frequency in the distribution, L is the lower class limit of the class containing the median, Cf_b is the total frequency in all the intervals below the median class, fw is the frequency of the median class and i is the class size. Thus from our example above, we can apply the formula in the following way

Median, $M_d = L + \frac{(N/2 - Cf_b)i}{fw}$

$$= 20.5 + \frac{(42/2 - 12)3}{10}$$

$$= 20.5 + \frac{(21 - 12)3}{10}$$

$$= 20.5 + \frac{9}{10} \times 3 \quad = 20.5 + 2.7 = 23.2$$

Example

The table gives the amounts in Kenya shillings of pocket money given to students of a particular school.

Pocket money (Ksh)	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-99
No. of students	5	14	40	38	24	20	15	10	4

Find the mean, median and state the modal class.

Solution

Pocket Money (Ksh)	No. of students (f)	Mid point (X)	Xf
90 – 99	4	94.5	378.0
80 – 89	10	84.5	845.0
70 – 79	15	74.5	1117.5
60 – 69	20	64.5	1290.0
50 – 59	24	54.5	1308.0
40 – 49	38	44.5	1691.0
30 – 39	40	34.5	1380.0
20 – 29	14	24.5	343.0
10 – 19	5	14.5	72.5
	$\Sigma f = 170$		$\Sigma Xf = 8425$

(i) Mean, $\bar{X} = \frac{\Sigma Xf}{\Sigma f} = \frac{8425}{170} = 49.55$

(ii) Median

Median class is 40-49

Now, $M_d = L + \frac{(N/2 - Cf_b)}{fw} i$ where $L = 39.5$, $N = \Sigma f = 170$ and $N/2 = 170/2 = 85$, $Cf_b = 59$, $fw = 38$, $i = 49.5 - 39.5 = 10$.

Substituting in the formula we get

$$M_d = 39.5 + \frac{(85 - 59)}{38}10$$

$$= 39.5 + \frac{26 \times 10}{38}$$

$$= 39.5 + \frac{260}{38} = 39.5 + 6.84 = 46.34$$

(iii) Modal class: The highest frequency is 40. This frequency is for the class interval 30 – 39. Hence the modal class is 30 – 39.

DATA REPRESENTATION

At this point you are in a position to present data in a frequency distribution table. However, the frequency distribution table does not give a very clear picture of the real situation though it can be supplemented with other methods of representation of the same data. These methods of representation of data include pictograms, pie charts, bar charts and graphical methods like line graphs, histograms and frequency polygons. Representation of data by pictograms, pie charts, line graphs and bar charts has been covered in your earlier work in lower classes. In this section, we shall revisit the pie chart and the bar chart and extend our knowledge of data representation to histograms and frequency polygons.

(a) Pie Chart

We are aware of how to represent data on a pie chart. At earlier stages of learning presentation methods we did learn that in a pie chart the frequency is represented by the area of a sector of a circle. For this reason, a pie chart is best used when you want to show how a given whole is divided into its parts. To do this, we evaluate the proportion of each part of the whole against 360^0. To illustrate this, consider the following two examples.

Example 1

Fifty students in a class had the following as total marks at the end of a term. Using intervals of 10 marks, show the information on a pie chart.

423	393	391	363	407	405	364	377	371	373
427	423	405	404	381	447	424	397	395	365
396	404	411	408	387	388	365	418	398	394
384	414	408	391	400	412	425	392	377	388
401	406	387	411	403	407	422	406	406	394

Solution

Note that using intervals of 10 marks implies making a grouped frequency distribution table. This can be constructed as below:-

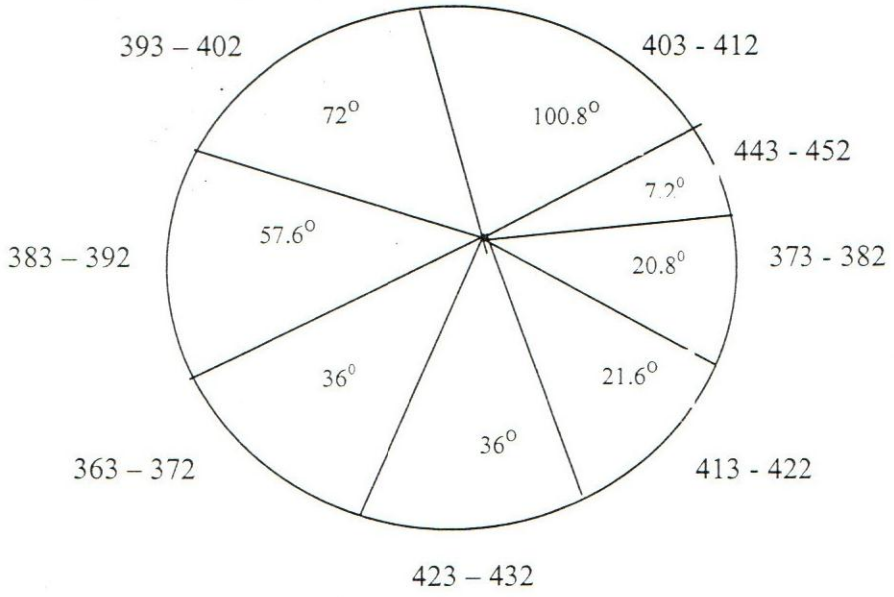
Marks	363-372	373-382	383-392	393-402	403-412	413-422	423-432	433-442	443-452
Frequency(f)	5	4	8	10	14	3	5	0	1

Now $\Sigma f = 50$. Calculating the proportion of each interval against the total 360^0 we have for example $5/50 \times 360^0 = 36^0$ for the interval 363 – 372, $4/50 \times 360^0 = 28.8^0$ for the interval 373 – 382, etc. Continuing in the same way, we get the angle for each interval in the table above. Accordingly a column or row can be added to the grouped frequency table as below.

Marks	363-372	373-382	383-392	393-402	403-412	413-422	423-432	433-442	443-452
Frequency(f)	5	4	8	10	14	3	5	0	1
Angle (0^0)	36^0	20.8^0	57.6^0	72^0	100.8^0	21.6^0	36^0	0^0	7.2^0

Using the angles, we can draw a pie chart as below:-

Figure 1: A pie chart representing students' total marks at the end of a term



Example 2

The number of accidents caused by different vehicles for one month was recorded as follows

Type of vehicle	Cars	Buses	Matatus	Lorries	Motor cycles
Number of accidents	48	9	31	27	5

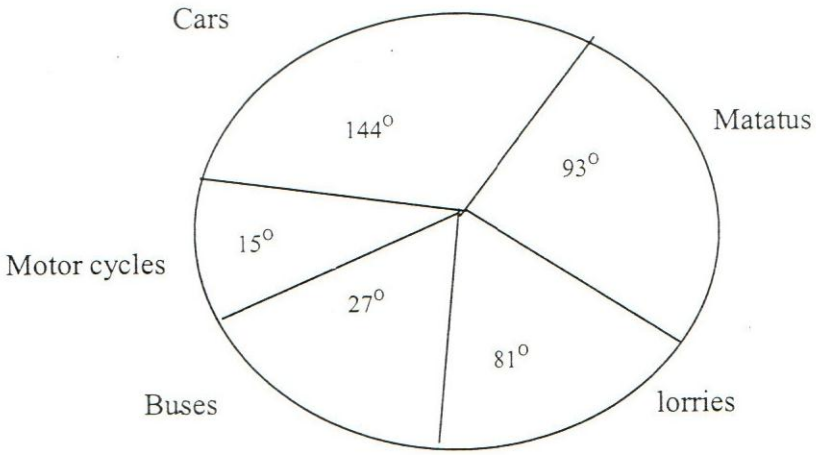
Illustrate this information on a pie chart.

Solution

Type of vehicle	Number of accidents (f)	Angle (0^0)
Cars	48	$48/120 \times 360^0 = 144^0$
Buses	9	$9/120 \times 360^0 = 27^0$
Matatus	31	$31/120 \times 360^0 = 93^0$
Lorries	27	$27/120 \times 360^0 = 81^0$
Motor cycles	5	$5/120 \times 360^0 = 15^0$
	$\Sigma f = 120$	

The pie chart can be shown as below:-

Figure 2: A pie chart showing the number of accidents caused by different vehicles



Comment: Cars caused more accidents than any other vehicle.

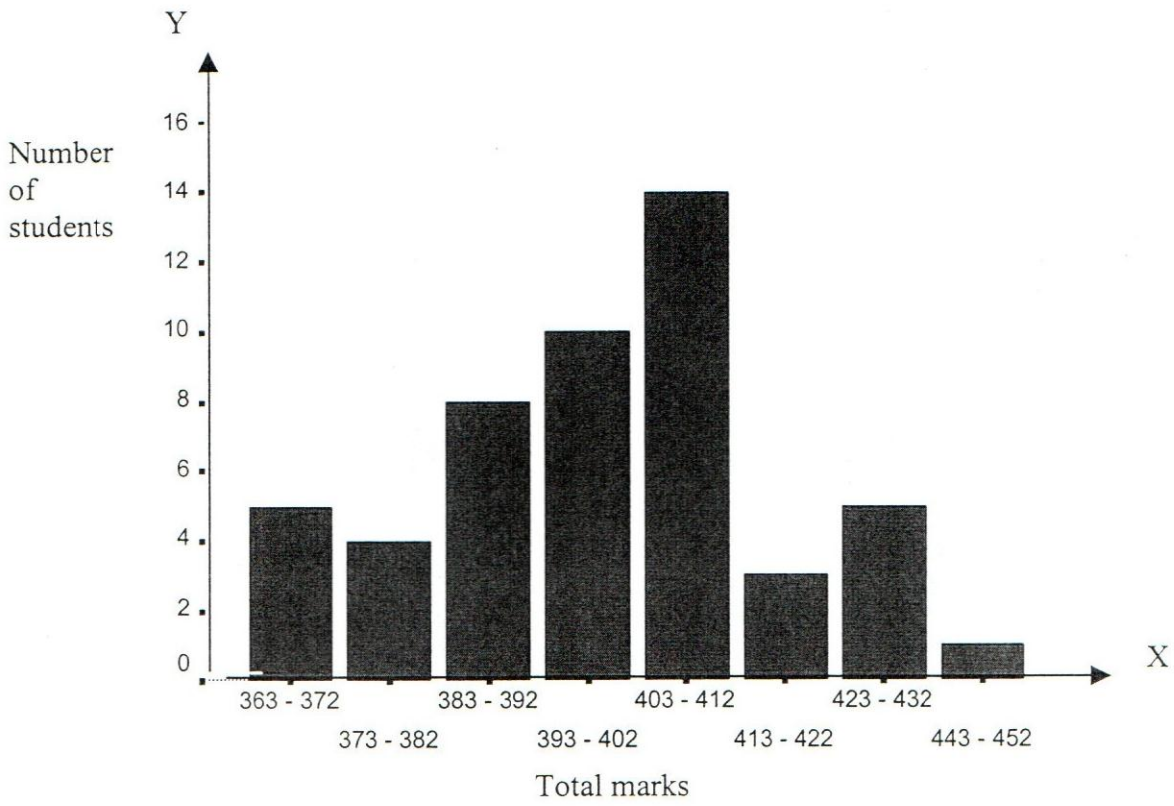
(b) Bar-Chart

As in the case of pie chart discussed above, we covered the bar chart in the earlier work in lower classes. However, at this stage, we need to note that in a bar chat, we represent the observation and its frequency using bars in the x and y axes respectively. The length or height of each bar in a bar chart represents the frequency. To illustrate this, consider the examples given on a pie chart.

Example 1

Consider the grouped frequency distribution table constructed in example 1 above. From this table, the marks will form the x–axis while the frequency will be the y-axis. Therefore, the bar chart can diagrammatically be presented as below:-

Figure 3: A bar graph representing the total marks obtained by students at the end of a term



More students scored between 403 – 412 marks than any other interval.

Example 2

Consider example 2 above where the number of accidents caused by different vehicles for one month was recorded as follows:-

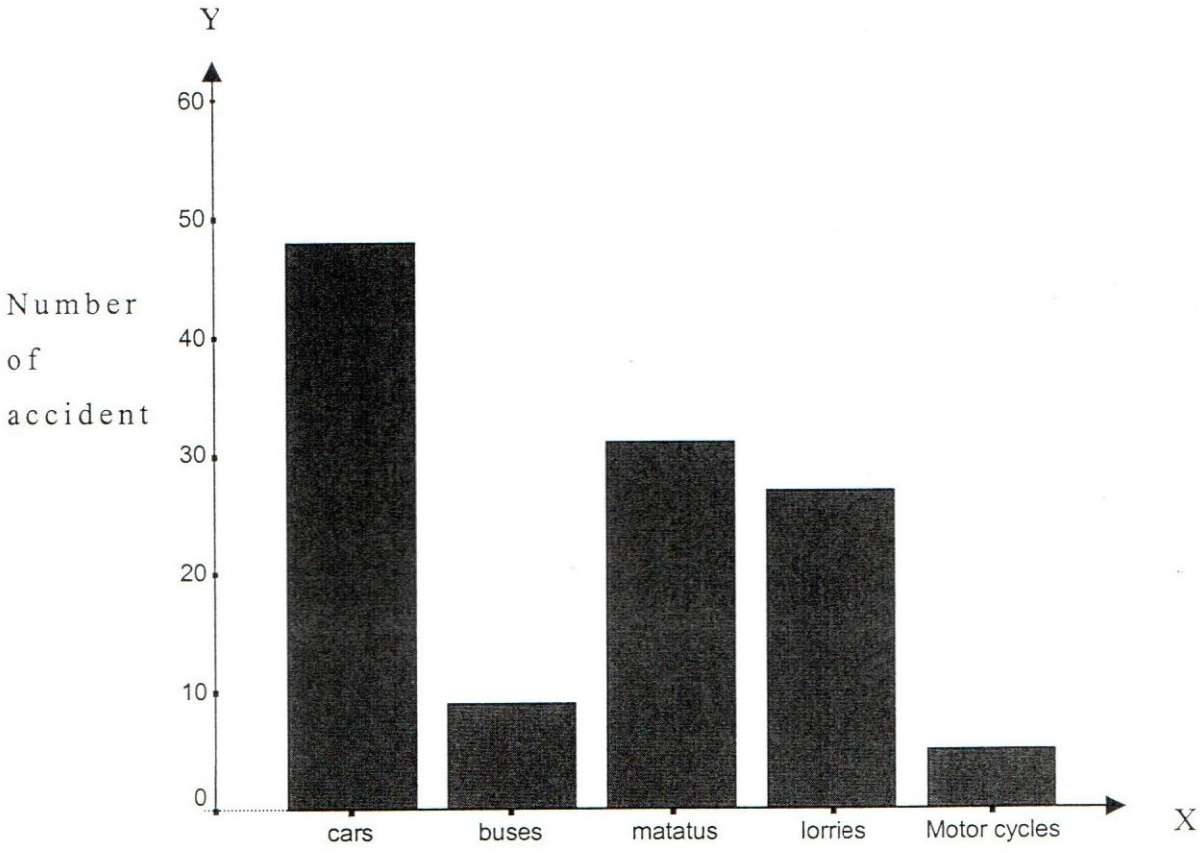
Type of vehicle	Cars	Buses	Matatus	Lorries	Motor cycles
Number of accidents	48	9	31	27	5

Draw a bar chart to represent this information.

Solution

The type of vehicles will be plotted on the x-axis while the number of accidents (frequency) will be on the y-axis. In this example, we need to come up with an appropriate scale to represent the frequency on the y-axis. This can be as the one used below.

Figure 4: A bar chart representing the number of accidents caused by different vehicles



Cars caused more accidents than any other vehicle.

(c) Histogram

The histogram is a series of columns or bars, each having as its base one interval and its height the number of observation or frequency in that interval. Two perpendicular lines (axes) – the horizontal and the vertical axes make the external boundaries of the histogram. This is known as the Cartesian plane in mathematics. The horizontal line represents the class interval and is called the abscissa or simply the x-axis while the vertical line represents the frequency and is called the ordinate or simply the y-axis.

Each column of the histogram is based on both the class interval and the relevant class frequency. The class interval corresponds to the width of each column whereas the class frequency determines the height of the column and is represented by a vertical line corresponding to the class frequency. This means that, the widths are marked on the abscissa and the frequency of each class interval is completed on the ordinate. The columns are centered on the midpoints of the class interval.

In other words, we mark off the class intervals on the abscissa using apparent class limits though sometimes true limits (class boundaries) are used. At the abscissa, various class intervals are joined to indicate the interval continuum. Therefore, in a histogram, a rectangular bar whose area is proportional to the frequency represents the frequency in each class. When the rectangular bars have equal widths, the height of the rectangle is proportional to the frequency. Thus, a histogram is a bar chart in which the area of each bar represents frequency except that in a bar chart, the frequency is represented by the length of each bar.

The procedure in constructing a histogram is that an appropriate scale should be selected. It is recommended to choose the scale that uses a greater proportion of the paper. To achieve this, the width of the histogram should be wide enough for readability. Whenever possible, the x-axis and the y-axis should intersect at the zero point. However for some data, this may yield an unusual looking data (skewed). As such, a small break (with a jagged line i.e. wavy or dotted) can be made on the axes; and then graduated according to the scale and/or demands of the data. Finally, a descriptive title, which states very clearly what is portrayed in the histogram, should be provided as heading.

Example

Draw a histogram to represent the statistics CAT scores given earlier in this module.

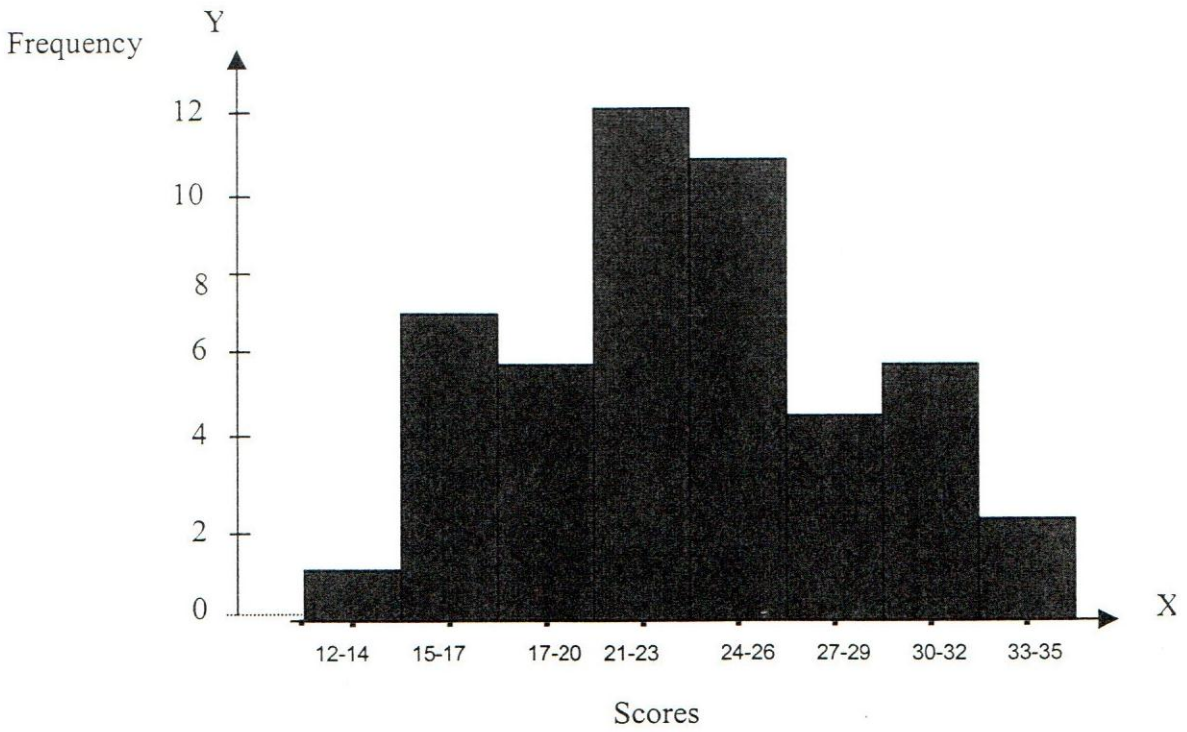
Solution

From the raw scores, the following grouped distribution was obtained.

Scores	12 – 14	15-17	17-20	21-23	24 - 26	27-29	30 – 32	33- 35
Frequency	1	6	5	10	9	4	5	2

A Histogram of statistics CAT scores is presented below.

Figure 5: A histogram representing statistics CAT scores



(d) Frequency polygon

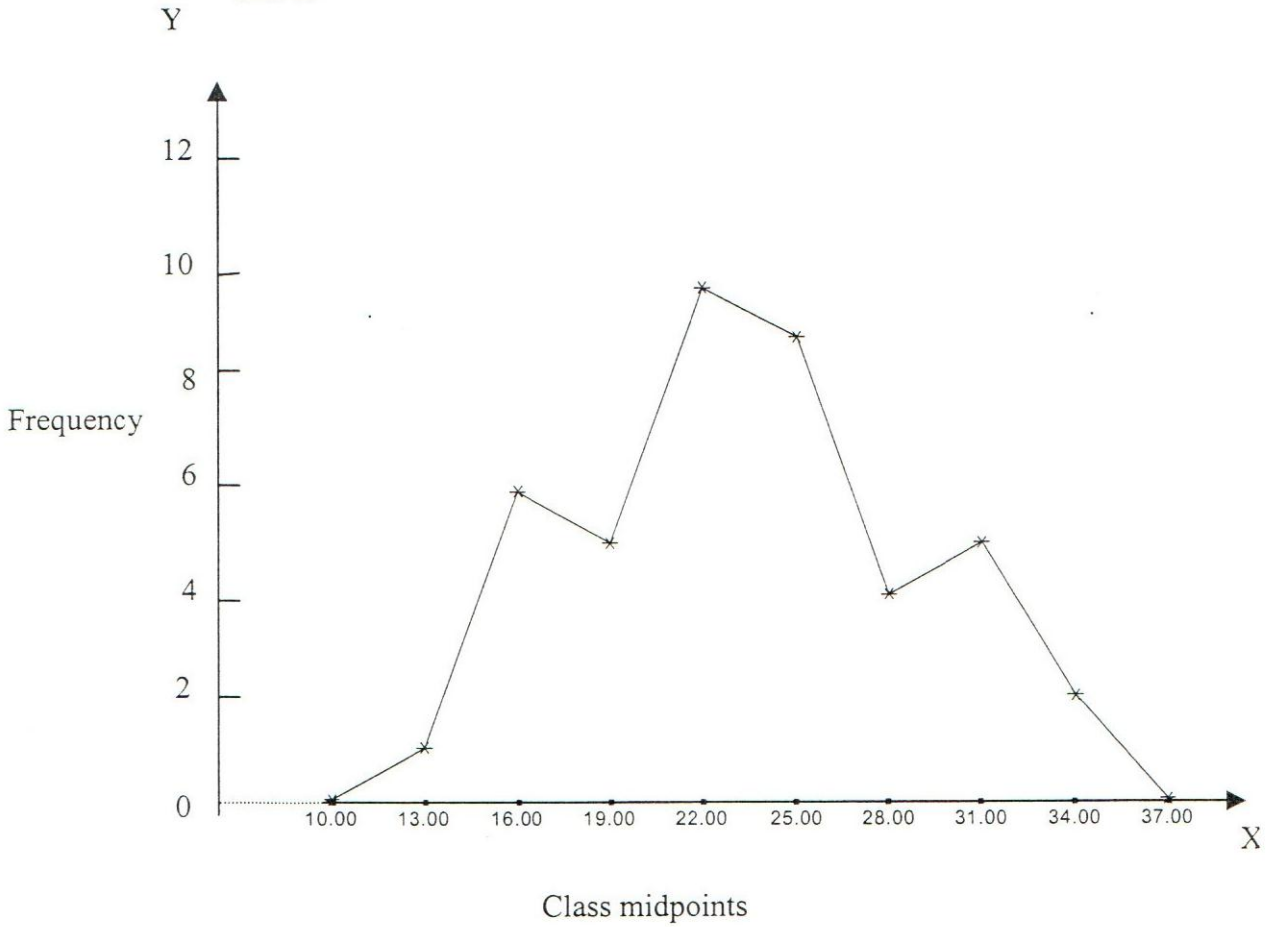
This is similar to a line graph you learnt earlier in lower classes. However, in constructing a frequency polygon, the same procedure as that in the histogram is used except that instead of erecting a column, a point is located above the mid point to each interval and at the proper height to represent the frequency in that class. Thus we use the midpoints of the class intervals and their frequencies to plot the frequency polygon. A straight line that is extended down to the x-axis one class below and one class above joins these points. When this is done, the resulting graph is called a *frequency polygon*.

Example
Draw a frequency polygon to represent the grouped statistics CAT scores discussed earlier.

Solution
The following grouped frequency table was obtained.

Scores	12 – 14	15-17	17-20	21-23	24 - 26	27-29	30 – 32	33- 35
Frequency	1	6	5	10	9	4	5	2
Mid point	13	16	18	20	25	28	31	34

Figure 6: A frequency polygon representing statistics of a continuous assessment test scores

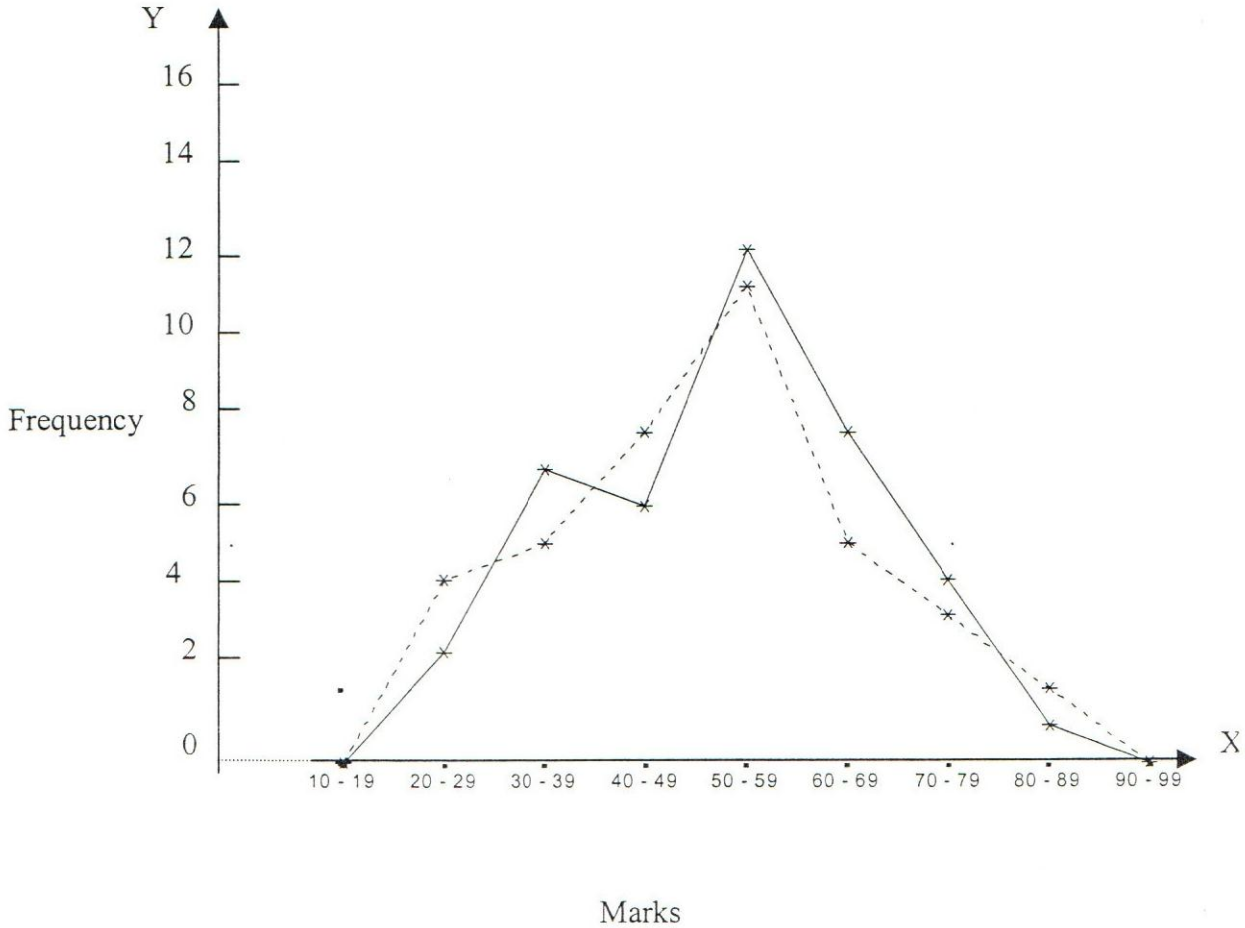


Note 1. Both the histogram and the frequency polygon discussed here represent the same data only that the data is treated in two different ways. One is based on discrete data i.e. whole number as in the histogram and the other is based on a continuos data i.e. traction data as in the frequency polygon.

2. More than one frequency polygon can be drawn on the same Cartesian plane (axes) for purposes of comparison. For example in an examination the marks in Kiswahili and English were grouped as given in the table.

Marks		20-29	30 - 39	40 – 49	50 - 59	60 - 69	70 - 79	80 - 89
Frequency	Eng	5	6	9	13	6	4	2
	Kisw	3	8	7	14	9	5	1

Figure: 7 Frequency polygon representing marks in Kiswahili and English



APPENDIX B

STUDENT PERCEPTION QUESTIONNAIRE (SPQ)

ADM.NO._____SCHOOL_____FORM_____GENDER_____AGE____

We are interested to know about what you perceive about the topic statistics.

INSTRUCTIONS:

1. This is not a test and there are no ***correct or wrong*** answers.
2. It is important that you give your ***honest*** view.
3. Read the items ***carefully and understand*** before choosing what truly reflects your perception of the learning environment during statistics lessons in mathematics.
4. ***Circle*** around the letter choice that corresponds with your view of learning in this topic.
5. The letter ***choices*** are: *A= Always, S= Sometimes, H= Hardly, N= Never, U= Uncertain.*

QUESTIONS:

1. We were encouraged to ask questions in class	A S H N U
2. The teacher praised us for good work	A S H N U
3. The teacher used examples to explain symbols and terminology	A S H N U
4. Our teacher paid more attention to girls than boys	A S H N U
5. We could solve problems from textbooks and past papers	A S H N U
6. Questions were given and discussed in groups	A S H N U
7. Mathematical symbols and terminology discussed were clear	A S H N U
8. We expressed ourselves mathematically during discussions	A S H N U
9. Boys had more opportunity in class discussion than girls	A S H N U
10. We worked in groups	A S H N U
11. We copied notes during mathematics lessons	A S H N U
12. We solved mathematical problems individually	A S H N U
13. Everyone was expected to participate in the group work	A S H N U
14. We understood mathematical symbols and terminology	A S H N U
15. Boys received more individual help than girls	A S H N U
16. We depended on each other more than the teacher	A S H N U
17. Ideas were tested and solved individually in class	A S H N U
18. Students were friendly and worked together as a team in class	A S H N U
19. We competed against each other in class	A S H N U
20. We had enough time to finish our work	A S H N U

APPENDIX C

TEACHERS' EVALUATION QUESTIONNAIRE (TEQ)

We are interested to know your feeling, views and opinion about the SML module for teaching and learning statistics.

INSTRUCTIONS:

1. This is not a test and there are no **right** or **wrong** answers.
2. It is important that you tell us your **honest** feeling, view and opinion.
3. Read the items **carefully** and **understand** before choosing what **truly** reflects your feeling, view and/or opinion in each case.
4. **Circle** around the letter(s) that corresponds to your choice
5. The letter **choices** are SA= Strongly Agree, A= Agree, D= Disagree, SD= Strongly Disagree and U= Undecided.

QUESTIONS:

1. The SML lessons were understandable	SA A D SD U
2. The SML lessons were dull	SA A D SD U
3. The SML lessons were friendly	SA A D SD U
4. The SML lessons were useful	SA A D SD U
5. The SML lessons were meaningless	SA A D SD U
6. The SML lessons were unimportant	SA A D SD U
7. The SML lessons were difficult	SA A D SD U
8. The SML lessons were useless	SA A D SD U
9. The SML lessons were important	SA A D SD U
10. I was uncomfortable with the SML lessons	SA A D SD U
11. I like the mathematics lessons taught without the use of the new approach	SA A D SD U
12. Mathematical symbols and terminology discussed were clear	SA A D SD U
13. Students actively participated during the SML lessons	SA A D SD U
14. Girls received more individual help than boys	SA A D SD U
15. I like the mathematics lessons taught with the use of the new approach	SA A D SD U
16. Students were friendly and worked as a team	SA A D SD U
17. Sufficient exercises were given in the SML lessons	SA A D SD U
18. Students could solve problems from textbooks and past papers	SA A D SD U
19. Students worked in groups	SA A D SD U
20. The SML lessons were adequate in content	SA A D SD U
21. Boys were more active than girls	SA A D SD U
22. Students competed against each other in class	SA A D SD U
23. Students had enough time to finish the exercises	SA A D SD U
24. Concepts were adequately explained in SML lessons	SA A D SD U
25. Students were motivated to ask questions and/or answer questions in class	SA A D SD U

APPENDIX D

MATHEMATICS CLASSROOM OBSERVATION SCHEDULE (MACOS)

SCHOOL_____ **LESSON**_____**DATE**_____ **TIME**_____

(A) TEACHER ACTIVITY	TALLY
1. Reinforces appropriate responses : praise, nodding head or saying go on etc	
2. Giving orders, directions or commands which students are expected to comply.	
3. Goes round to insure students are proceeding well with a given activity	
4. Asks questions about the content or procedure based on students ideas	
5. Guides or demonstrates how to perform a procedure or skill	
6. Explains or lectures giving opinion	
(B) STUDENT ACTIVITY	
1. responds to teacher questions	
2. follows instructions to perform, interpret, analyse, describe and explain data correctly	
3. Initiates classroom talk to make suggestions, express an idea and develop opinion	
4. Asks questions or seek clarity over ideas presented or skill performance	
5. Writes or copies from the book, chalkboard etc	
6. Expresses agreement or disagreement with, action etc	
7. Pauses or short periods of silence/inactivity/performance activity	
8. Consults other students	

APPENDIX E

MATHEMATICS ACHIEVEMENT TEST (MAT)

ADM. NO._____ SCHOOL_____ FORM_____ GENDER_____ AGE_____

INSTRUCTTIONS

1. Answer **all** questions.
2. Take your time **but** do not spend too much time on one question.
3. This paper contains two sections: **Section A** and **Section B**.
4. Section A contains **15** multiple choice questions with **three** choices, only **one** is the correct answer. **Circle** your choice.
5. Section B contains **5** unstructured questions. Show all your **workings clearly** in the space provided after each question.

SECTION A

1. The symbol Σ stands for
   (a) Mean (b) Sigma (c) Sum of

2. Which one of the following best describes the mode
   (a)The number that appears more than others (b) The most common number
   (c)The number with the highest frequency

3. The mean is also referred to as
   (a) Arithmetic mean (b) Average mean (c) calculated mean

4. Which one the following is not a measure of central tendency
   (a) Average (b) Mode (c) statistics

5. Data can be presented in the following ways except
   (a) Graphs (b) Frequencies (c) charts

6. The class limits for a class of 40-44 are
   (a) 40 and 44 (b) 39.5 and 44.5 (c) 39.5 to 44.5

7. The difference between the class boundaries is called
   (a) class interval (b) class size (c) class limits

8. A graph in which the frequency plotted against the midpoints of the classes is called
   (a) Bar graph (b) frequency polygons (c) Histogram

9. The formula ½ (n+1) is used to
   (a) determine the median when n is odd (b) determine the median when n is even
   (c) determine the number of classes for grouped data

10. The difference between the highest and the lowest values in a set of data is called
    (a) range (b) class size (c) mid-point

11. Which of the following is not an aspect of statistics
(a) collection of data (b) interpretation of data (c) calculation of data

12. Nine people had the following numbers of coins in their pockets; 4,8,10,8,10,5,5,10. Which of the following represents their mean mode and median.
(a) 7,10.8 (b) 7,8,10 (c) 10,8,7

13. Data collected and recorded as it occurred is known as
(a) raw data (b) primary data (c) secondary data

14. The difference between X and $\overline{X}$ is called
(a) class (b) range (c) deviation

15. In grouped data, the calculated measure of central tendency is always
(a) actual (b) estimated (c) not real

SECTION B

16. A test was given to 40 form two students and the following results were attained.
4 scored grade A, 12 scored grade B, 17 scored grade C, 6 scored below grade C
(a) show the above information on a piechart
(b) What percentage represented those students with at least grade B.

17. The number of students present in a certain class for a fortnight were:
43 38 39 37 33 31 32
38 36 41 34 29 35 27
Using classes of 25-29, 30-34,..., make a frequency distribution table and from it;
(a) find the modal class (b) estimate the mean and the median.

18. Forty five pupils in mixed class sat for a test. The mean mark for 25 girls in this class was 55.5 while the mean mark for all the pupils was 60.5. Calculate the mean mark for boys

19. Use the table below to answer the questions that follows

Class	30-34	35-39	40-44	45-49	50-54	55-59	60-64	68-68	70-74
Frequency	5	8	6	7	10	3	5	3	3

a) On the same axes, draw a histogram and a frequency polygon to represent the above information.
b) If the pass mark was 44.5, what percentage of students failed.

20. The number of vehicles passing through a check point was recorded for 20 days as follows.-
670,840,560,674,589,651,496,645,653,605,673,710,702,317,681,627,731,668,726.
Find the mean number of vehicles passing through this check point per day.

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