SEX DIFFERENCES : A STUDY OF SOME FACTORS INVOLVED IN THE LEARNING OF MATHEMATICS AMONG SECONDARY FORM III STUDENTS IN KENYA

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OF MASTER OF EDUCATION

BY

T. OMAR SHEIKH

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DECLARATION

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

G.O. Sheikh

T. Omar Sheikh

"This thesis has been submitted for examination with my approval as university supervisor."

G. S. Eshiwani

Dr. G.S. Eshiwani,

Senior Lecturer,

Mathematics Education.

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LIST OF ABBREVIATIONS

1.	S.M.E.A. :	School Mathematics of East Africa. Refers to the texts being currently followed for the 'modern' mathematics syllabus S in secondary schools in Kenya.
2.	C.P.E. :	Certificate of Primary Education. Awarded after examinations at the end of seven years of primary schooling.
3.	E.A.C.E. :	East African Certificate of Education. Awarded after examinations at the end of the first four years of secondary schooling.
4.	E.A.A.C.E: or H.S.C.	East African Advanced Certificate of Education or formerly the "Higher School Certificate". Awarded after two years of schooling after E.A.C.E.
5.	Coed. :	Coeducation or coeducational.
6.	Maths.:	Mathematics.
7.	Educ.:	Education or educational.
8.	I.Q. :	Intelligence Quotient.
9.	Exam.:	Examination.
10.	Approx.: or $\simeq$	Approximately.
11.	d :	Often appears in Tables. Should be taken to mean 'difference between means'
12.	S.D.:	Standard Deviation. Appears most frequently in tables.
13.	t :	Appears often in tables. Refers to student's t - statistic.
14.	p :	Appears often in Tables. Refers to level of significance.

CHAPTER ONE

1.0. Introduction

The foundation stones in the fields of technical and professional education lie in a sound background knowledge of mathematics. In the system of education in Kenya an analysis of the enrolment rates or of the number of applications for admission into mathematics classes or mathematically oriented courses, especially in the higher institutions of learning, will reveal a big discrepancy in the numbers for boys and girls. The percentage of girls in Kenya who study mathematics after Form Four shows a remarkable and drastic drop while the study of mathematics tends to be a predominantly male activity at the University levels. That girls do not choose to study mathematics for examination courses is a fact. That they do not do so because of lower intellectual ability is a claim very difficult to accept. Assuming that there is no sex difference in the innate capacity for learning mathematics it is difficult to explain the scarcity of women mathematicians and mathematics teachers, women engineers and scientists in Kenya. In these circumstances mathematics educators, curriculum development and examination bodies often turn out to be the scape attack by concerned parents and other members of the society. The possibility that factors other than those under the control of teachers curriculum designers and examination bodies play a major role in the decision by girls to discontinue further study of mathematics cannot be totally ignored and need further exploration. Thus for example, the very nature of the structure of the educational system in Kenya, with its large number of unisex schools could promote towards differentiation of curricula for boys and girls making it possible for girls' schools to avoid pure science subjects and offer only Domestic science subjects such as needlework and cookery. This study was an attempt to identify some of the factors which are likely to influence decisions by girls and boys to continue further study of mathematics and which are likely to affect their achievement in mathematics. It is expected to make suggestions to enable girls and boys to realize their mathematical potential so that each sex and particularly the girls play an active role in the economic development of the Nation especially in the fields of engineering, technology, industry, commerce and science.

1.1. Significance of the Problem

The significance and need for a study of this nature becomes apparent when we study the enrolment figures at the highest institution of learning in Kenya, the University of Nairobi. Table 1 gives the breakdown of students at the university in various faculties by sex.

Table 1: Enrolment figure[1] at the University of Nairobi by faculties and sex, 1975/1976.

Faculty	Number of Women	Number of Men	Total	% age of Women
Agriculture	33	163	186	17.74
Medicine	73	360	433	16.86
Science	34	316	350	9.71
Arts	157	383	340	29.07
Vet. Medicine	22	269	291	7.56
Education	276	686	961	29.72
Commerce	40	381	421	9.50
Law	36	147	183	19.67
Engineering (Mech. & Elec.)	4	499	503	0.79
Architecture (Design & Dev)	27	14	41	65.85
Architecture (Land & Buildg. Economics)	9	195	204	4.41
Architecture (Bach. of Arch.)	1	134	135	0.74
School of Journalism	2	29	31	0.61 6.1%
Totals	714	3566	4279	16.76

Note 1: Figures for Medicine in table 1 include enrolments for the recently opened pharmacy and dentistry departments, which therefore have students in the first and second years only. All other figures include students in every year of study.

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1. Source of figures is the Nominal Roll for 1975/1976, University of Nairobi.

Whereas women hold their own when total percent enrolment is taken into consideration (16.76%) in the faculties of agriculture, medicine, arts, education, law and architecture (Design and Development) they are grossly under-represented in veterinary medicine, commerce, engineering and Architecture (land and building economics and for the Bachelor of Architecture degree). The special case of the science and education faculties will be considered in details shortly. One is immediately struck by the fact that the second group of faculties (with the exception of Veterinary Medicine) have a principal level pass in mathematics at A levels as one of their entrance requirements. The implications of this are obvious. Either not enough girls attain an A level pass in mathematics to satisfy the rigid minimum entrance requirements for admission into these faculties or else women deliberately choose to keep their distance from those faculties although they have the necessary qualifications and are equally eligible for admission as their male counterparts. A special case of interest is the faculty of Architecture, in which the only department not requiring a principal level pass in mathematics is the department of Design and Development. In this department the female participation rate shoots up to an astonishing 65.85 percent, while in the same faculty but the department of Land and Building Economics and for the Bachelor of Architecture, which strictly need an A level pass in mathematics for entry, female participation rates are at the meagre 4.41 and 0.74 per cent levels.

The enrolment figures for the faculties of education and science show the striking contrasts between the subject preferences of males and females. Table II gives the numbers and percentages of males and females enrolled for "Arts" and "Science" subjects, in the Faculty of Education[2]

Table II: Distribution of men and women in the B. Ed. "Arts" and "Science" Groups, 1975/1976.

GROUP	MEN	%age of Men.	WOMEN	%age of Women.
Arts	526	76.68	245	88.77
Science	160	23.32	31	11.23
Totals	686	100.00	276	100.00

2. The "Arts" group of subjects includes English, Kiswahili, History, Geography, Literature and Religious Education. The Science group includes Mathematics, Physics, Chemistry, Biology and Economics.

Table II shows that while the percentages of men and women who take Arts subjects is almost the same (77% and 89% respectively) more than twice as many men take science subjects as women (23% and 11% respectively). A further breakdown of student enrolment for the science and arts groups by year of study is given in Table III.

Table III: Distribution of men and women in the arts and science groups by year of study in the Faculty of Education, 1975/1976.

Year of study	SCIENCE				ARTS			
	Men	Women	Total	%age women.	Men	Women	Total	%age women.
First Year	60	12	72	16.67	65	58	123	47.15
Second Year	55	10	65	15.39	196	114	310	36.77
Third Year	45	9	54	16.67	265	73	388	21.60

One interesting fact emerges from Table III. Over the three years under consideration (i.e. 1973, 1974 and 1975) the percentage of men and women has remained almost constant in the science group (about 84% and 16% respectively). Corresponding figures for enrolment in the Arts groups show a steady increase over the three years period for women (from 21.60% in 1973 to 47.15% in 1975) while the percentage of men in the Bachelor of Education Arts group shows a steady decline (from 78.40% in 1973 to 52.85% in 1975).

This analysis would be incomplete without considering the actual subject choices made by each of the sexes. This is complicated by the fact that each student takes two teaching subjects. A comparison between the sexes who are taking mathematics as one of their subjects may be made by examining Table IV.

Table IV: Number and percentage (in brackets) of men and women taking mathematics as one of their subjects in the Faculty of Education, 1976.

Subject Combination	Men	(%)	Women	(%)
Maths/Geography	27	(16)	1	(3)
Maths/Chemistry	21	(13)	6	(19)
Maths/Geology	1	(1)	0	(0)
Maths/Botany	2	(1)	1	(3)
Maths/Economics	14	(9)	1	(3)
Maths/Physics	35	(21)	1	(3)
Total	100	(61)	10	(31)

In view of the fact that the Faculty of Education has been the only source of graduate teachers up to 1974, it is not difficult to explain the scarcity of women graduate teachers in mathematics[3]. As Table IV shows only ten women graduate teachers in mathematics will be turned out over the next three years i.e. 1976, 1977, and 1978. The corresponding figure for men is 100. The proportion of men who take mathematics as one of their subjects is twice that for women. In the first and second years of the Bachelor of Education course, 73% of the women were in the Botany/Zoology group. The corresponding figures for men is 43%. Figures for the third year are not available as students were being prepared for Biology and not the Botany/Zoology combination.

An examination of the participation rates by subjects in the faculty of Science gives further support to the contention that mathematics at the University level is a predominantly male subject of study. In the second and third years not a single girl student could be traced who had taken mathematics as one of her major subjects. Again the majority tend to specialize in the biological sciences i.e. Botany/Zoology and Chemistry. Of the 30 girls registered in this faculty in the first, second and third years (1974/75) only 4 had obtained a principal level pass in mathematics, while two attained a subsidiary level pass. Compared to this exactly 100 men students (51%) attained a principal level pass, while 16 got a subsidiary level pass.

To gain further insight into the nature and significance of the problem the researcher delved into the Ministry of Education[4], summary of results for EACE, 1974. As a study of this enormous document for all the subjects being taken by all the schools in Kenya was beyond the scope of the present study,

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4. Summary of results for E.A.C.E. for schools in Kenya, Ministry of Education, 1974.

figures for results in mathematics and English for government aided schools of Nairobi province were analysed. Interesting and consistent patterns of sex differences in achievement in mathematics were observed. For ease of comparison results were categorised into four subdivisions namely, "Distinction", "Credit", "Pass" and "Fail". At the time of the study two mathematics syllabi were being followed in schools in Kenya. These were the traditional mathematics syllabus T, and the more recently introduced modern mathematics syllabus S. The tables which follow (Tables V, VI, and VII) present the number of candidates in each of the four categories of grades.

Table V: Distribution of pupils from Government Maintained Schools[1] in Nairobi, by categories of grades and sex in the E.A.C.E. English examination, syllabus 112, 1974.

Sex	Distinction	Credit	Pass	Fail	Total
Boys	144 (9.65%)	678 (45 44%)	456 (30.56%)	234 (15.68%)	1492
Girls	80 (9.88%)	342 (42.22%)	265 (32.72%)	234 (16.54%)	810

Note1: Government aided schools are partly supported by the Central Government and often a substantial proportion of finances for these schools is raised by private bodies, communities or self help schemes. On the other hand government maintained schools are fully supported, both financially as well as materially by the government which also pays the salaries for the teachers in the schools. A third group of schools in Kenya is the large number of "Private" schools. These are run entirely by individuals or independent bodies. Student fees are usually the only source of finance for running these schools.

Table VI: Distribution of pupils from government maintained schools in Nairobi, by categories of grades and sex in the E.A.C.E. mathematics examination, syllabus S.

Sex	Distinction Over 65%	Credit	Pass	Fail Under 40%	Total
Boys	76 (10.90%)	219 (31.42%)	153 (21.95%)	249 (35.72%)	697
Girls	31 (7.17%)	116 (26.85%)	75 (17.36%)	210 (48.60%)	432

From Table V it is evident that in the East African Certificate of Education English examination girls do just as well as boys, as none of the differences for any of the categories is significant at 5% or 1% levels. On the other hand, in every category of grades except the 'fail' category boys perform better than girls in both the traditional as well as the modern mathematics syllabi. Thus in the modern mathematics syllabus, almost half the girls (49%) failed as compared to 36% of the boys. In the traditional mathematics syllabus 64% of the girls in Nairobi failed as compared to 47% of the boys.

Table VII: Distribution of pupils from government maintained schools in Nairobi by categories of grades and sex in the E.AC.E. mathematics examination, syllabus T.

Sex	Distinction Over 65%	Credit	Pass	Fail Under 40%	Total
Boys	79	179	121	339	718
	(11.00)	(24.93)	(16.85)	(47.21)	
Girls	34	58	47	244	383
	(8.88)	(15.14)	(12.27)	(63.70)	

Figures in braces represent percentages in each sex attaining that grade.

The Z - test was used to test for significance of differences between the proportions of boys and girls in each grade category for English, traditional mathematics and modern mathematics. Table VIII presents the calculated Z - values.

Table VIII: Z - values for test of significance of differences between the proportion of boys and girls in each category of grades.

Subject	Distinction	Credit	Pass	Fail
English	0.015	0.91	0.28	0.18
Mathematics (Traditional)	0.32	0.51	0.81	4.05*
Mathematics (Modern)	0.49	0.77	0.53	3.93*

* Significant at the .05 level.

Thus we find that none of the differences between the proportions of boys and girls in any grade category were significant in English. However in both traditional and the new mathematics the proportions of girls and boys in the "fail" grade category differ significantly at the .01 level of significance. This means that significantly more girls failed the traditional and new mathematics examinations than boys.

The main points that emerge from the above are; 1. The study of mathematics at the University levels is dominated mainly by males. 2. Females are either grossly under-represented or not represented at all in courses which rely on a strong background of mathematics. 3. There are significantly more failures in mathematics among girls at the E.A.C.E. levels in the government aided schools in Nairobi. The proportions of boys attaining Distinctions, Credits and passes in the E.A.C.E. examinations in mathematics for 1974, is greater than that of girls. 4. Further evidence for Nyanza province[5], shows that the performance of boys in the E.A.C.E. as well as the E.A.A.C.E. examinations in mathematics is superior to that of girls. Further only one school in this province offered mathematics at A levels to its girls.

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5. Summary of facilities, courses and statistical information, Nyanza Provincial Education Office, Kisumu.

1.2. Statement of the Problem.

A whole series of pertinent questions arise from the discussion in section 1.0. Some of these are as follows;

Why do girls shy away from mathematics and subjects needing further study of mathematics at the University and high school levels? What courses or professions do girl students who do very well in mathematics at E.A.C.E. enter after secondary schooling? Or put in a more convenient and easy-to-test format; What are the educational and vocational aspirations of girls who do very well in mathematics examinations and in what ways do these aspirations differ from those of boys? Why are there more failures among girls in mathematics at school certificate level? What is the part played by society, culture, home background, methods of instruction etc. in contributing towards differential attainment in mathematics by the sexes? Are there sex differences in attitudes towards mathematics? If so, is performance in mathematics related to attitudes towards mathematics? Are there particular content areas in mathematics which girls and/or boys find very difficult? What specific mathematical abilities are called for in areas of mathematics which girls and/or boys find particularly difficult? What is the role of intrinsic factors such as motivation, personality and innate ability in producing differences between the achievement of boys and girls in mathematics. What part does the superior verbal ability of girls as shown by Eshiwani's[6], study in Kenya play in putting girls away from mathematics, which uses symbols etc. to express abstract ideas in as few words as possible?

1.3. Limitations of This Study.

1.31. Limitations on the Number of Variables to be Examined.

From the discussion in paragraph 1.2 it is evident that possible explanations for the existence of differences between the sexes on achievement and attitudes towards mathematics are many and diverse. Some of these factors, whether extrinsic or intrinsic to the child will not only affect his performance in mathematics but also his overall achievement in the subjects that he is taking, as well as his attitudes towards school, towards his teachers and towards society as a whole. Thus a study of the likely causes of sex differences in mathematics must, by its very nature, be severely restricted to an examination of a very few factors leaving out many equally important and crucial variables. One of these variables is the innate potential, often labelled Intelligence Quotient of the pupils, for which no satisfactory measuring instruments exist for Kenyan Pupils. Personality variables are recieving increasing

6. Eshiwani, G.S., 'Sex differences in the learning of mathematics. Maths. Educ. Report No. 3, Univ. of Nairobi, Aug. 1974, page 13.

attention of researchers in the West. However, due to difficulties in measuring personality variables for Kenyan children, it was not possible to test for differences between the sexes on various personality traits. The only exception was motivation, for which a test was constructed. Thus this study will be restricted to an examination of a few measurable traits for which measuring instruments already exist or can easily be constructed from those used in the West, such as attitude scales, cloze tests for reading ability etc.

1.32: Limitations on the Choice of the Research Sample

Research in the U.S.A. has shown that during the elementary school years sex differences in performance on achievement tests in mathematics are rarely found, while during the high school years and later on in college, differences if found are usually in favour of boys. Assuming this to be equally true for Kenyan school children we could expect sex differences to begin to appear at the end of the primary school and possibly for the gap in the achievement scores to widen as we move up the secondary school ladder. Hence what is necessary in this case is a longitudinal study in which sex differences are examined in relation to age. This study will be restricted to Secondary School Form III pupils only for the following reasons: 1) Studies have already been conducted using pupils in Form I and Form II. Thus Parkar's study (23,1974) used Form I pupils and Eshiwani's study (10,1974) used Form II pupils for their research sample. 2) Form III pupils had covered more than half of the SMEA syllabus and could thus be tested over a wide cross-section of this syllabus. and 3) Pupils of Form III had no major examinations immediately prior to or after the study which would affect performance. This was necessary to keep the sample to an appropriate size and maintain control over the data processing. Further, limited resources along with the need to test different aspects of achievement in mathematics precluded the gathering of information from very large samples.

1.33: Limitations on the Choice of Content Areas of S.M.E.A.

The research sample in this study was made up of pupils who had just entered the third form of secondary school, and it was necessary to examine only those content areas of S.M.E.A. books which had been covered by the pupils in school. With the exception of one or two classes, which had had no mathematics teachers for a term or so, all the schools had covered the first two books of S.M.E.A. and some of the classes had moved well into Book Three. The choice of topics was thus restricted to the content of S.M.E.A. Books One and Two. Secondly no attempt was made to include pupils following the traditional mathematics syllabus as this would have meant constructing a different set of achievement tests spanning topics of syllabus T. Besides, syllabus T is in its last phases of being abolished. All schools in Kenya will have switched over to the new mathematics syllabus by 1978. The majority of the schools in Nairobi have already switched to the syllabus S.

1.34: Restrictions on the Choice of Secondary Schools

Due to financial constraints all the schools used in this study were drawn from schools in and around Nairobi. No attempt was made to include schools from rural areas of Kenya although this would have enabled valuable Urban-Rural comparisons to be made, valuable in the sense that the effect of strong family ties, cultural and traditional values (which are highly esteemed in the rural areas) on sex differences on achievement in mathematics can be assessed.

One further natural restriction was in the choice of the coeducational schools, of which only one was used in this study. This is due to the fact that practically all the schools maintained by the government are single sex schools. In all, there were two[7] government maintained secondary schools with pupils from both sexes. One of these had been used for the Pilot Study, leaving the other which was used in the main study.

Lastly, some of the single sex schools, although satisfying all other criteria for selection in this study had to be left out due to pupils following traditional or modern mathematics syllabi within the same schools. Thus for example, in one girls school, girls in the same class would split up for mathematics lessons, one group going for modern mathematics lessons while the other went for traditional mathematics lessons.

1.4: Research Questions

In the statement of the problem (section 1.2, page 13) a series of questions concerning differences between the sexes were raised. In section 1.3 some of the limitations of this study were focused upon. In view of these restrictions the large number of questions raised earlier were narrowed down to five specific research questions. This helped to clarify

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7. Besides these two we have the Kenya Polytechnic, which accepts pupils of both sexes, and a large number of coeducational unaided schools.

the different issues involved and pinpoint the variables to be the focus of this study. The first two of the questions are;

1. Are there specific content areas in mathematics in which the performance of girls and boys is found to differ significantly?

2. What are the particular cognitive levels at which the performance of girls and boys differs significantly?

Answers to these questions would enable the researcher not only to identify the various content areas in which significant differences between the sexes exist but would also indicate the levels in a topic at which pupils begin to experience difficulties. It was decided to construct achievement tests so as to include items at four cognitive levels as proposed by Bloom[8], and at the same time try to span as wide a spectrum of topics covered in the first and second forms in mathematics. These items were designed so as to make specific demands on the pupils, for example, recall facts or terminology or carry out simple straightforward calculations. This would have made it possible to locate specific mathematical abilities at which girls or boys are weak as evident from their performance on the item.

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8. Bloom, B.S., Hastings, J.T., Madans, G.F., Handbook on Formative and Summative Evaluation of student learning, N.Y., McGraw Hills, 1971.

The remaining questions follow;

3. Are there differences in the reading abilities of boys and girls of Form Three? If so, are reading ability scores of boys and girls significantly related to their mathematics achievement scores?

4.i(a) Are there differences between Form Three boys and girls in their attitudes towards mathematics?

(b) Do girls differ from boys in their enjoyment of mathematics?

(c) Do girls and boys value mathematics equally?

(d) Do boys' and girls' scores on motivation scales in mathematics differ significantly?

(e) Do girls and boys differ in their educational and vocational aspirations?

ii. What part is played by the variables (a) to (e) above in bringing about differences in achievement in mathematics.

5. What part of the total variances in the scores on the mathematics achievement tests can be attributed to sex differences? A question related to this is;

Will sex differences in mathematics achievement be greater in coeducational schools or in single sex schools?

Significance of the Choice of the Independent Variables

The dependent variable in this study was mathematics achievement; this was measured at four cognitive levels using achievement tests, a score being obtained for each student at each of the four levels.

The independent variables in this study were reading ability, attitudes towards mathematics, educational and vocational aspirations, sex of pupils and motivation in mathematics. The attitudes towards mathematics scale had three subscales namely, enjoyment of mathematics subscale, value of mathematics subscale and difficulty of learning mathematics subscale.

Research carried out in the West has shown girls to be superior to boys on verbal ability. For example, an extensive review by Maccoby[9], showed that up to the elementary school years verbal differences are slight but after the ages of ten and eleven years girls begin to outscore boys at different verbal skills. This study attempted to find out if this was true of Kenyan secondary Form Three pupils. This variable can be regarded as important in that much of the "modern" mathematics introduced in Kenya in the sixties relies heavily on the use of symbols, notations and abbreviations in expressing mathematical ideas as briefly as possible. Does this excessive use of symbols put girls at a special disadvantage and make them concentrate their efforts on subjects like literature, art and languages where maximum use of words, phrases etc. is made to express ideas clearly and unambiguously. If this turns out to be the case then the possibility of presenting girls with mathematical content in a higly verbal form needs to be explored.

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9. Maccoby, E.E. and Jacklin, C.N., The psychology of sex differences; California, Stanford University Press, 1974.

Again research in the West has pointed out the importance of attitudes towards mathematics and its effect on the performance of students in school. For example, Husen[10], found mathematical ability significantly related to attitudes and the higher the ability the more favourable was the attitude to school. He also found that girls had more favourable attitudes towards the school teacher and towards school work. Hence the importance of attitudes towards mathematics should not be overlooked for Kenyan pupils, and we can reasonably expect that students' feelings will have a strong effect upon the amount of work done, the number of hours of effort put in and the learning acquired in mathematics.

Motivation in mathematics was another of the independent variables chosen for study in this investigation. The importance of this variable for inclusion cannot be over-emphasized. Highly motivated pupils could be expected to persist in their tolerance of difficult problems in the texts and to double their efforts when faced with impending failure. On the other hand pupils who score low on the motivation scale may simply give up at the first sign of difficulty. This in turn will affect pupils' performance and learning of mathematics.

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10. Husen, T., International Study of Evaluation in Mathematics, VII, Stolkholm: Almquist and Wicksell, 1967, page 153.

Finally, what the students want to be when they grow up can be expected to affect pupils' attitudes towards mathematics and the number of hours they are willing to devote to the study of mathematics. If males aspire to professions requiring a good grade in mathematics in the final examinations for admission as in engineering, accountancy etc. extra efforts will be made to attain these grades. On the other hand if females aspire to professions in which proficiency in languages is essential as for example as secretaries and typists or as social workers, where the grade in mathematics may not be important, we can hardly expect girls to have a high regard for mathematics, except may be to get a good overall result. This naturally has its set-backs as the study of mathematics is not taken for its own sake but as a means to an end i.e. as an entry to a profession.

1.6. Purposes of the study.

Specifically this study was carried out to;

1. determine if sex differences exist among Kenyan students who have completed the first two years of secondary education in their performance on the content areas of S.M.E.A. Books One and Two.

2. determine if sex differences exist among Kenyan students who have completed the first two years of secondary education in their performance on items categorised into the following cognitive levels: Knowledge, Comprehension, Application and Analysis.

3. determine if sex differences exist in the reading

ability scores of Kenyan Form III pupils as determined by cloze tests constructed using passages randomly selected from S.M.E.A. Books One and Two.

4. determine if sex differences exist in

a) attitudes towards mathematics as determined by Aiken's 'E' and 'V' scales for enjoyment of mathematics and value of mathematics respectively, and by Husen's scale for the difficulty of learning mathematics[11 & 12].

b) motivation in mathematics as determined by the Entwistle - Nisbet Scale modified for use here.

5. determine if sex differences exist in the expression of vocational and educational aspirations of Form III pupils in Kenya.

6. determine to what extent the independent variables considered above are valid predictors of achievement in mathematics as a whole and at each of the cognitive levels.

Statement of the Hypotheses

The following hypotheses were tested in the study. The first four stated in null form are as follows;

1.(a) H_{o11} : There is no difference in the overall achievement scores of boys and girls of Form III in mathematics.

(b) H_{o12} : There is no difference between boys and girls of Form III on their achievement

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11. Aiken, L.R., Two scales of attitudes towards mathematics, Journal For Research in Mathematics Education. Volume 5 No. 2, March 1974.
12. Husen, T., Op Cit., Volume I, page 119.

test scores in mathematics at each of the following cognitive levels; Knowledge, Comprehension, application and Analysis.

c) H_{o13} : There is no difference between boys and girls of Form III on their achievement test scores in various content areas of School Mathematics of East Africa Books One and Two.

2. H_{o21} : There is no difference between the reading ability scores of boys and girls as determined by cloze tests constructed using a random selection of passages from S.M.E.A. Books One and Two.

3. H_{o31} : There is no difference between girls' and boys' scores on Aiken's E Scale on Enjoyment of Mathematics.

H_{o32} : There is no difference between girls' and boys' scores on Aiken's "V" Scale on Value of Mathematics.

H_{o33} : There is no difference between girls' and boys' scores on attitudes about difficulties of learning mathematics as determined by Husen's Scale.

H_{o34} : There is no difference between girls' and boys' scores on motivation in mathematics as determined by Entwistle-Nisbet scale as used in this study in its adapted form.

4. H_{o41} : There is no difference between the educational and vocational aspirations of boys and girls of Form III. The fifth hypothesis was concerned with prediction.

5. $H_{o}5l$: Cognitive level Abilities, Enjoyment of mathematics, value of mathematics, Difficulty experienced in learning mathematics, Motivation, Educational and Vocational aspirations of pupils, and the number of hours of work devoted to mathematics will not be good predictors of achievement in mathematics for boys and girls of Form III.

The alternative hypotheses to the first four are all similar, asserting that there is a significant difference between girls and boys on the variable under consideration. The alternative to the fifth hypothesis asserts that all the independent variables considered will be good predictors of achievement of boys and girls.

CHAPTER TWO

REVIEW OF LITERATURE

Introduction

This chapter will be devoted primarily to a review of the relevant literature on sex differences in achievement in mathematics and on verbal ability. The studies that have been reviewed in this chapter vary considerably in their depth of treatment. This is due to the fact that only twenty three of the studies as originally reported by the authors could be located. These include studies by Milton (1,1964), Singhal and Crago (2,1971), Hancock (3,1975), Foshay et. al.(4,1961), Rogers (5,1975), Jay and Schminke (6,1975), Dale (7,1962), King (8,1965), Wozencraft (9,1963), Eshiwani (10,1974), Labor (11,1974), Husen (12,1967), Maccoby (13,1972), Fennema (14,1974), Callahan (15,1971), Stafford (16,1972), Lambert (17,1960), Muscio (18,1962), Jarvis (19,1964), Aiken (20,1972), Hanna and Lenke (21, 1970), Pidgeon (22,1967) and Parkar (23,1974). In all these studies sex differences were examined in some area(s) of mathematics though a few of the studies often concerned themselves with other areas of cognitive functioning such as languages and other school subjects (e.g. Foshay et.al. (4,1961)). The majority of the studies listed here were conducted in western countries. The only studies located in an African setting were by Eshiwani (10,1974), using Kenyan pupils, and by Labor (11,1974) using students from Western Sierra Leone[13]. An attempt has been made by the researcher to present these twenty two studies in as much details as was possible. Besides these studies several other studies as originally reported in various journals were located but as the research samples used were often outside the secondary school age range they were left out. As a general rule studies involving pupils below grade six in elementary schools were excluded. Obvious exceptions to this are studies like Singhal and Crago's (2,1971) in which pupils from several grades were involved (in this particular case pupils from grade one up to grade eleven were involved). Besides these twenty two studies it was possible to examine the findings of many studies through secondary sources. Three textbooks were particularly useful for this purpose. These were 'Gender Differences' by Ounsted and Taylor (24,1974), 'The Psychology of Human Differences' by Tyler (25,1965) and 'Differential Psychology' by Anastasia (26,1958). Other secondary sources included reviews in the twenty three articles listed above. Although some of these reports were often lacking in details e.g. details of sample sizes, ages, tests used etc, it was decided to include them as they provided useful information and filled in the missing gaps which would have made the present review lacking and incomplete in many respects.

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13. A Study by Parkar, K.D. (23,1974) did not take sex as a major variable in his study, although Kenyan Secondary School pupils were used.

An outline of the major findings on the areas covered by the researchers will be given in the first section (section 2.1) of this chapter. The second section (section 2.2) will then provide a summary of the explanations extended by various authors for the existence of sex differences in mathematics and on verbal ability. A few major studies will be subjected to a thorough and exhaustive treatment in section 2.3 of this chapter. An attempt will be made at further interpretations and implications of the findings, discussion of the methodological problems and criticism of the research procedures. Finally the fourth section (2.4) will present a summary of the state of the art with a view to point out the direction of present trends of research on sex differences in mathematics. An attempt will be made to show how this study fits in with the present trends.

2.1. An Outline of the Findings of Research Studies on Sex Differences.

Research studies conducted in the West have shown that girls and boys differ from each other in a multitude of ways:- physically, psychologically as well as in some behavioural aspects and in certain areas of cognitive functioning. Hochschild[14], sums this up as follows;

14. Hochschild, A.R., "A Review of Sex Role Research" in Changing women in a changing society, Ed. by Joan Huber (Chicago and London: University of Chicago Press, 1973), p. 253.

"The sexes differ in the way they think (Maccoby, 1966) percieve (Bieri, et.al., 1958) aspire (Horner, 1968; Turner, 1964) experience anxiety (Sinnick, 1956) daydream (Singer, 1968) and play competitive games (Uesugi and Vinachke, 1963). (Men tend to have an exploitative strategy, women an accommodative one, which even wins some games)." Page 253.

Generally, females are found to be superior in manual dexterity i.e. swift and deft movements of the hands, and in perceptual speed and memory; males are superior in mechanical and numerical skills, in spatial perception, and organization and in mathematical reasoning. (Review by Ounsted and Taylor, (24,1972)). Both genetic as well as environmental factors are considered by researchers in explanation of these differences.

As far back as 1906, Bonser[15], compared the performance of 385 boys and 757 girls using a variety of English and Arithmetic tests, to find "... real, measurable sex differences, small to be sure, but no less real." He found boys to be superior in arithmetic reasoning and arithmetic computation tasks, in completion tasks and in the selection of good reasons to explain statements such as "New York is larger than Boston because ______." The performance of girls was superior when it came to writing opposites to words and in the selection of good definitions and meanings for words or poetry.

15. Bonser,F.G. "The reasoning Ability of Children", Contribution to Education, No. 37. (New York: Columbia University, 1910) p. 90 as quoted by Wozencraft in <u>Arithmetic Teacher</u>, Dec. 1963. p. 486.

In the 1920's and 1930's several studies, for example by Lincoln (27,1927), Woody (28, 1932) and by Pease (29,1930), were carried out with similar results[16]. Wechsler (30, 1941) attempted to construct his now famous intelligence test scales for adults and for chidren, WAIS and WISC respectively, in such a way that neither sex would be at a particular advantage or disadvantage. He rejected all those items on which appreciable sex differences were found during testing. However as various studies using WAIS and WISC (e.g. Strange and Palmer, 31, 1953) reported finding sex differences on certain items Wechsler[17], had to concede, "... that men not only behave but think differently from women".

Stroud and Lindquist[18], after an extensive study involving 50,000 pupils from 300 different schools concluded, "Girls have maintained a consistent and on the whole a significant superiority over boys in subject tests, save in arithmetic, where small insignificant gains favour the boys". The variables under study included language, reading, workstudy, vocabulary and verbal comprehension.

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16. For example Lincoln's finding was that girls excelled boys in reading ability at the elementary school level.

17. Wechsler, D., The Measurement And Appraisal of Adult Intelligence, 4th Ed., Baltimore: Williams and Wilkins, 1958.

18. Stroud, J.B. & Lindquist, E.F. Sex Differences in Achievement in the elementary and Secondary schools, Jour. of Educ. Psychology, V33, 1942, pp. 657 - 667.

Hobson (32, 1947), Havighurst and Breese (33,1947) conducted separately two factor analysis studies involving Junior High School Children and found boys doing significantly better than girls on problem solving, but no differences were found on N, which was the ability to do with manipulation of numbers.

Hobson's study was concerned with both general and specific ability performance of eighth and ninth grade pupils. On the general intelligence test, The Khuhlmann Anderson Group IQ test, which has a high concentration of verbal items, he found a slight but significant female superiority. Thus for the eighth grade students the average IQ of boys was 111.0 and that for girls was 114.5. The "Test of Primary Mental Abilities" was used to yield scores on specific abilities. Girls were found better on the word fluency, reasoning and rote memory sub-tests while boys were superior on space and verbal comprehension subtest.

Sweeney (34,1953) reported his findings in a series of experiments in problem solving involving college students. He found that males were significantly better at solving problems where it was necessary to break a set, restructure and organize their concepts i.e. in discarding the first system of organizing the facts and then trying out new approaches. Even when the sexes were equated for general intelligence, verbal ability, mathematical ability and various background factors he found the differences still persisting.

A study by Milton (35,1957) considered in details on page 69 of this thesis, showed significant differences in favour of men on problem solving skills involving the restructuring of the initial set or 'Einstellung' for solution of straight forward problems, and of numerical and non numerical problems.

Terman and Tyler (36,1954) found significant differences in arithmetic tests requiring reasoning in what are commonly known as "Story problems" in favour of boys. No differences between the sexes were found on "mechanical arithmetic" tests at all the age levels considered. Also at Kindergarten and below, no differences were found on number tests involving simple counting or identification.

Kostik (37,1954) controlled for factors such as intelligence, reading ability, practice effect and certain personality traits in a study on high school seniors and found that boys excelled girls in their ability to transfer or apply skill and knowledge to new situations and tasks.

McDavid (38,1959) found girls more often imitating adults who were seen by them solving a similar problem whereas boys who had also seen the same adults performing the same task attacked the problem set to them without looking for assistance.

Clark (39,1959) compared boys and girls in grades 3, 5 and 8 on the California Achievement Tests, using a carefully chosen stratified sample of children from all 48 states in the United States. The six subtests in the battery included reading comprehension arithmetic reasoning, arithmetic fundamentals, mechanics of English and spelling. There were very few significant differences. Girls outscored boys in mechanics of English at the fifth and eighth grade levels and in arithmetic fundamentals at the eighth grade level. No differences were found between girls and boys on the reading vocabulary test.

Lambert (17,1960) examined the relationship between arithmetic ability and scores on a Masculinity-Femininity scale using a sample of 1372 undergraduates enrolled at the University of California. The interesting hypothesis tested was that women who have high interest and ability for mathematics are more masculine than women who have only average mathematical ability. Application of the t-test showed no differences between scores of male mathematics majors and female mathematics majors. Also no significant differences were found in the mean scores of <u>male</u> mathematics majors and <u>male</u> non-mathematics majors on the masculinity-femininity scale. However significant differences were found on the masculinity - femininity scale between the mean scores of <u>female</u> mathematics majors and <u>female</u> non-mathematics majors. Table IX, reproduced from Lambert's article shows that the correlation between mathematics ability and masculinity of interest for both men and women is very small.

Table IX: Correlation Between Arithmetic Test and Masculinity-Femininity Scale.

Reproduced From Arithmetic Teacher, January 1960, p.20

Sex	Group I (Maths. Majors)	Group II (Non-Maths. Majors)
Men	0.008	-0.025
Women	0.156	0.005

Lambert postulated that among girls who are good at arithmetic it is actually the more <u>feminine</u> who become mathematicians.

Muscio (18,1962) conducted a study using 413 sixth grade pupils from 14 classes in three schools, in which scores of pupils were obtained on "Quantitative Reasoning". This included measures on conception of quantity, number system, number process and of meaningful mathematical vocabulary. The 206 boys and the 207 girls involved in the study were compared on the basis of raw scores obtained on the measure of quantitative reasoning and Intelligence Quotient. Although no significant differences were found on intelligence test scores significant differences were found on the measure of quantitative reasoning. Neither general intelligence nor computational ability could account for the sex differences found in the study. Muscio[19] summed up the implications of the study as follows;

"It would seem important, therefore, to ensure that the instructional program in arithmetic considers such differences as are thought to exist in the areas of interests, attitudes, personality etc., that may affect the direction and quality of learning." (page 262).

Witkin and Others[20], have shown that the male with his more analytical attitude is able to "abstract and maintain a perceptual configuration without being distracted by its context". This ability was reflected in his superior performance on the rod and frame test. His findings were that women were less able to totally disregard the visual field and depend more on the surrounding visual field in which the given figure or pattern they were trying to grasp or locate was embedded. Further, women made larger errors when misleading cues were present. Witkin attributes this

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19. Muscio, R.D., 'Factors related to Quantitative reasoning in the 6th. grade, Arithmetic Teacher, May 1962, V 9. pp. 258 - 262.

20. Witkin, H.A., et al., Personality Through Perception, N.Y. Harper: 1954, p. 156, as quoted by Tyler, L.E. (25,1965) on pages 256 - 257.

to what he calls "Passive acceptance" of females and their greater dependence on the surrounding field rather than utilising the available perceptual clues with which they could have analysed the true situation. However, this fails to explain why women's performance was poorer in the rod and frame test, where a visual stimulus had to be judged independently of its surroundings.

Jarvis (19,1964) tested 347 girls and 366 boys of sixth grade in arithmetic fundamentals and reasoning. The pupils were placed into three groups according to their intelligence Quotient Scores. The major findings were that in general sixth grade boys of all I.Q. levels were slightly superior to their peer group of girls in arithmetic reasoning. However, in arithmetic fundamentals girls were found to be more adept except in the high I.Q. group where boys were slightly superior to girls.

Dale (7,1962) reviewed earlier researches comparing the relative attainment in mathematics of students from single sex schools and from coeducational schools. His finding was that in general boys in coeducational secondary schools do better than those in single sex boys' secondary schools and that there <u>may be</u> similar differences for girls, with girls from coeducational secondary schools being superior. Further he noted that girls in coeducational schools were younger, were from a lower social class and had a less marked tendency to drop weak subjects. Dale considered the part played by two factors namely the teacher variable and the amount of time devoted to mathematics in the two types of schools. He suggested that these could have an important effect on the achievement of boys and girls. With reference to the choice of subjects Dale[21], had this to say;

"Nor must we ignore the support which the study of physics and (to a lesser degree) chemistry gives to those who are also studying mathematics; this occurs rather more frequently among co-educated than among segregated girls". (Page 14).

King (8,1965) compared the attainment in mathematics of pupils from single sex "modern" and "grammar" schools with that of pupils in coeducational "modern" and "grammar" schools respectively. A random stratified sample of 46 secondary schools were involved in this study. Scores of pupils were obtained on three tests. These were the National Federation of Educational Research Maths Test One, Raven's Progressive Matrices which is a test on non-verbal reasoning and the Step 3A Mathematics Test. The major findings were that boys and girls in single sex schools did consistently better than those in coeducational schools in the "modern" category of secondary schools. In the grammar schools coeducated boys did better than boys in single sex schools. The performance of girls varied from test to test.

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21. Dale, R.R., Coeducation II, An analysis of Research on Comparative attainment in mathematics in single sex and coed. maintained Grammar Schools, Educ. Research, VIII, 2, pp. 155 - 160.

The overall comparison of the results of boys and girls on the three tests is summarised in table X.

Table X: Overall comparison of boys and girls on the tests used in Dale's Study.

Reprod. from Educ. Research, Vol. 8, 1962/63, p. 156.

Test	Sex	Mean	N	Significance
Raven's Progressive Matrices	Boys	46.35	1305	0.05*
	Girls	47.09	1251	
N.F.E.R. Maths Test I	Boys	68.98	1305	0.01*
	Girls	29.55	1251	
Step 3A Maths Test	Boys	31.29	1305	0.01*
	Girls	29.55	1251	

Hence girls were significantly superior on the test on non-verbal reasoning ($p < .05$) and boys were superior on their performance on Step 3A maths test ($p < .01$).

Maccoby (13,1966) made an extensive review of literature on sex differences in cognitive functioning and in social behaviour. A more up-to-date version of her findings have been reported in a recent publication[22], in which attempts were made to include major research

22. Maccoby, E.E& Jacklin, C.N., The Psychology of sex Differences, Stanford; California University Press, 1974. Also Book review in American Educ. Research Jour. 1975, V 12, No. 4, pp. 127 - 139.

findings of studies on sex differences conducted recently. According to Maccoby, in the area of verbal ability sex differences up to the elementary school age were slight, but the trend was for the differences if found to be in favour of girls. Most of the studies reviewed found no consistent sex differences. However, after the age of ten and eleven girls begin to outscore boys at different verbal skills, though again sex differences were not found in every study. On the question of variability in verbal ability, Maccoby[23] noted that as a rough estimate "..... girls score on an average about a quarter of a standard deviation higher than boys ....". Maccoby further suggests that there may be distinct stages in the development of verbal skills, one before the age of three and another at about the age of eleven, with very little sex difference in between the ages of three to eleven on verbal skills. Maccoby's review of literature on mathematics ability showed no sex differences on performance on number conservation tasks or on enumeration, in preschool children. During the early school years as well, no sex differences are found in the mastery of numerical operations and mathematical concepts. In the age range from nine to thirteen, Maccoby's review found that sex differences when found were usually in favour of boys. After the age of thirteen, the results of most studies become more

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23. Maccoby,E.E. and Jacklin, C.N., "Sex differences in Intellectual Functioning", <u>In Assessment in a Pluralistic Society</u>, ed. Anastasia, Princeton: Educ. Testing Services, New Jersey, 1972, p. 38 - 49.

consistent in their findings and boys are almost invariably found to be superior. However, Maccoby points out that the situation regarding variability between girls and boys varies considerably from study to study. Figures of between two thirds of a standard deviation (as in Project Talent[24]) to less than a fifth of a standard deviation (as "in a large Swedish Study") to no significant differences between variability of girls' and boys' performance were quoted by Maccoby. Overall Maccoby concludes that there is very little sex difference in variability prior to adulthood. On Spatial ability Maccoby[25], concluded in her review;

"Sex differences remain minimal and inconsistent until approximately the age of 10 or 11 when the superiority of boys becomes consistent on a wide range of populations and tests."(p. 41)

Singhal and Crago (2,1971) tested economically disadvantaged children from homes of migrant families in the New York State prior to and after completing a six week program. Pupils who participated ranged between the ages of five to sixteen years. Singhal and Crago tested the hypothesis that girls and boys from migrant families do not differ in their school gains in reading ability and arithmetic. Their

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24. Project Talent, initiated by Flanagan, J.C. was aimed at surveying the Talents of youth and relationships such as personality variables, abilities, interests etc. are under study.

25. Maccoby, E.E., Op. cit., page 41.

findings were that girls obtained higher mean grade scores in both reading and the arithmetic pretests at most of the grade levels. After the programme it was found that girls gained more in reading than in arithmetic and boys gained more in arithmetic than in reading.

One of the more recent reviews of literature on sex differences in mathematics achievement is by Fennema (14,1974). A review of 36 studies examining sex differences at three age/grade levels was made for all important studies reported in referred journals since 1960. The review included studies on preschool, Early Elementary and Upper Elementary/High School children. At the preschool level three out of four investigators reported no significant differences between boys and girls. The fourth study by Rea and Reys (40,1970) found girls' scores significantly higher on number, geometry, recall and total scores. At the elementary school level no consistent significant differences in the learning of mathematics by boys and girls were found. One study by Hervey (41,1966) assessing ability to solve verbal problems before instruction showed that boys solved significantly more problems than girls. Two studies,one by Lowery and Allen (42,1970) and the other by Wozencraft (9, 1963) found that girls performed significantly better than boys. The dependent variables in these two studies were ability to categorize items and a standardized achievement test.

Wozencraft, whose study is dealt with in details on page 71 of this thesis, also found girls significantly better at Arithmetic Reasoning, but no significant differences were found in arithmetic computation. Fennema examined twenty studies in all in which boys and girls in their preadolescent and early adolescent years were used as subjects. Nine studies reported no significant differences in tests ranging from Topology and Geometry, discovery of patterns, arithmetic reasoning tests to standardized achievement tests. Eight found girls better in some of their tests, for example, Olander and Ehmer (43,1971) on a test in mathematical vocabulary, Wozencraft (9,1963) on arithmetic computation and Parsley (44,1964) on arithmetic fundamentals. Boys were reported significantly better on some of the tests in eight studies e.g. Jarvis (19,1964) on tests on reasoning ability, Muscio (18,1962) on quantitative understanding. Fennema[26] concluded cautiously for the fourth to ninth grade pupils that "in overall performance on tests measuring mathematics learning ... there are no significant differences that consistently appear between the learning of boys and girls ..." Fennema reviewed three studies using high school pupils (grade nine to eleven) as their samples. Two of the studies reported no significant differences between girls and boys.

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26. Fennema, E., Mathematics Learning and the Sexes: A Review, Journal of Research in Mathematics Education, May 1974, page 128.

These were studies carried out by Bhushan et.al. (45,1968) on Plane geometry and Easterday and Easterday (46,1968) on algebra pre and post tests for ninth grade pupils. Significant differences in favour of boys were reported by Backman (47,1972) on a standardized test while Easterday and Easterday (46,1968) found differences in favour of tenth grade girls. As the studies reviewed at the high school level were too few in number no definite conclusions were drawn for this group by Fennema.

Finally, Hancock (3,1975) studied the interaction between sex differences and cognitive factors with two methods of presenting mathematical content to ninth grade pupils. In this study, 119 pupils were randomly assigned to one of two treatment groups where they studied through different programmed texts. One text used a verbal mode of presentation, while the other used a figural mode of presenting concepts and principles of linear order relations. The two texts were judged to be parallel in content. A 33 item multiple choice test was given to both groups after completion. This test contained items at two cognitive levels and measures on the dependent variable were obtained by taking scores on the test of the criteria at the two cognitive levels. A retention test was also given to the subjects after 4 weeks to test for retention of learning at the two cognitive levels. One of the comparisons made on the dependent variable was between the sexes. In this case the hypothesis tested was: MF_1 ; With respect to the dependent variable Y_1 , there is no difference in the mean scores of the male and female groups. The results of comparisons between the sexes extracted from the author's article are presented in table XI.

Table XI: Experimental Group means and t - scores of Dependent Variables.

Extracted from Table 7, Jour. Research in Maths. Ed.[27]

Variable	Males Mean	Females Mean	T-values.
Criteria Test I	5.26	6.31	2.24*
Criteria Test II	5.45	6.48	2.22*
Criteria Test Total	10.71	12.79	2.60*
Retention Test I	4.57	5.98	3.02*
Retention Test II	4.06	4.83	1.85
Retention Test Total	8.63	10.81	2.89*

$t = 1.98$ was taken as significant with $p = 0.05$ & $df = 52$.

As we can see from Table XI, females were superior on five of the six criterion measures. Further comparisons for treatments within sexes showed that males who studied the verbal program did significantly better than males who studied the figural program.

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27. Hancock, R.R. Cognitive Factors and Their Interaction with Instructional Mode, Journal For Research In Mathematics Education, V 6, No. 1, January 1975, Page 44.

Hancock explains the amazing superiority of girls by suggesting that there could have been a greater willingness on the part of females to involve in the experiment or that boys of ninth grade are more likely to apply themselves to a learning task if the instructional material is consistent with their cognitive preferences, while girls apply themselves diligently regardless of the cognitive fit. An earlier study by Hancock (48,1972) using verbal and figural modes of presenting concepts on linear order relations found that female subjects scored significantly higher on subtests measuring achievement at the highest cognitive level.

2.2. Reasons for the Origin of Sex Differences

Various reasons have been put forward to explain the existence of sex-differences in achievement. Although genetic factors play an equally important part, the extensive research literature on these factors will not be reviewed in this study. Carey (49, 1958) suggests that the poor performance of girls on achievement tests may be due to less favourable attitudes to mathematics. Looft (50,1971) attributes sex differences to differential socialization. His study considered children's aspirations as to what they wanted to be when they grew up. He found considerable unanimity in the responses of girls, seventy five percent of whom wanted to be either teachers or nurses. The responses of boys were more variable, the most often selected occupation being firemen and football player. Sells (51,1973) found a definite relationship between encouragement by parents, teachers and peer groups and the decision by pupils to take more years/of high school mathematics. Jenkins (52,1974) looks at the role of cultural and society's pressure in contributing to differences between performance by sexes in science and mathematics. His finding was that as late as the 1950's boards of education, permitted if not encouraged, through award of grants some differentiation of curricula. Thus for girls over 15 years "an approved course in a combination of domestic subjects may be substituted partially or wholly for science and mathematics other than arithmetic" reflects societal demands for girls to be obedient, nurturant, and responsible and boys to be independent, self reliant and aggressive. Barry et.al., (53,1957) also emphasized the importance of cultural rather than biological basis for sex differences. Sario and others (54,1973) considered the role of sex-role stereotyping in texts, achievement tests and curricula in promoting differences between the sexes. Rogers (5,1975) examined eight different trignometry and algebra texts to find that seven of these texts create the impression that women and their activities are comparatively dull and insignificant. Similar results were found by Jay and Schminke (6,1975) who showed that mathematical texts presented mathematics as a mainly masculine enterprise. An examination of 4,100 pages of instructional materials used in school mathematics for evidence of sex stereotyping revealed definite evidence of inequality of treatment of the sexes. For example, verbal problems show men far more active than women. There were 282 problems involving men exclusively, only 42 dealt solely with women and 82 included both. Some researchers have examined the role of personality traits such as aggression, independence, conformity, passivity, anxiety and extraversion in contributing towards sex differences in mathematics achievement. For example Maccoby (55,1966) hypothesized that sex-typed personality traits such as aggression-independence in boys and conformity-passivity-dependency in girls act as mediators of differences in intellectual performance. The role of dependency and conformity is fully explained by Maccoby[28], in the following words;

"An individual who is dependent and conforming is oriented toward stimuli from other people; perhaps he finds it difficult to ignore these stimuli in favour of internal thought processes .... Dependent children have been shown to be more distractible (Rau, 1963); their internal processing is interrupted perhaps because of their greater

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28. Maccoby, Eleanor, Ed., The Development of Sex Differences Palo Alto: California, University of Stanford Press, 1966, page 43.

orientation towards interpersonal cues ... The dependent conforming person is passive, waiting to be acted upon by the environment. The independent person takes the initiative." Page 43. Aiken (73,1972) examined the relationship between age and sex and their interaction with factors affecting attitudes and achievement in mathematics. A 97 item inventory was administered to 85 boys and 97 girls in the 8th grade. The difference between the means of the mathematics attitude scores of males and females was found to be non-significant (3.47 and 3.56 respectively). Besides these attitudes towards mathematics was found to be related to attitudes towards computations, mathematical symbols and terms and word problems in mathematics. The father variable was a significant factor in determining the attitudes of males but was not related to the attitudes of females. On the other hand, the mother variable was more significant for females than for males. One interesting conclusion reached by Aiken was that attitudes towards mathematics was directly related to interest in problem solving tasks in general, but inversely related to interest in language arts, social studies and other verbal persuits.

Besides Attitudes towards mathematics there have been attempts to link certain emotions, for example, aggressiveness to specific intellectual abilities. A current theory views mathematics as essentially a male activity and aggressive in nature. Aggressive in the sense that one must continually destroy existing statements and substitute these with new ones. Loughin et. al., (56,1965) found that the performance of girls was disrupted by anxiety and failure and that the levels of aspiration of boys were strongly linked to reality. The levels of aspirations of boys were determined by some degree of circumspection. Walter and Marzoff (57,1951) found the discrepancy score between aspiration and performance of boys and girls about four times in favour of boys. Stafford (16,1972) considered the role of six environmental factors which could contribute to sex differences in mathematics. The six environmental factors considered include attitudes towards mathematics, sex role identification, father absence, ordinal position in family and personality correlates. Stafford pointed out that studies, for example, by Berry (58,1958) show that attitudes towards mathematics were more favourable in men and clearly correlated to problem solving ability and further, that parental attitudes determine the right climate for favourable attitudes towards mathematics as was shown by studies which find mother-son but not father-son attitudes being correlated.

The part played by sex role identification was brought to the light by Milton, as reviewed by Stafford, who found that by changing the character of problems so as to make them less appropriate to the masculine role, sex differences could be reduced.

Stafford reviewed the findings of two separate studies, which considered the role of father absence. One was by Carlsmith (59,1964), which found that if the father was absent from home verbal scores were higher than mathematics scores for men. This was a reversal of the usual mathematics scores being higher than verbal scores for men. A study by Landy (60,1969) reported similar findings for women.

In the area of personality correlates Stafford reviewed studies by Nakamura (61,1958) who found a negative correlation between tendency to conform and problem solving ability and by Sanders (62,1960) who found pupils more dependent on authority if they score higher on problem solving ability than on verbal ability. Stafford concluded that Personality variables were correlated to mathematics ability.

2.3. Research Studies Considered in Detail

One of the very few studies dealing with sex differences in the learning of mathematics among Kenyan students was carried out by Eshiwani (10,1974). The study recognized the existence of sex differences as shown by research in the West and set out to find out to what extent the findings hold for African High School students. The chief aim of the study was to determine if sex differences exist in achievement and retention in mathematics among boys and girls. The study also considered the role of attitudes towards mathematics, mathematical reasoning, vocabulary of mathematical terms, vocabulary of science terms and computation in predicting the achievement of boys and girls in mathematics. Table XII gives the distribution of boys and girls in the study.

Table XII: Distribution of pupils by sex in each of the experimental group.

Reproduced with modifications from Res. Rep. No.3, 1974, University of Nairobi.

	CCA	IPI	PI	Totals
Boys (2 Boys Schools)	63	55	62	180
Girls (2 Girls Schools)	52	60	62	174
Totals	115	115	124	354

Within each of the four high schools, the three Form II classes were randomly assigned to one of the following treatments:

Programmed Instruction (PI), Conventional Classroom Approach (CCA), and Intergrated Programmed Instruction (IPI). Initially seven pretests were administered to all the pupils. The results are reproduced in Table XIII.

Table XIII: Boys versus Girls (Pretests) Comparison and t - values.

EXTRACTED FROM TABLE 5. MATHS EDUC. RES. REPORT No. 3 - AUGUST 74 P. 10.

Variable	Boys Mean	SD	Girls Mean	SD	t
1. Attitude towards Maths	136.50	12.24	136.34	14.83	.11
2. Five Dots (Reasoning)	10.12	3.64	10.36	3.29	.60
3. Fractions (Computations)	6.17	2.23	6.12	2.25	.20
4. Arithmetic Reasoning	8.25	2.64	7.49	2.41	2.89*
5. Probability Pretest	2.58	1.72	3.48	2.25	4.09*
6. Comprehension (Maths Voc.)	5.53	3.28	5.93	2.77	1.24
7. Comprehension (Science Voc.)	6.18	3.44	6.01	2.99	.47

A significant difference in favour of boys was found on the arithmetic reasoning test while significant differences in favour of girls was found in the probability pretest. Slight differences in favour of boys were found on attitudes towards mathematics, Fractions, (Computations) and Comprehension of Science vocabulary. Surprisingly, girls did slightly better than boys on the Five Dots test of reasoning while boys did significantly better on the Arithmetic Reasoning Test. The programmed Instruction (PI) group was taught a unit on probability through a programmed text, the Conventional Classroom Approach (CCA) through a teacher and the Intergrated Programmed Approach (IPI) through a teacher and program. The two achievement tests were administered followed by a retention test six weeks after instruction. Table XIV gives the results of these three tests. Significant differences were found on the second achievement test in favour of girls. To compare the performance of the sexes in each of the three treatment groups, additional analysis was performed by the present researcher using the means and standard deviations as quoted in Table 4 (page 8) of the report. The t-values for sex differences for each group in the first achievement, second achievement and retention tests as calculated , are presented in Table XIV.

Table XIV: t-values for differences between boys and girls in the PI, CCA and IPI groups.

Test	PI	CCA	IPI
1. First Achievement Test	+3.19*	-9.75*	-0.12
2. Second Achievement Test	-1.95	+0.76	-2.38*
3. Retention Test	-0.62	+7.57*	+5.38*

* Significant at .01 level.

1. The t-values were computed from the data in tables 3 and 4, page 7 and 8 respectively, of the Report.

2. A minus indicates that differences are in favour of girls, while a plus sign indicates that differences favour boys.

It is clear from table XIV that boys gained significantly more as measured by the retention test when the instruction was through the CCA and IPI methods while girls gained more than boys through the PI method of instruction.

2.311. COMMENTS:

The study provides useful information on overall comparisons between girls and boys. On five out of the seven tests administered prior to the experiment no significant differences between boys and girls were found. The only case of significant differences favouring girls was their performance on the probability pretests.

In an experimental study of this nature, it is very difficult to control all the extraneous factors that might affect learning and possibly explain the reversal of the performance on the achievement tests by the sexes. It is not clear what steps were taken to ensure that the content as taught by the teachers and the program was parallel. A possible explanation for the reversal of the findings from one achievement test to another could be that as girls were initially superior (as found on the pretest scores on probability) an attempt should have been made to adjust for achievement scores on the criterion tests using these. This was very likely the reason for the overall t-values showing significance in favour of one of the sexes in the first achievement test while the position was reversed on the second achievement test. Possibly other explanations could lie in the "Hawthorne effect". Parkar's study in 1974, using Form I pupils, from Nairobi schools showed that there were sudden changes in attitudes during the first term but the gains had evened out by the end of the program. He attributed this to the novelty effect. In Eshiwani's study the instruction was on for two weeks. Whether the CCA group were told they were involved in an experiment is not known. It appears as if the CCA group was not aware of this as evident from their means on first and second achievement tests (7.20 for CCA as compared to 10.71 and 9.8 for the PI and IPI on the first achievement test; and 5.41 for CCA as compared to 8.60 and 7.80 for PI and IPI groups respectively on the second achievement test.) When the effects of the "Hawthorne effect" had worn out the means of the CCA group shoot up to values well above the PI and IPI group means. (5.38 for CCA, 4.78 and 5.21 for the PI and IPI group respectively on test.)

The only other study located in a Kenyan setting was a study by Parkar (23,1974) involving 219 students from six classes in two different schools. Although the study did not take sex as a major variable , comparisons were made between girls and boys on achievement and attitudes towards mathematics.

The study used intact Form I classes which were randomly assigned to two groups, a Control and an experimental group. The Control group was taught the contents of SMEA Book One through the traditional chalk-talk, teacher dominated approach while the experimental group learnt the contents of SMEA Book One through what Parkar labels "Programmed Work Cards". Three attitude scales were used in this study. These were:

1. Attitudes towards mathematics as a process
2. Attitudes about difficulty of learning mathematics.
3. Attitudes towards the place of mathematics in society.

Reliability data for these scales or for the achievement tests are not given in the study. Three tests assessing achievement of the groups were given at the end of the first, second and third terms of the school year. A summary of the findings on achivement tests is given in Table XV, and will prove useful for reference in the section on comments.

Table XV: Table of t - values contrasting performance of boys and girls in Parkar's study, 1974.

The t - values were obtained from Table 1, 2 and 3 (Pages 141, 142, 143) of the thesis.

Group	First Achievement Test	Second Achievement Test	Third Achievement Test
Exptal Boys Versus Exptal Girls	-4.21*	-5.04*	+4.25*
Control Boys Versus Control Girls	-5.55*	+1.15	+7.29*

*: Significant at 5% level. A plus sign indicates differences in favour of boys.

At the end of the program the achievement tests were given to pupils. Comparison of boys and girls were again made. A summary of the results is presented in table XVI. Again girls in experimental groups showed more favourable overall attitudes towards mathematics while boys had on the whole a more favourable attitude towards mathematics.

Finally a comparison was made to find out which sex groups had had significant changes in their attitude scores during the experiment.

Again the results are presented in table XVII.

Table XVI: Table of t-values contrasting performance of boys and girls on attitude scales after the program in Parkar's study (1974).

Extracted from table 6 and 7, page 150, 152 and 153 of Parkar's thesis.

Group	N	Total scores Attitude Scale	Attitudes towards Maths as process	Difficulty of learning maths.	Place of maths in society.
Exptal Boys versus Exptal Girls	64 / 40	-0.59	-1.34	+0.47	+0.79
Control Boys versus Control Girls	69 / 38	+1.72	-2.77*	+2.25	+3.28*

* Significant at .05 level.

Table XVII: Pretest and Post-Test attitudes scale scores: A Comparison for Boys and Girls.

t - values extracted from Parkar's Thesis, Table 8 Page 154.

Group	t - values
1. Experimental Group (Boys)	-0.97
2. Experimental Group (Girls)	-1.65
3. Control Group (Boys)	+0.65
4. Control Group (Girls)	-1.42

A + sign indicates an improvement in attitudes over the year of program. None of the t - values were significant.

In brief, girls performed significantly better than boys in both the groups on the first test of achievement. On the second test, girls were significantly better than boys in the experimental group but not so in the control group, where slight differences favour the boys. The performance on the third achievement test shows boys doing significantly better than the girls in both the groups.

Only two attitude towards mathematics scales were given to the pupils during the course of the study, one at the beginning and one at the end of the study. Table XVIII gives a summary of the findings.

Table XVIII: Table of t-values contrasting performance of boys and girls in Parkar's study on the attitude scales.

The t-values were obtained from Tables 4, and 5 of Parkar's Thesis page 145, 147.

Group	N	Pretest in attitudes towards maths total scores	Pretest on maths as a process	Difficulty of learning maths	Place of maths in society
Exptal Boys versus Exptal Girls	64 40	-1.70	-1.18	-1.12	-0.99
Control Boys versus Control Girls	69 38	+0.47	-0.59	-0.58	+0.38

A + sign on the left of the t-values indicates that the difference favour boys.

For the experimental group, girls had slightly more favourable attitudes on all the three scales, as well as on the total attitude scale. In the Control group boys had more favourable attitudes on the 'Place of Maths in Society's scale and on the overall scores on the attitude scales. However none of the differences were significant for either group.

2.321. COMMENTS:

Parkar's study has provided the present researcher with valuable information regarding boys' and girls' achievement and attitudes towards mathematics in secondary schools of Kenya. What is most surprising is the close agreement on sex differences in the findings of Parkar's study and in the findings of research studies carried out in the West. The girls and boys used in the study had just left the primary school and begun their secondary school education. At the end of their first term in secondary school, girls did significantly better than boys in both the Control and the experimental groups. The situation had not changed much by the end of the second term. Experimental girls did significantly better than boys while no significant differences were notable in the Control groups, During the third term there is a total relapse in the performance of girls. BOYS did significantly better than girls in both the groups. As Table XVIII has shown the attitudes of boys become slightly more favourable (as in the Control group) while the attitudes of girls became considerably less favourable towards mathematics during the first year of secondary schooling. While it would be unsafe to generalise or draw conclusions from the rather small sample sizes used in the study (number of boys is 123 and number of girls is 109) it seems as if the first year of secondary schooling has a strong influence in bringing about changes in the attitudes and achievements of Form I pupils. One would expect to find attitudes of primary school children to mathematics (whether traditional or modern) to carry over into the secondary schools. This may in turn affect their performance in the secondary school. It was necessary to reproduce t - values from Parkar's thesis so as to summarize his findings as clearly as possible.

2.33. A study seeking evidence of relative attainment in mathematics of boys and girls in single sex and coeducational schools was carried out by Adonis Labor (11,1974) using 17 secondary schools in Western Sierra Leone. The subjects were 857 pupils who sat for the mathematics papers in West African School Certificate and G.C.E. exam of June 1972. The 17 secondary schools included five girls' schools, nine boys' schools and five co-educational schools. Mathematics achievement scores were the reversed stanine grades for the School Certificate and G.C.E. mathematics examination. These grades were categorised as "Bare pass", "Credit and above" and "Fail". Table XIX was drawn up from the data given in the article and shows the overall number of boys and girls in the three categories of grades considered for mathematics.

Table XIX: Numbers and Percentage of Boys and Girls in each Category of Grades.

Data compiled from Labor's article, <u>Afr.Jour. of Res.VI,1974</u>

	N	Boys %	N	Girls %
Credit above	178	(32.1%)	21	(7.0%)
Bare pass	86	(15.5%)	39	(12.9%)
Fail	291	(52.4%)	142	(80.1%)
	555	(100%)	302	(100%)

Examination of Table XIX reveals the startling figure of 80.1% as the failure rate for girls. Almost five times as many boys got a credit or above as girls.

The main aim of the study was to compare the attainment of boys and girls from single sex and coeducational schools. Table XX reproduced from the Journal indicates the percentage in each of the categories of grades considered for boys and girls in single sex and coeducational schools. The proportion of boys and girls who reached "barely passed" grades shows startling discrepancies. From single sex schools, 45.8% boys failed as compared to 76.9% girls who failed. Contrary to expectations, figures for coeducational schools showed that 63.7% boys failed while 91.2% of the girls failed.

Table XX: Number and percentage of boys and girls in the three grade categories in single sex and coeducational schools.

Reproduced from African Journal of Education, Res.Dec.74,VI

Grade Category	Single Sex Schools		Coeducational Sch.	
	Boys	Girls	Boys	Girls
Credit and above	139 (54.2%)	18 (23.1%)	39 (32.7%)	3 (8.8%)
Bare Pass	69	36	17	3
Fail	176 (45.8%)	180 (76.9%)	115 (67.3%)	62 (91.2%)
Total	384 (100%)	234 (100%)	171 (100%)	68(100%)

Finally the z - test was used for contrasting pairs of proportions of candidates obtaining "Credit and above" grade in mathematics. The proportion of "Credit and above" for boys was significantly greater than that for girls in both the single sex schools (z value = 7.90 and $p < .01$) and coeducational schools (z value = 3.91, and $p < .01$).

Sex differences were also considered among the "bare pass" group of pupils. No significant differences were found between the proportion of boys and girls from single sex schools in the "bare pass" category of grades. However, significant differences between boys from single sex schools and girls from coeducational schools were found ($z = 2.82$, $p < .01$) in this category.

The author concluded that the proportions of "pass and above" in mathematics for boys and girls in single sex schools were significantly higher than for their counterparts in coeducational schools and the proportion of "pass and above" grade for boys was higher than that for girls irrespective of the sex of pupils in the school.

2.331. <u>Comments</u>.

This study gave further support to Dale's (7,1962) finding that boys in coeducational schools do better than boys in single sex schools. According to Labor the finding that the failure rate among girls (91.2%) in coeducational schools is higher than that in single sex schools (76.9%) is contrary to expectations.

However, it should be noted that this depends very much on a large number of factors such as whether there are real differences in the set up of the two types of schools. The very fact that girls have been placed in coeducational schools will not necessarily raise their performance in mathematics. It is often the case that in coeducational schools there is a greater diversity in the choice of subjects available to the pupils and pupils are encouraged to take subjects appropriate to their sex, in the same ways as the single sex schools do by excluding subjects traditionally reserved for the opposite sex from the school altogether. Thus for example, whoever has heard of woodwork or metalwork and engineering drawing being offered as subjects to girls in single sex girls' schools. Obvious exceptions are countries like Tanzania and China, which have a policy of diversification/vocationalization of secondary education and where girls are taught technical subjects in technical-bias secondary schools. Hence coeducational schools could act as transmitters of cultural and traditional values in exactly the same way as the single sex schools by restricting pupils in the choice of subjects and encouraging the belief of "mathematics and science for men and domestic science for women". Thus it is felt that Labor should have examined variables such as teachers (availability, qualifications and experience) and choice of subjects in the single sex and coeducational schools as well as factors such as the school time tables, number of periods devoted to mathematics etc. in the two types of schools. These, it is felt by the present researcher, would have had a bigger influence on performance than the mere fact that pupils are in coeducational schools or single sex schools. A comparison between pupils in Western Sierra Leone and Nairobi schools reveals that the failure rate among girls in Western Sierra Leone is much higher (80%) for girls than that of girls in Nairobi (55%). However, this does not mean anything as the tests used were different and possibly the syllabi followed are not the same. It is not clear what category of schools were used.

2.34. The findings of a major international comparative study of achievement in mathematics using students from 13 different countries were reported by Husen (12,1967) One of the variables in a total of 45, was sex. A pilot study was conducted in June 1961 and was reported by Fashay et. al. (4,1962). A total of 9,918 pupils spread over 12 countries were tested in reading comprehension, mathematics, science, geography and non-verbal ability. The mathematics test had 5 items requiring simple computation, 7 verbal problems, 5 basic concept items and 9 problem sequences. Overall, girls did better than boys on the mathematics test in 11 out of the 12 countries. An interesting finding of the study was that boys varied more from country to country (falling a fifth of a standard deviation above the girls over all countries). Girls performance was best on the reading test and poorest on the science test. This was found in each of the 12 countries. Girls also did relatively better on the non-verbal tests (in ten out of the 12 countries). Other variables of relevance to this study considered in the pilot study were the effect of the father's levels of educational and occupational status on the achievement of girls and boys. Findings on these variables varied from country to country. For example, boys whose fathers were in the unskilled and semi-skilled occupations in Germany did better than girls. Girls with fathers in clerical category perform better than boys. The main study was conducted in 1964 using four sample groups, two from the thirteen year age groups, a group consisting of mathematics students in their final year of secondary school and non-mathematics students in the final year of secondary education. These were labelled Target populations Ia, Ib, 3a and 3b respectively. In all nearly 39,000 boys and 34,000 girls were involved in the study. In the words of the authors the aims of studying sex differences were, to determine;

"... the way in which cultural views of the role of men and women influence not only the taking of mathematics courses but also achievement of boys and girls.... whether sex differences are reflected in verbal as compared to computational problems ... and to understand how sex roles are related to interest in mathematics, plans to take further mathematics and attitudes about difficulty of learning mathematics." Husen (12,1967) page 204.

An attempt has been made by the present researcher to summarize Husen's findings on sex differences in Table XXI.

Table XXI: Summary of Findings in Husen's Study of Achievement by boys and girls in Mathematics.

Variable	Findings
Total Maths Score:	Significant differences were found in favour of boys in all four target populations - Boys showed greater variability in their achievement.
Verbal Problems:	Clear differences in favour of boys were found in all populations. Only in Israel were girls superior to boys.
Computational Problems:	Clear differences in favour of boys were found in all populations. Girls were superior to boys in Israel, U.S.A. and Sweden . The variance between countries and sexes was significant in all cases.
Interest in Mathematics:	Boys show significantly greater interest than girls in all populations. The correlations between sex and interest range from 0.09 to 0.12. Only in England, Sweden and France did girls of population 3a show greater interest.
Plans to take further Mathematics:	No significant differences in population 3a and 3b. Boys more frequently plan to continue and girls to cease study of mathematics. Only in Populations 3a girls of three

Table XXI: Continued from Page 67.

Variable	Findings
Plans to take further mathematics:	countries plan to study mathematics more than boys.
Difficulty of Learning Mathematics:	Very few significant differences found. The only significant case of girls finding mathematics easier than boys was in Israel. In Finland and Netherlands, boys find mathematics easier than girls.
<u>Sex of School</u> Single sex schools:	Boys were significantly better than girls in all populations on achievement in mathematics. No significant differences between boys and girls on interest in mathematics. Only in Australia and Israel were girls superior to boys in the single sex schools.
Coeducational Schools:	Only in population 3b were boys significantly better than girls. In populations 3a differences almost disappear.

2.341. <u>COMMENTS</u>: The summary in table XXI hardly does any justice to all the findings of Husen's study on sex differences in mathematics achievement. However, if any single study has influenced the course of the present research undertaking then Husen's study could be said to be the one. Husen's study proved to be most useful and was often the only source of inspiration when in doubt. There are more similarities between this study and Husen's than there are differences. Husen's study used very large sample sizes (≃ 73,000). The present study used only 600 pupils. Husen's study had 48 variables examined in it. This study examined 14.Husen's study used a total of ten tests containing some 174 items. This study used seventeen achievement test booklets containing about 320 items. A rather ambitious undertaking this! No wonder more than a quarter of the original 25 tests were rejected, leaving 17 tests. However at the time it was felt necessary to span as much of the S.M.E.A. text books as possible. As some of the world's leading authorities in mathematics education were involved in Husen's study the study is reported here without any critical comments.

Milton (1,1957) using 129 students, of whom 63 were males and 66 females, from an introductory psychology class at Stanford, tested the hypothesis that;

a) there is no relationship between masculine identification and problem solving achievement and

b) sex differences in problem solving will be reduced when adjustment is made for between sex variance contributed by sex role identification.

Twenty problems involving two types of problem solving skills were used in this study. Ten were straight forward questions solvable by direct means, while ten needed restructuring in which it was necessary to change the initial set for solution. In every case differences between men and women were significant at the .01 or .02 level of significance. Significant correlations between problem solving skills and sex role identifications were also found both within sexes and across sexes. Milton next performed an Analysis of Covariance to determine if the differences between the sexes persisted when adjustments were made for masculinity-femininityscores. Milton showed that after adjustment the significant sex differences on problem solving skills were no longer significant at any level. Finally to find out what portion of the variance within a sex could be accounted for by the scores on the Masculinity-femininityscale Milton fitted the variables to a regression equation. For both men and women the scores on the masculinity-femininityscales were found to be significant contributors to the variance in problem solving. Milton concluded that men who are more masculine are better problem solvers. According to Milton this implied that females will not develop problem solving skills as long as they identify with feminine roles and relearning of sex roles will be necessary to acquire problem solving skills.

2.351. <u>Comments</u>

What are classed masculine and feminine roles in Milton's study vary from society to society. Even within society the roles of females and males vary. For example, in Kenya, urban populations may not see the same distinctions between male and female roles as would the more conservative rural populations. Often there is a reversal of sex roles of men and women. It seems that a more important factor to consider would be the part played by experience and specific training. Milton's contention implies that the masculine roles are more appropriate to developing problem solving skills. What happens in a culture in which the sex roles are reversed, and where men for example engage in activities which are reserved in the West for females, and vice versa[29]? Hence the part played by experience would be more important. In this case experience would play an equalizing role and bring about a convergence of the abilities of the sexes.

One of the few studies that found sex differences in favour of girls was a study by Wozencraft (9,1963) using a random sample of 5,708 pupils from grade three and 5,059 pupils from grade six, from a total of 121

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29. Lambert (40,1960) found that the more feminine women become mathematicians refuting Milton's earlier finding. This indicates the very arbitrary nature of the scale. Besides, the correlation between scores on this scale and mathematics achievement was very small.

schools. Approximately ten percent from each school were selected using a table of random numbers. Each grade was divided into three IQ levels, a low, an average and a high IQ level. A series of tests were given to measure knowledge skills and understanding of elementary school mathematics. The tests mainly measured lower cognitive behaviour i.e. factual learning. On arithmetic reasoning the mean scores of girls were significantly higher at the 1% level of significance than the means of boys. For pupils of low and middle intelligence levels, the girls' mean scores were significantly higher than those of the boys. For the sixth grade the difference between the sexes does not reach the 4% level of significance. However, at arithmetic computation the scores of sixth grade girls was significantly higher than that of boys at the 2% level of significance. When comparisons were made for high intelligence, middle intelligence and low intelligence groups of the sixth grade the differences were significantly in favour of girls only for the middle class intelligence group. An interesting finding was that between the bright and slow boys in the third grade the difference was $1\frac{1}{2}$ years while for girls this difference was 1.1 years. Figures for sixth grade were $2\frac{1}{2}$ years and 2.7 years respectively for boys and girls. In conclusion Wozencraft recommends a broad program of work in which pupils can work at their own levels of ability.

2.361. <u>Comments</u>

Wozencraft's study has pointed out the fact that differences exist not only between sexes but also within sexes and that these differences are as wide as 2.5 years at the sixth grade and 1.5 years at the third grade. This implies that some pupils are capable of working on 7th grade work while others were only capable of doing 4th or 5th grade work. Also the differences within sexes appear to increase during the primary school years. One could expect to find a similar situation in Secondary schools as well, with differences between the pupils not so wide in Form I when the pupils have passed their first bottleneck of selection after C.P.E. and gradually in Form II, III and IV the differences between the bright and dull widen. Selection for Form Six again narrows the gap by bringing together the brighter pupils. Thus in Kenya,the problem is more serious as at each bottleneck there are large numbers of dropouts. Hence a need for alternative programs which the less bright can master effectively.

Callahan (15,1971) used an attitude scale, constructed by Dutton to gather data on the attitudes of eighth grade pupils from a single Junior High School in New York. A total of 356 pupils from 17 classes with approximate enrolments of 23 pupils each were used. The scale consisted of two parts, one having 22 statements on attitudes towards mathematics and the other was on the likes and dislikes of pupils. Pupils were asked to indicate their feelings by checking on a scale ranging from I to II, the latter score being the extreme position for dislike. A neutral score was 6. Analysis of the data showed that 44 boys liked mathematics as compared to only 28 girls (24% and 15% respectively). The number of boys who showed extreme dislike for mathematics was 12 as compared to 7 girls (7% and 4% respectively). Girls and boys showed about the same dislike for mathematics. Also Girls showed a much more stronger dislike for word problems than did boys.

2.371. Comments

The small sample sizes used in this study make it difficult to draw general conclusions on the likes and dislikes of girls and boys. Further only one school was used which means several age groups or grades were involved. Also no statistical tests were used to find out if the differences between boys and girls were significant. Mere comparisons of differences make it next to impossible to draw definite conclusions.

2.4. Summary of the State of the Art.

The foregoing review of literature compared the performance of boys and girls on achievement tests and attitudes towards mathematics. The main points which emerge from the review are as follows;

1) At the nursery and early primary school levels sex differences on achievement tests in mathematics are virtually non-existent. This was reported in most studies but these were not reviewed here.

2) For children in the Western countries differences in the performance of boys and girls on achievement tests first begin to appear towards the end of the primary school. The differences consistently favour boys in the secondary school years.

3) The three studies for African children at the secondary school levels reviewed here found significant differences favouring boys. These were the studies by Eshiwani, Parkar and Labor. The differences were not so consistent in Eshiwani's study.

4) In the upper primary school and secondary schools in Western countries differences were often found in favour of boys when the higher level cognitive abilities in mathematics were being tested. However, at lower level cognitive abilities the differences were in favour of girls.

5) The review of literature pointed to a large number of environmental factors contributing towards differences between the sexes on their achievement in mathematics. However, studies like Stafford (16,1972) have suggested that innate factors are more important. The present researcher views that

both environmental as well as innate factors are equally important. Evidence for this comes from the fact that sex differences in mathematics are virtually absent during the primary school years. Some of the environmental factors considered as important contributors to sex differences in mathematics by researchers in the West include attitudes of pupils towards mathematics, differences in socialization, differences in educational and vocational aspirations, parental encouragement, cultural and societal pressures, sex role stereotyping and differences in the personalities of boys and girls.

Much of the directions for the conduct of the present study and for the choice of variables for examination in the study came from the studies reviewed in this chapter. The more recent trends of research in the West examine sex differences on achievement tests in content areas of mathematics with items at different cognitive levels. For example studies by Carry (69,1970), Carry and Weaver (70,1969), Husen (12,1967) and Kilpatrick and Mcleod (71,1970). The present study also examines the performance of boys and girls at different content areas at four cognitive levels i.e. Knowledge, Comprehension, Application and analysis. As it would have been impossible to justify the choice of one content area over another for studying sex differences it was decided to examine sex differences in as many areas of the S.M.E.A. as possible.

The independent variables chosen for examination in this study have been shown to be important by research studies in the West. However, as pointed out in Chapter One, section 1.33, due to limitations of non-availability of suitable measuring instruments for some of the variables, the choice of these was made with some degree of circumspection. Thus attitudes towards mathematics, reading ability, motivation, educational and vocational aspirations were the variables chosen for study.

One variable which is considered important and which has so far not received much attention in studies in the West is the teacher variable. This variable was initially included for study in the draft proposal preceding the research, but it was found necessary to omit it in view of the limitations outlined in section 1.3. in Chapter One of this thesis. Three different teaching methods were to be the focus of the study. These were expository, discovery and laboratory methods. It was proposed that the three methods would have differing effects on the learning by the sexes of certain mathematical concepts.

CHAPTER THREE

DESIGN OF THE STUDY

3.0. Introduction

This chapter gives a description of the sources of data and the type of the research design and procedures used in obtaining and processing the data.

Section 3.1 considers in details the stages involved in the development of the achievement test battery, the student questionnaire, the close tests and the attitude towards mathematics scales.

The pilot study is the subject of discussion of section 3.2. Its aims, purposes, item and scale analysis data results and the major findings are reported in this section.

Finally section 3.3. gives a description of the main study. The research sample, its selection, test administration procesures, methods used for scoring the tests and coding the responses are outlined in this section.

3.1. Construction of the Tests

3.11. The Achievement Test Battery

During September, October and November 1975 test items were constructed to cover the 35 chapters of School Mathematics of East Africa Books One and Two. Initially the items were written out on 3" X 4" cards of four different colours, each colour representing a particular cognitive level. Various systems of classification were available to the researcher which could have led to the construction of the achievement test battery and to the classification of items to test various cognitive level objectives. Examples of these systems are as proposed by Fraser (63,1972) and Gronlund(72, 1972). However, the Taxonomy of Educational Objectives produced by Bloom (65,1971) and his colleagues provided an adequate outline for the classification of items. Only the broader cognitive level categories such as Knowledge, Comprehension etc. were used as it was found that Bloom's subdivisions of these into finer sub-categories, such as ability to recall facts, carry out algorithms etc. were extremely narrow and too specific. However, these sub-categories proved useful for the classification of items into the cognitive levels. At first the selection of items and their classification by content and level was haphazard. Much of this could be attributed to the fact the objectives of a chapter in the S.M.E.A. books are not clearly stated. Thus no clear strategy for placing an item as belonging to a certain chapter could be used and often the only means of finding out the overall objectives of a chapter was through a careful examination of the questions at the end of the chapter itself. This task was further complicated by the fact that the content areas of several chapters overlap , a particular chapter often representing one or two cognitive levels while the application and analysis of the concepts being taught appeared in a different chapter. Thus for example, the chapter on coordinates (chapter 4 of Book One) presents and tests factual information, applying it in a limited sort of way tothe reading of coordinates and loci. This is built upon later on in the chapter on lines, curves and equations (chapter 11, Book One) which has questions on the further application and analysis of coordinates. This is not to imply that the use of a spiral approach to presenting mathematical concepts in the S.M.E.A. books is a major weakness of the texts. On the other hand this could be one of the strong points of the S.M.E.A. texts, developing and applying concepts already learnt and at the same time introducing the concepts at a higher cognitive level. Thus, for the construction of the tests it was necessary to combine together the content of several related chapters and place them under a single heading. This process made it easier to find sufficient number of items to represent each of the cognitive levels adequately. As mentioned earlier items had been written out on cards. The items were next screened through, reviewed and assessed for content validity, ambiguity, appropriateness of alternatives, relevancy and clarity. To make the task of marking easier it was decided to use only multiple choice items. From an initial collection of nearly 1200 items over 500 were rejected as being unsuitable for use in the study. The remaining 700 items were given further scrutiny by a mathematics teacher and finally the items were submitted to the supervisor, for examination in late November. The screening process had a particularly detrimental effect on items at the higher cognitive levels, i.e. application and analysis levels, a large number of which had to be rejected. However attempts were made to raise the number of these items so as to keep them to a minimum of four, in each test for all levels.

3.12 Description of the Major Categories in the Cognitive Domain into which Items were Categorised

As mentioned in section 3.11 four major categories from the cognitive domain of Bloom's Taxonomy of educational objectives were involved in this study. These were knowledge, comprehension, application and analysis. Although Bloom gives two more higher level categories, namely Synthesis and Evaluation, it was felt that these were well outside the objectives of S.M.E.A. and as such were left out. A brief description of the cognitive levels follows.

Knowledge is defined as the remembering of previously learnt material and is the lowest level of learning outcomes in the cognitive domain. Under this category instructional objectives tested include knowledge of facts, terminology and algorithms. An example of an item in this category is;

Q.1. Test 01. The four in the numeral 5042_{six} stands for

A. Ones
B. Sixes
C. Six sixes
D. Thirty Six sixes
E. None of these

In this question pupils are required to recall and state the value of the second digit which has a place value of two, in base six. Similarly Question Four, Test 01, tests for knowledge of algorithm necessary to multiply out; 125_{12} X 6_{12}.

<u>Comprehension</u> is defined as the ability to grasp the meaning of material. Items requiring translation (e.g. words to numbers), interpretation (e.g. reading information from graphs, charts, figures etc.) and extrapolation (e.g. estimating trends in data) were included in this category, which goes a step beyond the simple remembering of information and also represents the lowest level of "Understanding". Examples of items in translation and interpretation are the following;

Q.2. Test 01. 35_{eight} expressed as a numeral in base two is;

A. 11101
B. 100011
C. 101011
D. 10111
E. None of these.

Q.6. Test 08. The bar chart gives the price of a bag of maize during the first six months of 1975. The price of maize was 800 sh. in;

A. Jan & Feb. C. May

B. March D. April

E. May and April

Application refers to the ability to use material already learnt and apply it to new situations. This category includes questions in which pupils are required to solve problems, make comparisons, and analyse data by constructing charts, graphs and so on. Examples of questions placed into this category are;

Question 21, Test 01: Which of the following expressed in base seven is both prime and odd?

A. 11 C. 13 E. 15

B. 12 D. 14

This goes a step further than comprehension in that pupils translate the numbers from base seven to base ten and then examine the results to find out which are odd and prime.

Question 4, Test 02: In a class of 44 boys, 28 play tennis 20 play football and 6 do not play any game. The number of pupils who play both tennis and football in the class is;

A. 6 C. 8 E. 12

B. 7 D. 10

To solve this, pupils draw a Venn diagram showing two intersecting sets, work out the number in each set in terms of x, the number who play both football and tennis and then solve for x.

Finally, <u>Analysis</u> refers to the ability to break down material into its components so that its structure may be understood. This level calls for abilities such as solving non-routine problems, discovering relationships, constructing and criticising proofs etc. An example of items placed into this category follows;

Question 5, Test 01: A number system in base three uses the symbols X, +, ⊙, +X, ++, ... to correspond to zero, one, two, three, four, ... in the base ten. In this system five is represented by;

A. X⊙ C. +⊙ E. ++⊙

B. ⊙+ D. ⊙X

This item goes beyond the comprehension and application stages in that pupils are given symbols which they have never met before for numerals and they must apply their knowledge of number bases and place values to give the numeral for five.

3.13. <u>Final Arrangement of Items in the Tests</u>

After the selection of items for each of the major content areas at the four cognitive levels, the items were mixed in a random order within a test so that each of the levels was randomly spaced within the tests. This was necessary to ensure that pupils

did not devote all their time to lower cognitive level items and also to cut down on the number of subtests, a large number of which would otherwise have been necessary.

3.14. The Student Questionnaire

For the pilot study a sixteen item student Questionnaire was constructed for obtaining general information concerning pupil interests and background. Information on variables such as sex, age of pupils, educational and vocational status was sought.

3.15. The reading ability Tests (Cloze Test)

Initially five passages were selected randomly from the S.M.E.A. Books One and Two. Care was taken to avoid choosing passages beginning in the middle of a series of deductions or mathematical proofs. The first sentence of each of the selected passages was reproduced verbatim. The succeeding sentences had every fifth word deleted. Any figures, diagrams or graphs referred to in the passage were reproduced. Operations such as +, x, ÷, etc and symbols such as $\in$, $\geqslant$, $<$, were taken as distinct words. The students had to use the remaining words as clues to guess the words that had been deleted.

3.16. Attitudes Towards Mathematics Scale

The mathematics attitude and motivation scale used in the pilot study was a 48 item, Likert type of instrument. This scale had four subscales. These were an enjoyment of mathematics subscale, a subscale on difficulty of learning mathematics, a value of mathematics subscale and a scale on motivation in mathematics. The enjoyment and value of mathematics scales were developed by Aiken[30], and have high internal consistencies of 0.95 and 0.85 respectively. When Aiken analysed data by sex on these two scales the mean scores of men and women were found not to be significantly different on either of the scales. Further the correlations between the scores on the two scales were 0.64 showing that they were not measuring the same thing. Husen's scale on the attitudes about the difficulty of learning mathematics which had a high coefficient of reproducibility of between 0.89 and 0.92 for the thirteen year olds, was used in this study. The motivation in mathematics subscale was constructed by the researcher. Items for this scale were drawn from a general scale on motivation developed by Entwistle and Nisbet[31]. Thus in all, there were 48 items in the attitudes towards mathematics scale used in this study. Students were

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30. Aiken, L.R. Two scales of attitudes towards Mathematics. Journal of Research in Mathematics Education, Vol.5, No. 2, March 1974.

31. Entwistle, N. Scale on General Motivation developed by Entwistle and adapted for use here. Rep. In Br. Journal of Education. Psych. 1971

asked to respond to each of the statements by choosing one of five alternatives. These were 'Strongly agree', 'agree', 'uncertain', 'disagree' and 'strongly disagree'. These alternatives were weighted 2, 1, 0, -1, and -2, respectively with positive statements. The weights were reversed for negative statements. No points were given for items which were omitted.

3.2. The Pilot Study

In January 1976 a pilot study was carried out to gather information on the tests and to clarify and determine the exact steps and procedures to be followed in marking the tests, coding and arranging data and carrying out the statistical analysis necessary. For the pilot study a representative sample of 40 Form III students which included 19 girls and 21 boys was used. Factors such as age, level of ability (as reported by teachers), ethnic composition etc. were taken into consideration for the selection of the sample. It was found more convenient to use a coeducational school in the same category as the other secondary schools to be used in the main study. This made it easier to gather a sample of boys and girls, subjecting them to the same conditions of testing, timing etc., while at the same time making it unnecessary to have to duplicate the efforts separately for girls and boys.

3.21. Item and Scale Analysis of Tests used in the Pilot Study.

For each of the achievement tests the test reliability, test standard deviation and standard errors of measurement were computed. Besides these for each of the items in the achievement tests the item mean, the item standard deviation and item discrimination index was found. On the basis of values of item means, item standard deviations and item discrimination indices decisions were made as to whether an item was to be retained, improved upon or rejected altogether, and replaced by more suitable ones. As a rough guide decisions on items were made using values of facility indices and discrimination indices given by Macintosh and Morrison (66,1969, p. 67). For ease of reference this table is reproduced here, Table XXII.

Table XXII: Range of facility values and discrimination indices for decisions on items.

	Facility Values		
	Below 40	40 to 60	Above 60
Discrmn. Index			
Above 0.4	Difficult	Accept	Easy
0.30 - 0.39	Difficult	Improvable	Easy
0.20 - 0.29	Difficult	Marginal	Easy
Below 0.20	Reject	Reject	Reject

Thus generally items which had discrimination indices below 0.20 were rejected. Similarly items with facility values above 60% were regarded as too easy.

Kuder Richardson Reliability Coefficients for the tests were calculated using Stanley's approximation to K - R formula 20 based on the top 27% and bottom 27% of the candidates. Table XXIII gives the values of the reliability coefficients calculated after the pilot study.

Table XXIII: Reliability Coefficients of Achievement Tests from Pilot Study Data.

Test Title	Rel. Coeff.	Test Title	Rel.Coeff.
Number Systems	0.57	Integers&Rationals	0.88
Sets	0.79	Mappings	0.32
Fractions	0.80	Drawing & Measuring	0.42
Number Patterns	0.74	Angles	0.08
Equations & Identities	0.40	Order & Punctuation	-0.70
Rotation	0.80	Reflection	0.67
Statistics	0.70	Similarity & Enlargmt	0.40
Area	0.60	Natural Numbers	0.15
Polygons & Polyhdra	0.45	Linear relations	-0.93
Vectors	0.30	Logarithms	0.29
Computation	0.47	Sine & Cosine	-0.49
Pythagoras theorem	0.87	Coordinates	0.57

This table shows that out of the 25 tests, 5 tests had reliabilities of 0.30 and less. These were the tests on Angles, Order and Punctuation, Natural Numbers, Linear relations and Sines and Cosines. These tests were found to contain on an average more than 75 per cent unacceptable items. As a fresh start in constructing items to replace these would have considerably upset the timing of this study it was decided to omit these tests altogether from the achievement test battery.

Besides these, ten tests had poor reliability coefficients in the range from 0.29 to 0.60. These were the tests on Number systems, Equations and Identities, Polygons and Polyhydra, Vectors, Computation, Mappings, Drawing and Measuring Solids, Similarity and Enlargement, Logarithms, and Coordinates. The remaining nine tests had reliabilities in the range of 0.60 to 0.88. These tests were accepted with slight changes of items. A detailed item analysis by tests was carried out and has been reported in a separate "Pilot Study Report" submitted to the Supervisor in February, 1976.

3.22. <u>Analysis of Pilot Study Data on the Achievement Tests</u>

To gain insight into the nature of the statistical analysis involved in the testing of the hypotheses as set out in the proposal,a detailed analysis of the data from the pilot study sample was carried out. This was not in any way intended to prove or disaprove any hypothesis as such as most of the tests used would not be valid for the small size of samples used. A four way analysis of variance was found most convenient in testing the hypothesis of no differences between the performance by content areas and levels, as well as interaction due to levels, sex or content. The t - test proved useful for testing differences

between the sexes on variables such as reading ability, value of mathematics, enjoyment of mathematics etc.

Aitken's method of pivotal condensation as outlined by Ferguson (67,1971) was found more convenient in establishing a regression equation relating the dependent variable (mathematics achievement) to the independent variables used in the study (e.g. reading ability, aspirations of pupils and attitudes towards mathematics).

3.23. The Major Findings of the Pilot Study

Despite the limitations of the pilot study in terms of sampling and the poor reliability coefficients of some of the tests the major conclusions drawn from the pilot study were;

1) There are no significant differences at the .01 or .05 levels between the performance of girls and boys on their overall achievement in mathematics.

2) There are no significant differences in the performance of pupils in the pilot study sample on tests assessing mastery of topics from the S.M.E.A. Books One and Two.

3) Although no significant sex differences in the performance of the pilot study sample at the four cognitive levels tested were found, differences in the performance at the four levels were significant at the .01 level for the pilot study sample as a whole (i.e. boys and girls considered together on tests). In general the pilot study pupils performed best on application items, followed by comprehension,

knowledge and least well on analysis items.

On the attitude subscale it was found that boys tended to enjoy mathematics more, were more strongly motivated and had a higher value attachment to mathematics than girls. Surprisingly enough, girls found mathematics easier. The multiple correlation coefficient calculated was 0.424 showing that the six independent variables considered (namely age, reading ability, motivation, enjoyment of mathematics, value of mathematics and difficulty of learning mathematics) were poor predictors of mathematics achievement as a whole.

3.3. THE MAIN STUDY

3.31. Preliminaries: Test Revision

During February 1976, the 25 tests used in the pilot study were redesigned taking into consideration the item and scale analysis data for each of the items and tests. The loss of items was fairly high. As already noted 5 out of the 25 tests were totally rejected, as they had more than 75 percent unacceptable items and the reliability coefficients were less than 0.30. Thus the tests on Angles, Order and Punctuation, Natural Numbers, Linear relations and Sines and Cosines were excluded from the main study. Besides these, three other tests, which were found to have "improvable" reliability coefficients had to be left out of the main study as difficulties arose in finding enough testing sessions in the three stream schools. This left a total of seventeen tests. Seven of these had acceptable reliability coefficients in the range from 0.70 to 0.88 and these were therefore used in the main study with minor alterations. The remaining ten tests which had reliability coefficients between 0.30 and 0.70 were completely revised before being used in the main study.

The final result was seventeen separate test booklets, each having between 16 to 21 items. All the items were of the multiple choice type. Copies of five of the tests as used in the main study are included in the Appendix (Appendix V). Appendix VII records the classification of items into cognitive levels for each of the seventeen tests.

3.32. Selection of the Research Sample for the Main Study

The sample used in this study consisted of a random stratified sample of six secondary schools drawn from Nairobi Province. All the schools were category A fully maintained schools. There are four main categories of schools in Kenya. These are category A, B, C and D schools. The majority of category A and B schools are fully supported by the Government, are foften well-established schools with between 3 to 6 streams in each form Category C and D schools are mostly unaided or semi-aided single stream schools. The majority of private schools fall in this category. There is a total of 22 category A, fully maintained secondary schools in this province and these constitute the target population being aimed at in this study. The distribution of schools by sex in the target population and in the research sample is laid out in table XXIV:

Table XXIV: Distribution of schools in the Target Population and in the Research Sample.

Group	Number of Boys' Schs.	Number of Girls Schs.	Number of Coed.Sch.	Total
Target Population	13	8	2	23
Research Sample	3	2	1	6

Thus a representative random sample of 6 schools, stratified by sex were selected. Three of these were boys' schools and two were girls' schools. The sixth was a mixed school. Only two girls' schools were chosen as on the whole there are fewer girls' schools. However, the proportion of girls' schools chosen for the main study is the same as that for boys (approximately a quarter of the total population of schools for each sex). The choice of a mixed school was necessary as this would have made it possible for the researcher to find out if sex differences are just as large, smaller or altogether absent in coeducational schools. Also it would have enabled the teacher variable and its effect to be more rigidly controlled, as girls and boys in coeducational schools would have undergone the same instruction and any differences observed would have to be explained in terms of factors other than instruction. There were only two coeducational secondary schools in Nairobi Province and as one of these had been involved with the pilot study it was decided to use the only remaining school for the main study. Unfortunately, the proportion of girls in this school was very small (30 out of the total of 106 students in Form III). It was decided to use all the students from each of the Form III classes within the schools. In this way it was hoped to avoid bias in selection as all the schools had pupils streamed according to ability or according to subject combinations (Arts or Science and General), which results in the cleverer pupils being put into classes offering pure science subjects and the "weak" pupils ending up in the 'General' classes. Table XXV gives the distribution of pupils within schools and by sex.

Table XXV: Distribution of Pupils in the Research Sample by Schools and by Sex.

		No. of Pupils	Totals
BOYS	School 1	107	410
	School 2	129	
	School 3	108	
	School 4	76	
(MIXED)			
GIRLS	School 4	30	204
	School 5	71	
	School 6	103	
			614

Only one of the schools had four streams. One girls' school had two streams. The ratio of boys to girls in the research sample was originally intended to be approximately 2 to 1. However, in practice it turned out that only 382 of the boys had scores on all the variables involved in this study. This was due to absenteeism or due to other disturbances especially in the schools tested during the last week of the school term. Attendance in girls' schools was more regular and there were very few cases of absenteeism. Often the cooperation of teachers was requested in giving tests to pupils who had missed a test and the returns were almost 100 percent. In one case completed tests were sent to the researcher by a teacher who had to wait for more than a week for pupils who were absent. Only one of the boys' schools had classes doing "A" levels. Similarly one of the girls'schools had two streams for "A" levels. The mixed school also had three streams for "A" levels. All the schools had pupils with similar ethnic and social backgrounds. This may not be true for socio-economic status of pupils. One of the boys' schools draws its pupils from low socioeconomic background pupils, orphans or handicapped pupils. One of the girls' schools draws its pupils from high socioeconomic status homes with parents in well paid professional occupations.

3.33. Test Administration Procedures

3.331. Testing Problems:

For one reason or another the headmaster of three of the schools chosen in this study would not allow more than a single morning and afternoon session for testing. One of these compromised by allowing testing to start after break and proceed into the following afternoon. The remaining three schools preferred to have the testing done during the mathematics periods only, as the headmasters claimed this would otherwise lead to interruptions in the normal school schedule and to complaints by other subject teachers who would miss their lessons. Hence in these schools it was necessary to give the tests during the normal periods for the mathematics lessons. This often meant that each class had to be visited separately for the administration of the tests and the testing had to be spread over as long as a week in these schools. This was further complicated by the fact that some of the streams had only five periods a week for mathematics while other streams in the same school had as many as nine periods per week. In general the cooperation of the mathematics teachers was sought in carrying out the testing in the classrooms in these three schools. Thus there was at one hand the problem of squeezing in a sufficient number of testing sessions into a single morning and afternoon session in three of the schools without over-burdening the teachers or pupils and on the other hand using isolated 40 minute periods to complete single tests in the other three schools. It was therefore necessary to strike a balance between the number of tests to be given to each class and the maximum time available. All the seventeen achievement tests and the General Questionnaire, cloze test and Attitude Scale could obviously not be given to all the pupils as was done in the pilot study which was spread over a two week period with a single class. Finally, it was decided to administer the General Questionnaire, cloze test and Attitude Scale to all the pupils but to allocate randomly the seventeen achievement tests so that each class sat a minimum of three of them. Further it was decided to have all the seventeen achievement tests administered in each school. This made it possible to have at least 80 boys randomly chosen from the boys' schools sitting each of the seventeen achievement tests and 50 girls randomly chosen from the girls' schools sitting each of the seventeen achievement tests. Hence, in all each boy or girl sat the General Questionnaire, the Cloze test, the Attitudes Questionnaire and between three to six achievement tests.

3.34. Test Scoring and Data Coding

The achievement tests were marked manually, one mark being given for each correctly answered question. In each test the total score and subscores at the four cognitive levels being tested were recorded onto computer coding sheets. Responses to all the items in the General Questionnaire were also coded so as to enable the researcher to use the University computer services for analysis of the data. Initially, data was coded giving a score of 1 to response A, 2 to response B, 3 to response C etc. for all items in the general questionnaire but this turned out to be highly inconvenient and made it necessary to recode this.

For example, the responses to the question; "Do you want to do your 'A' levels after Form four?" were initially coded as a '1' for 'Yes', '2' for 'No' and '3' for 'Uncertain'. This was later changed to the more useful form of '2' for 'Yes', '1' for 'Uncertain' and '0' for 'No'.

The biggest problem facing the coding of the responses to the Attitudes Questionnaire was in the resorting of the items so as to obtain a total for each of the four attitude subscales. As previously observed the attitude tests had items randomly mixed up. This made the recording process extremely laborious and time consuming, especially as 47 items in all were involved. Also the codes, +2, +1, 0, -1, -2 as employed in the pilot study for the attitude scales were found inconvenient when it came to using the computer for analysis as the signs occupy a separate column by themselves. Hence these weights were changed to 5, 4, 3, 2, and 1 with a weight of 5 & 4 being given for positive statements, and the order being reversed for negative statements.

CHAPTER FOUR

FINDINGS.

4.0. Introduction

This chapter gives an outline of the techniques of analysis and a description of the findings pertinent to each of the hypothesis as given in chapter One, page 23 . A discussion of the Analysis of Variance procedures used for testing the null hypotheses of no differences between the sexes, the tests and the four cognitive levels is given in section 4.1. Modifications were necessary for data analysis using Analysis of Variance. These are described in section 4.11. The use of University computer services is outlined in section 4.12. This is followed in section 4.13 by a description of Duncan's New Test for Multiple Comparisons of means. This was used to establish which of the particular differences in the means for tests or levels were significant. The t-test was used to test for significance of differences between means of boys and girls on the attitude scales and the other variables such as educational and vocational aspirations and reading ability scores. In section 4.14 details of the regression analysis carried out to determine which of the variables were significant predictors of achievement in mathematics are given.

Section 4.20 presents the results of the data analysis and on the basis of the results indicates whether the null hypotheses as set out in chapter one are rejected or accepted. The results of the

Analysis of Variance on the achievement tests are given in section 4.21. This is followed by the results of the comparisons between boys and girls on the three attitude scales, the personality variable, reading ability scores and the educational and vocational aspirations of the Form III pupils (section 4.3 to 4.6). The results of the regression analysis are included in section 4.70. Finally, a description of other findings not related specifically to any of the hypotheses is included in section 4.80. This includes, for example, findings of comparisons between pupils from single sex schools and coeducational schools.

4.1. DESCRIPTION OF STATISTICAL TESTS USED FOR ANALYSIS OF DATA.

4.10. Analysis of Variance

Figure Ldepi
Figure I depicits the research situation of a simple one way analysis of variance design.

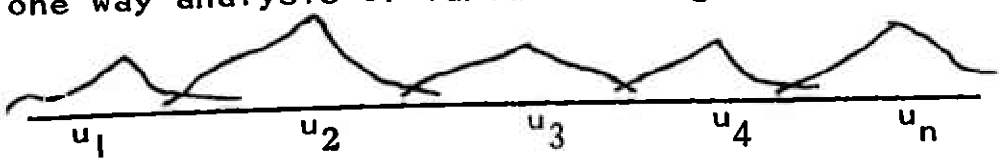

Figure I: A simple One Way ANOVA Research Situation.

u_1, u_2, u_3, u_4... u_n represent the means of n different populations on the dependent variable and the research issues concern the "realness" or significance of differences in the population or sample means. The dependent variable is assumed to be normally distributed in each of the populations. To test for hypotheses concerning the equality of the means the F - distribution is used. There are three basic assumptions for the use of an F-distribution in testing the null hypothesis of no differences between the means of the samples. These are;

1. Observations are drawn randomly from a normally distributed population.
2. Observations represent random samples from populations, and
3. Variances of the populations are equal.

While the basic question concerns the equality of the means it is the sample variances which are analysed. Each score on a test, represents the effects of several sources of variability such as internal variation from one sample to another, variability due to experimental conditions or uncontrolled variables such as distractions etc. Thus in a research design an attempt is made to break down the total variation in the scores into its components.

In the present study, the dependent variable is the score of pupils on the mathematics achievement tests. The total variation of scores of pupils on the tests was attributed to three factors. These were the content of the tests, the cognitive levels of items in the tests and the sex of pupils. Thus the total sum of squares was partitioned into sums of squares representing a source of variation due to content, cognitive level and sex of pupil. Figure 2 is an attempt to show the steps followed in the partitioning of the total sum of squares.

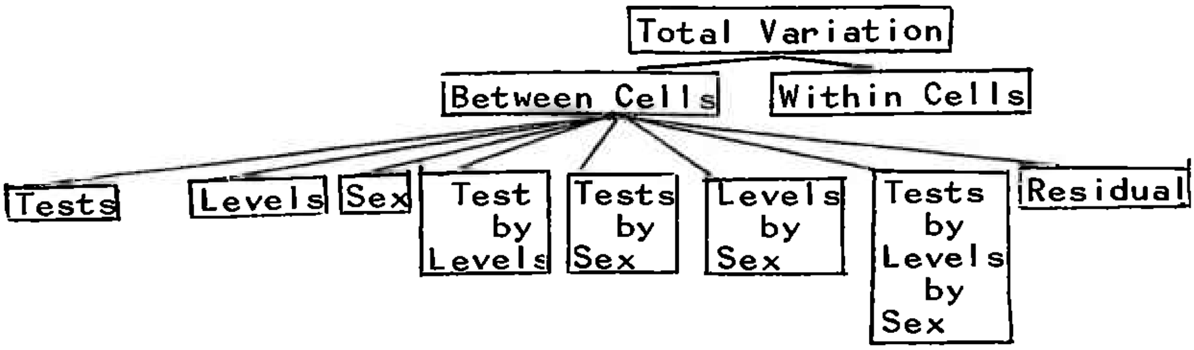

Figure 2: Breakdown of variation in total scores in the study.

The total variation was separated into the differences between Cells and differences within cells, a cell containing the score of a pupil in a particular sex group for a test at a certain cognitive level. Differences between cells were then analysed into components sum of squares due to what are known as main effects due to tests, levels, and sex. Besides this there are three first order interactions (Tests by Levels, Tests by Sex, and Levels by Sex). There is one second order interaction (Tests by Levels by Sex). In addition a sum of squares for differences between pupils was removed from the variation within the tests by levels interaction, leaving a residual sum of squares which expresses the interaction of pupils with levels, within the test by level classification.

In the pilot study the 'pupil' factor was nested within the sex factors, but within each sex was crossed with content or test and level factor. Therefore a four way analysis of variance was used in the pilot study - a four way in that each score could be classified in four ways i.e. as belonging to a sex, a content area, a cognitive level and a pupil. Further in the pilot study it was possible for each pupil to sit each of the tests and therefore all the subtests included in them, with the result that each of the cells for Boys and Girls contained the scores of the same forty pupils in the same order. This can be seen more clearly by examining table XXVI, in which a score like

Table XXVI: Layout of the Data in the Research Study.

		(CONTENT AREAS(TESTS)				
Sex	Levels	1	2	3	4	17
	Knowledge	$x_1, x_2 ..$	$x_1, x_2 .$	$x_1, x_2 ......$		$x_1, x_2 ..$
Boys	Comprehension	$x_1, x_2 .$	$x_1 ..$	$x_1 .....$		$x_1 ....$
	Application	$x_1, x_2 ..$	$x_1, x_2 ..$			
	Analysis	$x_1 ..$	$x_1 ...$			$x_1 ....$
	Knowledge	y_1	y_1	y_1		y_1
Girls	:					
	Analysis	y_1	y_1	y_1		y_1

Note: x_1 : indicates the score of one boy at each level and test.

y_1 : indicates the score of one girl at each level and test.

x_l or y_l represents the score of the same pupil. A cell contains scores such as x_1, x_2, x_3, x_4, ... x_n.

4.11. Modifications of Analysis of Variance Procedures for Data Analysis in the Main Study.

In the main study it was no longer possible to use the same layout of the analysis of variance as was done for the pilot study. There were a number of reasons for this. As mentioned earlier each of the seventeen achievement tests were administered randomly to the pupils. Inspite of attempts by the researcher to control the distribution of tests so that approximately the same number of boys and girls sat each of the tests, it was discovered that eventually some of the tests were administered more often than others with the result that more pupils sat a certain test than necessary while, too few sat another. This was further aggravated by pupil absenteeism and other distractions. Thus, for example, in one class when the researcher turned up for testing half the class was out on punishment for truancy on the previous day. In one of the girls' schools which had allowed only a morning and afternoon session for testing, the entire Music Club, involving some 20 girls of Form III, was called away to rehearse for appearance on Voice of Kenya Television. Besides this subject mortality (e.g. pupils 'disappearing' after a test or two for unknown reasons, incomplete answer sheets e.g. missing names) resulted in unequal and disproportionate cell frequencies. The magnitude of the problem can be assessed when it is pointed out that out of a total enrolment of over 410 boys a regression analysis could be carried out only on 382 boys, who had scores on each of the variables under study.

In the present case, for the achievement tests the cell frequencies ranged between 134 and 171, and using the usual formulae for computing the Sums of Squares involved would have been erroneous as each Sum of Squares would then contain the variation from a mixture of sources including two or more main effects. One way out of this situation was to undertake the cumbersome analysis of variance procedures based on the least squares principles, which although mentioned by most statistical texts as the alternative to the case of equal cell frequencies, is rarely treated in details by the authors. It was therefore decided to eliminate data from certain of the cells by a random process so as to achieve balance in the sense of equal or proportional cell frequencies. By this method it was found that for each of the seventeen tests, scores were available for random samples of 82 boys and 52 girls. This enabled the researcher to use the computational procedures for unequal but proportional cell frequencies, as described for example by Kirk (68,1968) or by Glass and Stanley (69,1970).

4.12. Use of the University Computer Facilities for Data Analysis

Two sets of data were submitted to the University computing centre for punching and subsequent running on the computer. However, the use of the computer was limited by the fact that data had to be analysed by the available program packages which have rigid input and output formats. Thus for example, the two way analysis program available catered only for twelve by three by two factorial design. Modifying the program for use here would have proved expensive in terms of time as well as finances. A One Way Analysis of Variance package was available (SO4A) and was useful for testing the significance of certain variables. The first set of data punched and run were the scores of pupils on the seventeen achievement tests with scores on each of the four subtests. The other set of data punched onto computer cards and eventually transfered to a magnetic tape included pupil responses to the General Questionnaire and the Attitude Scales. The attitude subscale totals, percentage scores for Knowledge, Comprehension, Application and Analysis as well as total mathematics scores were also recorded on the same card. Program package SFPE and Regression Analysis Package XDS3 were run for this set of data, separately for boys and girls. SFPE provided frequency count results for each of the variables and also gave values of means and standard deviations for all the variables. XDS3 gave the results of the regression analysis for 14 variables.

4.13. Supplementary Analysis Following the Analysis of Variance.

Following rejection of the null hypothesis of no differences between the means of the samples it was necessary to find out which particular means differ significantly from each other. As the numbers of tests involved was 17 this would have meant using the t-test 136 times ($\frac{1}{2}$ X 17 X 16) to make all pairwise comparisons. Duncan's New Multiple Range Test was used to make all pairwise comparisons. For this the means were ranked in order of size in the form of a matrix and the differences between the means were entered in the table. This has been done for example in table XXX, page 116 . Duncan's table of percentage points was entered using the degree of freedom for Error Sum of Squares and values of r, which is the number of steps separating the two means. The difference W_r, that a comparison must exceed in order to be significant was given by Duncan's formula as:

$$W_r = q_r; \alpha_r \sqrt{\frac{MS_{error}}{n}}$$

where q_r was obtained from Duncan's table of percentage points, α is the level of significance (0.01 or o.05) and r is the number of steps separating the two means.

4.14. Multiple Regression Analysis

The aim of performing a regression analysis was to study the relation between the independent variables such as attitudes, educational and vocational aspirations of pupils, and motivation scores as compared to the scores on the dependent variable i.e. mathematics achievement scores. This was necessary for the hypothesis on prediction, and to explain the variance of the dependent variable by estimating the contribution of each of the independent variables. The amount of variance shared by two variables was found using the square of the correlation coefficients between the two variables[32]. One of the statistics obtained from the multiple regression was the Coefficient of Multiple Correlation, R. This tells us about the magnitude of the relation between the independent variables and the dependent variable. To find out if the relation was significant the F ratio was used:

$$F = \frac{R^2 / k}{(1 - R^2) / (N - k - 1)}$$

where k is the number of independent variables and N is the total number of cases. R is the Coefficient

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32. This was not possible as it later turned out that the correlation between the independent variables were not zero.

of Multiple correlation. If the calculated F ratio was greater than the tabled F value for k and N-k-1 degrees of freedom the relation between the independent variables and mathematics achievement was taken to be significant.

4.20. FINDINGS OF THE INVESTIGATION

4.21. Results of the Analysis of Variance on the Achievement Test Scores

Table XXVII presents the results of the Analysis of Variance on the achievement test scores of the random samples of 82 boys and 52 girls, who sat the tests.

Table XXVII: F - ratios of the mathematics achievement test scores for effects of Sex(A), Tests (B) and Levels (C) and their interactions.

Source of Variance	Sum of Squares	Degrees of Freedom	Mean Squares	F	P
Sex (A)	27.94	1	27.94	22.53	0.01
Tests (B)	779.85	16	48.74	39.31	0.01
Levels (C)	560.54	3	186.85	238.56	0.01
Sex by Tests	66.71	16	4.17	3.36	0.01
Sex by Levels	7.05	3	2.35	3.01	.025
Tests by Sex	734.83	48	15.31	19.63	0.01
Sex by Tests by Levels	59.18	48	1.10	1.58	n.s.
Pupils within Sex by Levels	2,780.10	2,244	1.24		
Residual	5,269.40	6,732	0.78		
Totals	10,284.58	6,799			

This analysis of Variance was repeated using the scores of a random sample of 50 boys and 50 girls. The analysis of Variance summary table for this case is included in the Appendix(Appendix II). Comparison between the two tables showed that the results in both the cases were identical in every respect, except that the sex by levels interaction was not significant in the 50 boys - 50 girls random sample while in the 82 boys - 52 girls the sex by levels interaction was significant at the 2.5% level of significance. The general conclusions drawn from the Analysis of Variance are as follows;

1. There are significant differences between the sexes in their overall performance on the achievement tests. Thus the null hypothesis of no differences between the performance of Form III boys and girls is rejected.

2. There are significant differences in the performance of Form III pupils i.e. boys and girls considered together, on tests assessing mastery of topics from the SMEA text Books One and Two. Thus the null hypothesis I(c) asserting that there are no differences on the achievement test scores in various content areas of SMEA Books One and Two is rejected.

3. There are significant differences in the performance of Form III pupils (boys and girls considered together) on subtests assessing their ability at the four cognitive levels under consideration. Thus the null hypothesis that there

are no differences on the achievement test scores at the Knowledge, Comprehension, Application and Analysis cognitive levels is rejected.

4. There are significant interactions between tests and sex i.e. The performance of Form III pupils on the tests is dependent on the sex of pupils. Thus the null hypothesis of no differences between girls and boys of Form III on their achievement test scores in various content areas of S.M.E.A. Books One and Two is rejected.

5. There are no significant interactions between sex and cognitive levels at the 1% level of significance. However, these interactions are significant at the 2.5% level of significance. Thus we can conclude that at the 2.5% level of significance, there are no differences between girls and boys in their performance on Knowledge, Comprehension, Analysis and Application subtests.

6. Significant interactions occur between tests and levels. Thus the performance of pupils varies not only from test to test but also by levels.

7. The interactions between tests, levels and sex are not significant at the 1% level of significance.

4.22. <u>Sex Differences in total scores on the Achievement Tests</u>.

The analysis of variance showed that there are significant differences between the achievement test scores of Form III boys and girls. The t - test was used to find out which of the sexes the differences favour. Table XXVIII records the means, standard deviations and t - values for comparisons between the sexes on the overall scores expressed as percentages.

Table XXVIII: Means, Standard Deviations and t-values for comparison between the sexes on overall scores on the Achievement Tests.

Sex	Number	Mean	Standard Deviation	t-value	p
Boys	382	41.406	10.961	3.922	.01
Girls	204	35.657	11.086		

Hence significant differences in the overall mathematics achievement scores occur in favour of boys.

4.23. Test for Violation of the Homogeniety of Variance Assumption.

The sample groups used in this study were independent random samples of boys and girls. A basic assumption for the use of the t-test or the ANOVA for comparing means is that the sample variances are homogeneous. To find out if this was true for this study the F-ratio was used to test the hypothesis that the variances of the two populations are equal. The calculated F-ratio was;

$$F = \frac{(11.086)^2}{(10.961)^2} = 1.023$$

This is less than the tabled value for 203 and 381 degrees of freedom. Hence it was concluded that the variances of the two populations on their mathematics achievement scores are homogeneous.

4.24. Differences in the performance of Form III students on Achievement Tests.

As mentioned in section 3.21, Chapter 3, tests which had reliability coefficients below 0.30 were rejected. Tests which had reliability coefficients in the range of 0.30 to 0.69 were completely overhauled. These were the tests on Number Systems, Equations, Area, Polygons and Polyhdra, Vectors, Mappings, Computation, Coordinates and drawing and Measuring. The recalculated reliability coefficients for these tests are recorded in Table XXVIV.

Table XXVIV: Reliability Coefficients of tests reconstructed after the pilot study.

Test Title	(1)	(2)	Test Title	(1)	(2)
Number system	0.57	0.66	Computation	0.47	0.86
Equations	0.40	0.78	Coordinates	0.57	0.58
Area	0.60	0.76	Mappings	0.32	0.47
Polygons & Polyhydra	0.45	0.55	Drawing & Measurement	0.42	0.78
Vectors	0.30	0.59			

N.B. (1) Column 1 records the reliability coefficients as obtained in the pilot study.

(2) Column 2 records the recalculated reliability coefficient from the Main Study data.

For comparison purposes the reliability coefficients obtained in the pilot study are given. Thus it can be reasonably assumed that the reliability coefficients of the achievement tests lie between 0.47 and 0.88.

The analysis of variance summary table revealed significant differences between the performance of pupils on the seventeen tests used in this study. Table XXX, gives the results of Duncan's multiple comparison procedure carried out for the all Pairwise Comparisons among the means of the achievement tests.

The Form III pupil's performance was best on test number ten, the test on "Polygons and Polyhdra". Infact, the pairwise ontrasts between the means of this test and the means of all the other sixteen tests was significant at the 0.01 level. After this came test number seventeen, the test on "Percentages and regions". However, comparison with the means of other tests shows that the difference in means is significant only with nine other tests. Other tests which were fairly well done include the test on "Sets" and "Rotation" on which the pupils score 47% and 46% respectively. The Form III pupils obtained between 40% and 60% marks on the tests on fractions, Three Dimensional Geometry, Statistics and on the test on Area. The least well done test was the test on Equations, on which the Form III pupils scored an average of 29%. Surprisingly the

Table XXX : Comparison Of Means Of Achievement Tests For Form III.

Test Title	Mean	Differences Between Means of Tests.																
Equations	4.64	-	.22	.32	.83	.90	1.22	1.27	1.54	1.63	2.09	2.1	2.14	2.31	2.47	2.75	2.83	4.45
No. Systems	4.86		-	.10	.61	.68	1.0	1.05	1.32	1.41	1.87	1.88	1.92	2.09	2.25	2.53	2.59	4.32
Vectors	4.96			-	.51	.58	.90	.95	1.22	1.33	1.77	1.78	1.82	1.99	2.15	2.43	2.51	4.22
Pythag. Therm.	5.47				-	.07	.39	.44	.71	.80	1.26	1.27	1.37	1.48	1.64	1.92	2.0	3.71
Computation	5.54					-	.32	.47	.64	.73	1.19	1.20	1.24	1.41	1.57	1.85	1.93	3.64
Number Patterns	5.86						-	.05	.32	.41	.87	.88	.92	1.09	1.25	1.53	1.61	3.32
Rational Nos.	5.91							-	.27	.36	.82	.83	.67	1.04	1.20	1.48	1.56	3.27
Coordinates	6.18								-	.09	.55	.56	.60	.77	.93	1.21	1.29	1.30
Mappings	6.27									-	.46	.47	.51	.68	.84	1.12	1.20	2.96
Area	6.73										-	.01	.05	.22	.38	.66	.74	2.45
Statistics	6.74											-	.04	.21	.37	.65	.73	2.44
3- Dim. Geom.	6.78												-	.17	.33	.61	.69	2.40
Fractions	6.95													-	.16	.44	.52	2.23
Rotations	7.11														-	.28	.36	2.07
Sets	7.39															-	.08	1.79
Percent. Region.	7.47																-	1.7
Polygons & Polyh.	9.18																	-

*Significant at .01 level of Significance

Notes on Table XXX ;

1. The Standard Error Of Means was 0.217.
2. The values of the Shortest Significant Ranges were as follows ;

Rank Difference Between Two Means	2	3	4	5	6	7	8	9	10	11
Shortest Significant Range	.80	.84	.86	.88	.90	.91	.92	.92	.93	.94

Rank Difference Between Two Means	12	13	14	15	16	17
Shortest Significant Range	.94	.95	.95	.95	.96	.96

3. A difference Between two means is significant if it exceeds the values of the Shortest Significant Range as entered in Note 2 above. The rank difference between two adjacent means is two, and those further away have rank differences of three, four and so on.

test on Number Systems was also poorly done as were also the tests on Vectors , Pythagoras theorem and Computations, Number Patterns, Rational Numbers, Coordinates and Mappings (Scores between 30% - 39%). Thus we can conclude that there are significant differences in the performance of Form III pupils on tests assessing mastery of topics from S.M.E.A.

4.25. Differences in the performance of the Form III Pupils on Cognitive level subtests.

The Analysis of variance also showed that the form III pupils differ significantly in their cognitive level abilities, i.e. pupil performance depends on whether the items were testing Knowledge, Comprehension, Application or Analysis. Duncan's New Test on Multiple Comparisons was used to test for significance of differences between the means at each of the cognitive levels for the pupils. Table XXXI records the results of comparisons between the means of the tests. The means recorded in table XXXI are the percentage scores obtained at each cognitive level.

Table XXXI: Comparisons between means of total cognitive level subtest scores for pupils of Form III.

Cognitive	Means (as %age)	Analysis	Application	Comprehension	Knowledge
Analysis	30.41	-	8.41*	13.66*	16.00*
Application	38.82		-	5.25*	7.59*
Comprehension	44.07			-	2.34*
Knowledge	46.41				-

* Significant at .01 level.

Degrees of Freedom for Error Sum of Squares was 2340.

The Standard Error of Mean, S_m was 0.198. The values of the Shortest Significant Ranges (SSR) were as follows;

For a rank difference of two between means SSR = 0.72

For a rank difference of Three between means SSR = 0.76

For a rank difference of Four between means SSR = 0.78.

Table XXXI shows that all the six pairwise comparisons between the means for each of the cognitive levels were significant at the .01 level of significance. The difference between the means of pupil scores for knowledge items and Analysis items were largest (16.00) while small (though significant) differences are found between the Knowledge and Comprehension means (2.34*). In general Form III pupils do best on subtests for Knowledge items obtaining an average of 46.41% while the performance on the highest Cognitive level i.e. Analysis, was the poorest (30.41%).

4.26: Sex by Tests Interaction.

The analysis of variance revealed that there were significant sex by test interactions in the performance of Form III pupils. To find out more about this the performance of boys and girls on the tests was compared using the t-test. Table XXXII presents the means and standard deviations for the tests.

Table XXXII: Means, Standard Deviations and t-values for comparisons between sexes.

Test No.	Content	Boys Mean	SD	Girls Mean	SD	d	t-value	P
1	No. Systems	5.22	2.95	4.50	2.47	+0.72	1.32	n.s.
2	Sets	7.36	2.18	7.42	1.92	-0.06	0.15	n.s.
3	Natural Nos.	6.02	1.77	6.34	2.51	-0.32	0.74	n.s.
4	Fractions	6.62	2.61	7.28	3.14	-0.66	1.14	n.s.
5	No. Patterns	6.04	2.16	5.68	2.12	+0.36	0.84	n.s.
6	Equations	5.26	1.48	4.02	1.87	+1.24	3.36*	0.01
7	Rotation	7.70	2.84	6.52	2.80	+1.18	2.12*	0.05
8	Statistics	7.10	2.70	6.38	2.74	+0.72	1.33	n.s.
9	Area	7.02	2.28	6.44	2.62	+0.58	1.18	n.s.
10	Polygons and Polyhydra	9.14	1.54	9.22	3.04	-0.08	0.17	n.s.
11	Pythagoras theorem	5.84	1.70	5.10	2.35	+0.74	1.80	n.s.
12	Vectors	4.62	1.98	5.30	2.27	-0.72	1.66	n.s.
13	Computation	5.44	2.31	5.64	2.50	-0.20	0.42	n.s.
14	Rational Nos.	6.66	2.01	5.16	2.84	+1.50	3.05*	0.01
15	Mappings	6.08	1.80	6.46	2.72	-0.38	0.83	n.s.
16	3 dimensional Geometry	7.86	2.70	5.70	2.30	+2.16	4.31*	0.01
17	Percentages, Regions	6.88	2.13	8.06	3.16	-1.18	2.69*	0.01

A minus indicates differences favour girls.

Significant differences between boys and girls were found on five out of the total of seventeen tests. On three of these, boys were significantly better than girls at the 1% level of significance. These tests were the tests on Equations, Rational Numbers and Three Dimensional Geometry. Boys were significantly better than girls, at 5% level of significance, on one other test. This was the test on Rotation.

Girls' performance was superior to boys on eight of the tests. However, significant differences were found in favour of girls only on the test on Percentages and Regions at the 1% level of significance. On the remaining seven tests differences favoured girls but were not significant. Thus in all, boys were superior in nine tests, girls on eight tests. Boys did significantly better on four of the tests and girls on only one test.

4.27. Sex by Levels Interaction

The analysis of Variance using the random sample of 50 boys and 50 girls revealed no significant sex by levels interaction. However, this interaction was found to be significant at the 2.5% level of significance using the total research sample of 82 boys and 52 girls for each of the achievement tests. However, the F-ratio for the sex by levels interaction Sum of Squares was not significant at the .01 level. To gain further insight into the nature of these differences between the sexes the t-test was used to compare the performance of boys and girls at the four cognitive levels for each of the tests. Table XXXIII gives the means, standard deviations and t-values for comparison of boys and girls for the lowest cognitive level i.e. Knowledge. Boys performed significantly better than girls on the Knowledge items in test Number 16, the test on Three Dimensional Geometry.

Table XXXIII: Comparison of boys' and girls' Scores on Knowledge Items by tests.

Test Title	Boys Mean	S.D.	Girls Mean	S.D.	d	t	p
Number Systems	1.80	1.21	1.52	1.34	+.28	1.05	n.s.
Sets	2.74	1.16	2.90	1.04	-.16	0.73	n.s.
Natural Numbers	1.76	0.89	1.82	1.06	-.06	0.31	n.s.
Fractions	1.70	0.68	1.74	0.60	-.04	0.99	n.s.
Number Patterns	1.78	0.93	1.72	0.57	+.06	0.39	n.s.
Equations	1.46	0.84	1.30	0.68	+.16	1.31	n.s.
Rotation	2.22	1.33	1.86	1.20	+.36	1.43	n.s.
Statistics	1.62	0.92	1.46	0.97	+.16	0.85	n.s.
Area	2.00	1.07	1.96	1.26	+.04	0.17	n.s.
Polygons Polyh.	2.80	0.86	2.66	1.04	+.14	0.74	n.s.
Pythagaras therm.	1.60	1.09	1.74	0.88	-.14	0.71	n.s.
Vectors	1.20	0.88	1.64	0.78	-.44	2.65*	0.01
Computation	1.70	0.65	1.80	0.86	-.10	0.65	n.s.
Rational Numbers	2.08	1.07	1.78	1.09	+.30	1.39	n.s.
Mapping	1.260	1.05	1.78	1.13	-.52	2.39*	0.05
3-Dim. Geometry	1.94	1.06	1.30	1.06	+.64	3.02*	0.01
Percent, Regions	1.98	0.74	2.16	0.91	-.18	1.10	n.s.

A minus sign in column headed 'd' means girls were better.

On two tests girls did significantly better than boys. These are the tests on Mappings and the test on Vectors. Thus overall, boys' performance was superior to that of girls on Knowledge items in nine tests, and in only one case were these differences in favour of boys significant. Girls on the other hand did better in eight of the Knowledge subtests and the differences were significant on two of the tests.

The results of comparisons between scores on Comprehension subtests are presented in Table XXXIV. Significant differences between boys and girls were found on only one test. This is the test on Pythagoras Theorem. For all the other tests the differences between the performance of boys and girls on comprehension level items which were in the tests, were not significant at the 5% or 1% levels.

Table XXIV: Comparison of Girls' and Boys' scores on Comprehension items by tests.

Test Title	BOYS		GIRLS				
	Mean	S.D.	Mean	S.D.	d	t	p
Number Systems	1.08	1.40	1.00	0.73	+.08	.48	n.s.
Sets	1.40	0.78	1.48	0.68	-.08	.55	n.s.
Natural Numbers	1.58	0.86	1.50	1.04	+.08	.42	n.s.
Fractions	2.18	0.89	1.96	0.95	.22	1.22	n.s.
Number Patterns	1.24	1.08	1.04	1.01	.20	.96	n.s.
Equations	1.16	0.74	0.90	0.54	.26	.21	n.s.
Rotation	2.12	0.94	1.86	0.70	.26	1.56	n.s.
Statistics	2.22	0.98	2.30	0.79	-.08	.45	n.s.
Area	1.84	0.93	0.66	0.82	.18	1.03	n.s.
Polygons Polyh.	2.16	0.84	2.23	0.94	-.07	.40	n.s.
Pythagoras Therm.	1.94	0.65	1.60	0.61	.34	2.45*	.05
Vectors	1.44	1.01	1.68	0.98	-.28	1.44	n.s.
Computation	1.90	0.76	1.72	0.93	.18	1.06	n.s.
Rational Numbers	1.46	0.73	1.18	0.98	.28	1.61	n.s.
Mappings	2.26	0.90	2.28	1.02	-.02	.99	n.s.
3-Dim.Geometry	1.92	1.60	1.52	1.37	.40	1.34	n.s.
Percent, Regions	2.00	0.64	2.14	0.86	.14	1.23	n.s.

Table XXXV gives the results of comparison between the sexes on their performance on items placed in the Application level of cognitive ability. Significant differences between the performances of boys and girls were found on the Application subtests on six tests in all. In all the six cases the differences were in favour of boys at the 1% level of significance. Girls' performance was superior in four of the tests but the differences were insignificant.

Table XXXV: Comparison of boys and girls scores on Application items by tests.

Test Title	BOYS		GIRLS		d	t	P
	Mean	S.D.	Mean	S.D.			
Number Systems	1.38	0.73	1.12	0.78	.26	1.71	n.s.
Sets	1.68	0.71	1.84	0.71	-.16	1.13	n.s.
Natural Numbers	1.60	0.78	0.58	0.77	.02	0.13	n.s.
Fractions	1.20	0.96	1.44	1.13	-.32	1.53	n.s.
Number Patterns	1.32	0.79	1.08	0.75	.24	1.56	n.s.
Equations	1.50	0.81	0.92	0.83	.58	3.56*	.01
Rotation	2.04	1.48	1.80	1.68	.24	0.76	n.s.
Statistics	1.84	0.84	1.38	0.90	.46	2.67*	.01
Area	1.78	0.68	1.90	0.65	-.12	0.10	n.s.
Polygons Polyh.	2.90	0.91	2.90	0.81	.00	0.00	n.s.
Pythogaros theorm.	1.36	0.69	1.12	0.75	.24	1.67	n.s.
Vectors	1.92	0.80	1.00	0.93	.92	5.28*	.01
Computation	1.24	1.29	1.32	1.19	-.08	0.32	n.s.
Rational Numbers	2.04	1.23	1.18	1.22	.86	3.31*	.01
Mappings	1.78	0.86	1.48	0.81	.30	1.79	n.s.
3-Dim. Geometry	2.00	0.93	1.30	0.95	.72	3.82*	.01
Percent, Regions	2.04	1.02	2.64	0.75	.60	4.13*	.01

A minus sign in the coloumn headed d means girls were better.
* Significant at .05 level.

An examination of Table XXXV shows that boys did significantly better on application items in the tests on Equations, Statistics, Vectors, Rational numbers, Three Dimensional Geometry and the test on Percentages and Regions.

Finally, table XXXVI presents the result of comparisons between boys and girls on the analysis subtests.

Table XXXVI: Comparison of boys and girls on Analysis items by Tests.

Test Title	BOYS Mean	S.D.	GIRLS Mean	S.D.	d	t	p
Number Systems	0.96	1.03	0.86	0.86	0.10	0.65	n.s.
Sets	1.54	0.73	1.30	0.70	0.34	2.36*	0.05
Natural Numbers	1.08	0.90	1.44	0.91	-0.36	2.00*	0.05
Fractions	1.62	1.38	2.14	1.39	-0.52	1.88	n.s.
Number Patterns	1.70	0.65	1.84	0.65	-0.14	0.92	n.s.
Equations	1.14	0.86	0.90	0.79	0.24	1.46	n.s.
Rotation	1.32	0.89	1.00	0.76	0.32	1.92	n.s.
Statistics	1.42	1.14	1.24	1.08	0.18	0.81	n.s.
Area	1.40	1.23	0.93	1.01	0.48	2.14*	0.05
Polyg. & Polyh.	1.28	0.64	1.34	0.85	-0.60	0.40	n.s.
Pythagoras Therm.	0.94	0.84	0.64	0.63	0.30	2.02*	0.05
Vectors	1.06	0.84	0.98	0.82	0.08	0.48	n.s.
Computation	0.60	1.03	0.80	1.07	-0.20	0.95	n.s.
Rational Numbers	1.08	0.85	1.02	0.69	0.06	0.35	n.s.
Mappings	0.78	0.68	0.92	1.14	-0.14	0.75	n.s.
3-Dim. Geometry	2.00	0.99	1.60	0.57	0.40	2.50*	0.05
Percent, Regions	0.86	0.78	1.12	0.92	-0.26	1.55	n.s.

A minus sign in the d column means girls were better.

* significant at .05 level.

Significant differences between the sexes were found on five subtests in all. Four of these were in favour of boys at the 5% level of significance. These four subtests contained the Analysis items from the tests on sets, Area, Pythagoras theorem and three dimensional geometry. The only case in which girls' performance was superior to boys were the Analysis items from the test on Natural Numbers.

Thus the additional analysis carried out to determine the nature of the sex by levels interaction turned out to be most useful in pointing out the major features of the differences in performance at the four cognitive levels. It is possible to draw the following general conclusions from the sex by levels interaction analysis;

1. Sex differences on the Knowledge subcategory of cognitive level are very small and tend to favour girls just about as often as they favour boys. It was found that on two of the Knowledge subtests significant differences favour girls as compared to only one favouring boys significantly. Hence the overall differences between the sexes on their scores on the Knowledge level of cognitive ability are not significant for the Form III pupils.

2. Sex differences on the Comprehension subcategory are virtually non existent for Kenyan secondary school pupils. Significant differences were found on only one comprehension subtest favouring boys. On the remaining sixteen tests the differences were not significant. Overall there are no significant differences between the Form III boys and girls on their scores on the Comprehension level of cognitive ability.

3. Girls begin to show clear signs of fading into the background when their performance is compared with that of boys at the Application subcategory of cognitive ability. It is here that boys come into a class of their own. Significant differences were found on six of the seventeen tests. In all the six cases they were in favour of boys. This was further confirmed when the total scores for boys on Application items, expressed as percentages, were compared with the corresponding percentages for girls.

4. Boys maintained overall superiority on subtests assessing the Analysis level of Cognitive ability. Significant differences were found on five subtests, on four of which differences favour boys and in only one case differences favour girls. When the total scores expressed as percentages for the Analysis items for boys were compared with the corresponding percentages for girls, significant differences in favour of boys at the .05 level were found. The differences were not significant at the .01 level.

4.30. SEX DIFFERENCES ON VARIABLES IN GENERAL QUESTIONNAIRE

4.31. Educational Aspirations of Pupils in Form III

Three items in the General Questionnaire were used to obtain information on pupils' educational aspirations. One of the items enquired if pupils want to do their A levels and another if the pupils would have liked to attend University. The third item asked pupils who wanted to do their A levels if they would take mathematics as one of their subjects for study. To each of the three items pupils could have responded by choosing one of the three alternatives i.e. Yes (coded as 2), No (coded as 0) and Uncertain (coded as 1). Table XXXVII presents the numbers and percentages of boys and girls responding to each of the three alternatives for the three items by sex.

Table XXXVII: Total numbers and percentages of pupils responding to the three items on educational aspirations.

Variable	Response Category	YES		UNCERTAIN		NO	
		No.	%age	No.	%age	No.	%age
1.Plan to do "A" levels	Boys	337	88.22	38	9.95	7	1.83
	Girls	162	79.40	29	14.22	13	6.37
2.Plan to attend Univ.	Boys	285	74.61	71	18.58	26	6.81
	Girls	128	62.75	64	31.37	12	5.88
3.Plan to take maths for "A" levels	Boys	218	57.07	116	29.58	48	12.57
	Girls	61	29.90	69	33.8	74	36.27

Using the weights of 2 for "Yes", 1 for "Uncertain" and 0 for "No", the means and standard deviations and t-test values for comparison between boys and girls were found. These are presented in Table XXXVIII.

Table XXXVIII: Means, Standard deviations and t-values for comparison between boys and girls on the three Educational aspirations Variables.

Variable	BOYS(N=382)		GIRLS(N=204)			
	Mean	S.D.	Mean	S.D.	d	t
1. Plan to do 'A' levels	1.864	0.397	1.730	0.571	0.134	3.337*
2. Plan to attend University	1.678	0.591	1.569	0.596	0.109	2.119*
3. Plan to take maths for 'A' levels	1.445	0.701	0.936	0.803	0.509	7.931*
Total Educ. Aspir.	4.979	1.198	4.279	1.454	0.700	6.240*

* p is less than 0.01.

Thus on each of the three variables significant differences favour boys in the expression of Educational aspirations. To find out which of the percentages recorded in Table XXXVII were significant the Z-test was used. The Z values for differences in the proportions of boys and girls in each response category are recorded in table XXXIX.

Table XXXIX: Z-values for comparison between boys and girls in the test for differences between proportions.

Variable	Response Category		
	Yes	Uncertain	No
1. Plans to do 'A' levels	2.78*	-1.52	9.09*
2. Plans to attend University	2.99*	3.61*	0.42
3. Plans to take maths for 'A' levels.	6.27*	-1.05	-6.71*

* difference in proportions significant at .01 level.
A minus sign indicates differences favour girls.

The general conclusions that can be drawn from Table XXXVIII, and XXXIX are the following:

1. The proportion of boys aspiring to do their 'A' levels is significantly greater than that of girls. Significantly fewer girls wish to do "A" levels. There are no significant differences in the proportions of girls and boys who are "Uncertain" as to whether they will do "A" levels.

2. Significantly more boys plan to take mathematics during their "A" levels than girls. In fact, the proportion of boys is more than twice that of girls intending to take mathematics for "A" levels. Again the proportions of girls and boys who are not certain as to whether they will take mathematics for "A" levels do not differ significantly.

3. Plans to attend university also differ for boys and girls. Significantly more boys wish to attend university than girls. Girls are far more "Uncertain" than boys as to whether they will attend university. Significantly more girls are uncertain as to whether or not they will go to university.

4.32. Sex differences in the Vocational Aspirations of Form III pupils.

Only one item was used to gather information on the vocational aspirations of boys and girls. This was an open item which asked pupils to specify the job they want to enter after their schooling. It was hypothesised in the introduction to Chapter One that pupils' vocational aspirations will have considerable influence on the achievement of pupils in mathematics. Thus, pupils aspiring to technical and professional occupations were expected to do better at mathematics and vice-versa. The relation between vocational aspirations on pupils' achievement scores on mathematics will be considered in Section 4.70, on Regression analysis. This section will examine sex differences in the vocational expressions of Form III pupils. Table XL presents choices of occupations made by the research sample.

Table XL: Choice of Occupations made by the Form III Pupils in the Research Sample.

Occupation	BOYS		GIRLS	
	Number	Percent	Number	Percent
Scientist	10	2.88	1	0.01
Teaching	38	10.95	23	14.80
Medicine (Doctors)	57	16.43	19	12.30
Journalism	2	00.01	6	3.88
Pilot (Airhostess)	6	1.73	17	10.96
Nurse	1	0.00	32	20.68
Law	9	2.59	15	9.67
Engineering	97	27.95	1	0.01
Secretary/Clerk	7	2.02	14	9.04
Chemist/Pharmacy	8	2.30	7	4.52
Farming/Agriculture	6	1.73	0	0.00
Accountant/Insurance Banking	57	16.42	5	3.23
Hotelier/Tourism	9	2.59	10	6.46
Business/Shopkeeping	9	2.59	1	0.01
Administration/Civil Ser.	7	2.02	0	0.00
Others	14	4.04	28	16.78
Uncertain	35	9.16	29	14.20
Totals	382	100.00	204	100.00

The percentages for boys and girls were computed out of the totals of 155 girls and 347 boys who responded to the item in the Questionnaire. The "Uncertain" category in the table includes all those who did not respond to the item.

The choices of boys as well as those of girls appear to be concentrated in certain fields. There is a tendency for the choice of professions of boys to be more spread out than those of girls. About 21% of the girls who gave a choice of prefession aspire to nursing, followed by 15% for teaching and about 10% each for pilot/airhostess, Doctors and Secretary or Clerk. These professions were chosen by a total of 66% of the sample. On the other hand 28% of the boys want to become Engineers/Technicians/Surveyors, 16% want to become accountants/Bankers/Insurance agents, 16% want to be doctors and 10% want to be teachers. These figure clearly support the hypothesis that boys tend towards or aspire to technical and professional occupations more so than girls. To test this hypothesis the vocations were grouped into three categories. The aim of this exercise was to group together vocations that need at least an A level pass in mathematics for entry, from vocations which require a pass at O levels and finally vocations which do not need a pass at O levels in mathematics for entry. The three categories were;

1. Professional and technical occupations such as engineering, Banking/Accountancy/Mathematicians, Scientists etc.

2. Professional but non-technical such as Doctors, Lawyers, teachers, Journalists etc. and

3. General Vocations such as farming, Hairstyling, Hotel and tourist management etc.

The three categories of vocations were weighted 3, 2 and 1 respectively. Table XLI presents the number and percentages of pupils by sex in each of the three job categories.

Table XLI: Distribution of Form III pupils in each of the Three Job Categories by Sex.

Sex	JOB CATEGORY					
	Technical & Professional		Non-technical & Professional		General Vocations	
Boys	161	(42.15)	129	(33.77)	47	(12.30)
Girls	14	(6.86)	95	(46.57)	63	(30.88)

Figures in brackets represent percentage of pupils in that category.

From Table XLI it is evident that almost six times as many boys aspire to technical and professional occupations as girls. The difference between the proportions is significant at the .01 level in favour of boys ($Z = 4.065$, and $p < .01$). The difference in proportions of boys and girls aspiring to non-technical professions was not significant. Also the differences in the proportions in the case of General Vocations is significant at the .05 level in favour of girls. Hence the hypothesis that there are no differences in the vocational aspirations of boys and girls of Form III is rejected. Table XLII records the means and standard deviations obtained when the weights as given / above were used.

Table XLII: Means, Standard deviations and t-values for comparison between boys and girls on vocational aspirations.

Sex	Means	Standard Deviation	Difference	t-value	p
Boys	2.063	1.007	0.617	7.86*	.01
Girls	1.446	0.838	0.617		

Table XLII confirms the earlier finding that boys aspire towards technical and professional occupations significantly more than girls.

4.40. SEX DIFFERENCES ON ATTITUDES TOWARDS MATHEMATICS

The present investigation collected information from all the students on their attitudes towards mathematics. Three subscales were used. These were a subscale to assess pupil enjoyment of mathematics, a scale to measure pupil value of mathematics and a scale to assess the difficulty experienced by pupils in the learning of mathematics. The reliability coefficients computed using the total research sample of 586 students are recorded in Table XLIII. These were calculated using the Kuder Richardson Formula 20.

Table XLIII: Reliability Coefficients of the Attitude Subscales used in the Main Study.

Scale	Reliability Coefficient (K.R. 20)
Enjoyment of Mathematics	0.898
Value of Mathematics	0.702
Difficulty of Learning Mathematics	0.609

Thus while the Enjoyment of Mathematics Subscale had almost the same internal consistency as originally reported by Aiken (0.95), Aiken's Value of Mathematics and Husen's scale on the Difficulty of Learning Mathematics were found to have fairly low reliability Coefficients when used with Kenyan Secondary school pupils. Surpringly, the Motivation in Mathematics Scale constructed by the researcher using Entwistle-Nisbet general scale for motivation had a reliability coefficient of 0.677, slightly higher than the reliability coefficient for the Difficulty of Learning Mathematics. However, this result may not be so surprising in view of the fact that personality measurements such as those of motivation are not as stable as measures of cognitive potential or to a lesser extent measures of attitudes. To each of the statements on the attitude scales pupils could have responded by choosing one of five responses. These were "strongly Agree" (SA), "Agree" (A), "Uncertain" (U), "Disagree"(DA) and "strongly disagree" (SDA). For purposes of comparisons the responses SA and A and the responses SDA and DA were combined, and for each of the attitude scales the percentage of pupils in these two categories i.e. SA and A and the SDA and DA are given.

Table XLIV gives the percentage of pupils in the SA and A and the SDA and DA categories for each item on the Enjoyment of Mathematics subscale.

Table XLIV: Percentages of Favourable and Unfavourable Responses to Items on the Enjoyment of Mathematics Subscale

Item Number	Statement	BOYS		GIRLS	
		SA&A	SDA&DA	SA&A	SDA&SA
1.	Mathematics is dull and boring because it leaves no room for personal opinion.	14%	76%	51%	34%
8.	Maths makes me feel uneasy and confused	25%	56%	48%	32%
13.	Maths makes me feel nervous and uncomfortable	20%	69%	33%	33%
17.	I have always enjoyed studying maths in school	72%	17%	43%	40%
24.	I enjoy going beyond the assigned work and try to solve new problems in maths.	72%	18%	43%	35%
29.	I have never liked maths and it is my most dreaded subject.	14%	76%	32%	54%
36.	Maths is very interesting and I have usually enjoyed courses in this subject	72%	12%	51%	29%
39.	I am interested and willing to use maths outside school and on the job.	80%	6%	57%	27%
42.	I would like to develop my mathematical skills more and study this subject more.	81%	5%	55%	24%
46.	Maths is enjoyable and stimulating to me.	73%	11%	38%	39%

Item numbers are the numbers as given on the actual Questionnaire.

On all the items the percentages of girls giving a favourable response is less than that of boys. More than 50% of the girls find mathematics dull and boring as compared to 14% for boys. 32% of the girls dread mathematics as compared to 14% of the boys. About twice the percentage of girls feel nervous, uneasy, confused and uncomfortable in mathematics as compared to the corresponding percentages for boys. The proportion of girls who find mathematics stimulating, interesting, enjoyable is far less than the proportion of boys. To find out if the differences between the responses of girls and boys on each item and for the total scale were significant the t-test was used. Table XLV presents the results of comparisons between boys and girls.

Table XLV: Means, Standard Deviations and t-values for comparison between boys' and girls' scores on the subscale on Enjoyment of Mathematics.

Item Number	BOYS		GIRLS				
	Mean	Variance	Mean	Variance	d	t	p
1	3.96	1.23	2.74	1.83	1.22	14.08	.01
8	3.42	1.42	2.70	1.77	0.72	6.69	.01
13	3.66	1.47	3.20	1.80	0.46	4.42	.01
17	3.78	1.63	3.03	1.64	0.75	7.35	.01
24	3.75	1.27	3.07	1.49	0.68	6.77	.01
29	3.98	1.50	3.22	2.30	0.76	6.64	.01
36	3.86	1.11	3.25	1.56	0.61	6.25	.01
39	4.09	0.81	3.41	1.84	0.68	7.26	.01
42	4.25	0.84	3.49	1.69	0.76	8.15	.01
46	3.81	0.98	2.93	1.44	0.88	9.51	.01
Totals	36.68	50.155	31.16	69.12	7.52	7.54	.01

On all the items on the Enjoyment of Mathematics scale, as well as on the total scores on the scale, significant differences in favour of boys were found. Besides this the responses of the girls were considerably more variable than those of boys. If the F - ratio for the test of homogeneity of variances is violated the use of the t-test would have been invalid. This would have made it necessary to employ either non-parametric statistics or tests in enumeration statistics such as the Chi-Square test to test for differences between the sexes. However, a further check revealed that the departures from homogeniety of variance are moderate and since the t-test is robust for moderate violations of the assumption of homogeniety of variance the results obtained using the t-test can be considered to be in close agreement with those obtained through the use of non-parametric statistics or enumeration statistics. Thus, on the basis of the comparisons using the t-test the hypothesis of no differences between girls and boys of Form III on their scores on the Enjoyment of Mathematics subscale is rejected at the 1% level of significance.

Are there sex differences on the value of mathematics scores obtained from pupils' responses on the "Value of Mathematics Subscale" used in this study? Table XLVI gives the percentage of pupils by sex who "strongly agreed" or "agreed" and "strongly Disagreed" and "Disagreed" with statements on this scale.

Table XLVI: Percentage of Boys and Girls giving various Responses to statements on the Value of Mathematics Subscale.

Item Number	Statement	BOYS SA&A	BOYS SDA&DA	GIRLS SA&A	GIRLS SDA&DA
2.	Mathematics is needed in designing practically every-thing.	81%	9%	72%	16%
3.	A thorough Knowledge of Advanced maths is the key to an understanding of our world in the 20th century.	64%	14%	58%	17%
4.	I can get along perfectly well in everyday life without maths.	12%	76%	24%	58%
9.	Maths is a very worthwhile and necessary subject.	93%	3%	86%	9%
10.	It is important to know maths inorder to get a good job.	79%	9%	77%	13%
14.	I think my father uses maths on his job.	74%	12%	78%	13%
16.	Maths is not important in problems of everyday life.	13%	72%	18%	61%
18.	Maths is needed inorder to keep the world running.	79%	8%	66%	16%
21.	An understanding of maths is needed by artists and writers as well as scientists.	76%	10%	73%	10%
23.	Maths has contributed greatly to science and other fields of knowledge.	90%	4%	83%	7%
25.	Maths is less important to people than art and literature.	12%	75%	18%	63%
26.	Maths helps develop a person's mind and teaches him to think.	90%	7%	75%	8%
33.	There is nothing creative about maths; it is just memorizing formulae and things.	34%	45%	38%	41%
37.	In the near future most jobs will require a knowledge of advanced maths.	4%	79%	7%	78%
41.	Outside the school I would like to use maths.	78%	6%	52%	27%

Table XLVI: Continued from Page 138.

Item Number	Statement	BOYS SA&A	BOYS SDA&SD	GIRLS SA&A	GIRLS SDA&DA
43.	Maths is not important for the advance of civilization and society	9%	78%	15%	69%
47.	Most of the most able pupils should be encouraged to become mathematicians and mathematic teachers.	76%	6%	68%	12%

Item Numbers were the numbers as on the actual Questionnaire:
The percentages are given to the nearest whole number.

Examination of Table XLVI reveals a striking similarity in the responses of boys and girls to almost all the items in the subscale. There is little doubt about the fact that both boys and girls value mathematics highly. The responses to most items are very favourable and in very few cases does the percentage of favourable responses fall to below 70%.

Table XLVII: Means, Standard Deviations and t-values for comparison of the responses of Form III boys and girls to items in the Value of Mathematics Scale.

Item Number	BOYS Mean	BOYS S.D.	GIRLS Mean	GIRLS S.D.	d	t
2	4.10	0.98	3.90	1.18	.20	2.19**
3	3.76	1.08	3.64	1.21	.14	1.44
4	2.07	1.13	2.49	1.35	-.43	4.12*
9	4.52	0.75	4.23	1.06	.29	3.90*
10	4.17	1.04	4.07	1.23	.10	1.00
14	3.95	1.10	4.06	1.22	-.11	1.20
16	3.92	1.18	3.66	1.26	.26	2.45*
18	4.14	1.02	3.83	1.22	.31	3.29*
21	4.03	1.04	3.96	1.06	.07	0.80
23	2.45	0.87	4.29	1.03	.16	1.94
25	4.06	1.13	3.69	1.31	.37	3.54*
26	4.28	0.95	4.03	1.11	.26	2.95*
33	3.19	1.33	3.03	1.37	.16	1.35
37	4.18	0.91	4.03	1.00	.15	1.82
41	3.95	0.91	3.30	1.27	.65	7.20*
43	4.13	1.06	3.86	1.23	.27	2.77*
47	4.15	0.98	3.93	1.13	.22	2.46**
Totals	66.798	7.61	63.833	8.37	2.97	4.33*

* Significant at .01 Number of boys = 382

** Significant at .05 Number of girls = 204

Girls obtained a higher mean score on item number four and item numbers fourteen as can be seen from Table XLVII which gives the means, standard deviations and t-values for comparison between the sexes on each item in the subscale. The difference between the sexes on item four is significant at the .01 level. Thus significantly more girls feel that they can get along in every day life without mathematics. From table XLVI we find that the percentage of girls who strongly agree or agree with statement number four is twice the percentage of boys. Boys obtained higher mean scores on items 9, 16, 18, 25, 26, 41 and 43, as well as on the total score on this scale. Thus more boys than girls consider mathematics important in problems of everyday life, regard it as a worthwhile and necessary subject, consider it just as important as literature and art and regard it as helping them to think clearly. However neither boys nor girls think that a study of advanced mathematics will be essential for jobs in future. This is revealed in item 37, where only 7% of the girls as compared to 4% of the boys strongly agree or agree with the statement. Over 70% disagree or strongly disagree with this statement.

The third attitude subscale used was the difficulty of learning mathematics scale. This scale had seven items. The percentage of pupils by sex who "strongly agreed" or "agreed" and "strongly disagreed" or "Disagreed" is given in table XLVIII for each of the items.

Table XLVIII: Percentage of Boys and Girls giving Various Responses to statements in the Difficulty of Learning Mathematics Subscale.

Item Number	Statement	BOYS SA&A	BOYS SDA&DA	GIRLS SA&A	GIRLS SDA&DA
3.	A thorough Knowledge of Advanced maths is the key to an understanding of our world in the 20th century.	77%	10%	72%	14%
12.	Even complex maths can be made understandable and useful to every secondary school pupil.	13%	61%	12%	63%
19.	Very few people can learn maths.	58%	22%	50%	29%
27.	Almost anyone can learn maths if he is willing.	81%	9%	80%	12%
30.	Only people with a special talent can learn maths.	12%	71%	16%	66%
34	Almost all pupils can learn complex maths if it is properly taught.	69%	8%	61%	17%
44.	Anyone can learn maths.	59%	16%	69%	11%

Number of boys = 382, Number of girls = 204.

The only item in the study which asked pupils about the role of teaching was an item in this scale, item 34. 69% percent of the boys agreed with the statement that almost all pupils can learn mathematics if properly taught as compared to 61% of the girls. More than twice the proportion of girls disagreed with this statement as the proportion of boys. The t-test showed that the scores of boys were significantly greater than those of girls on this statement. Thus, it appears as if girls do not have as high a regard for mathematics teaching (or possibly the mathematics teacher) as boys. Table IL presents the means, standard deviations and t-values for comparison between boys and girls on their views about the difficulty of learning mathematics.

Table IL: Means, Standard Deviations and t-values for comparisons between girls and boys on the views about Difficulty of Learning Mathematics.

Item Number	BOYS		GIRLS			
	Mean	S.D.	Mean	S.D.	d	t
3	3.86	0.97	3.86	1.09	0.00	0.00
12	3.64	0.98	3.69	1.03	-0.05	1.53
19	3.49	1.22	3.33	1.30	0.15	1.50
27	3.90	1.10	3.78	1.14	0.12	1.08
30	3.94	0.99	3.68	1.15	0.26	2.83*
34	3.66	1.12	3.93	1.17	-0.27	2.68*
44	4.08	1.01	4.08	1.14	0.00	0.00
Totals	26.60	3.83	26.34	4.88	0.26	0.71

A minus sign indicates differences favour girls.
* Significant at .01 level.

Thus overall there are no differences about the views on the difficulty of learning mathematics between boys and girls of form III and the hypothesis asserting no differences between the sexes on this scale is accepted. There were significant differences between the responses of boys and girls on two items on this scale. These were on items numbered 30 and 34. In item 30 there are significantly more girls who disagree with the statement that only people with a special talent can learn maths. In item 34 as we have already seen fewer girls think that they can learn complex mathematics even if they are properly taught. Only 8 percent of the boys disagree with this statement.

4.50. Sex Differences on Motivation in Mathematics

Motivation was the only personality variable being examined for sex differences in this study. A thirteen item scale was used. This scale was found to have a Kuder Richardson Reliability Coefficient (Formula 20) of 0.677, which is fairly acceptable. Table L records the percentages of boys and girls who "Strongly Agreed" or just "Agreed" with each statement and the percentages of boys and girls who "Strongly Disagreed" or just "Disagreed" with each statement, on the motivation in mathematics scale.

Table L: Percentage of Boys and Girls giving various responses to items on the Motivation in Mathematics scale.

Item Number	Statement	BOYS SA&A	BOYS SDA&SA	GIRLS SA&A	GIRLS SDA&DA
6.	I sometimes wish I could choose another subject instead of maths.	28%	60%	50%	37%
7.	It is important for me to do really well in maths here.	92%	4%	84%	6%
11.	I can't see any relevance in the maths we do here.	18%	58%	18%	49%
15.	I usually take the easy things first and leave the more difficult ones to the end.	85%	8%	90%	5%
20.	I enjoy the challenge of a difficult new topic in maths.	59%	23%	47%	39%

Table L: Continued from page 143.

Item Number	Statement	BOYS SA&A	BOYS SD&DA	GIRLS SA&A	GIRLS SDA&DA
22.	It is not often that I can stick to maths work for more than an hour.	43%	43%	60%	30%
28.	I do maths problems to get high marks not just for fun.	72%	18%	77%	8%
31.	I am an average student in maths; I will never be particularly good, so there is no point in striving for something beyond me.	15%	68%	25%	56%
32.	I am willing and interested to acquire further knowledge of maths.	85%	13%	69%	18%
35.	I hate admitting defeat even in the easiest of questions in maths.	70%	18%	57%	28%
38.	It is most unusual for me to be late in handing my maths homework.	62%	13%	59%	27%
45.	I get disheartened and give up easily if something is too difficult for me.	24%	59%	46%	36%
40.	My friends always seem to do better than me at maths.	31%	41%	51%	27%.

Item Numbers correspond to the numbers as on the actual Questionnaire .

K.R. 20 reliability coefficient = 0.677.

Number of boys = 382, Number of girls = 204.

Table LII, records the means, standard deviations and t-values for comparing the responses of pupils to items on the motivation scale. On the whole this scale provides very interesting and useful information regarding the nature of sex differences in mathematics.

Table LI : Means, Standard Deviations and t-values for Comparisons between girls and boys on their scores to items in the motivation in Maths scale.

	BOYS		GIRLS				
Item Number	Mean	S.D.	Mean	S.D.	d	t	p
6	3.49	1.32	2.77	1.44	.73	6.16	.01
7	4.47	0.83	4.38	0.97	.10	1.27	n.s.
11	3.60	1.14	3.41	1.21	.19	1.90	n.s.
15	1.78	0.97	1.63	0.89	.15	1.83	n.s.
20	3.51	1.21	3.11	1.32	.40	3.67	.01
22	2.97	1.26	2.60	1.27	.40	3.68	.01
28	2.13	1.21	1.88	1.04	.25	2.55	.05
31	3.79	1.13	3.46	1.32	.33	3.17	.01
32	4.21	0.93	3.82	1.26	.38	4.19	.01
35	3.78	1.20	3.43	1.29	.35	3.29	.01
38	3.55	1.18	3.41	1.24	.14	1.37	n.s.
40	3.08	1.12	2.64	1.21	.44	4.42	.01
45	3.45	1.20	2.78	1.28	.67	6.29	.01
Totals	43.66	6.44	39.67	3.99	7.17	6.72	.01

Number of boys = 382
Number of girls = 204

Item Number 6 reveals the startling fact that 50% of the girls wish they could choose another subject instead of mathematics. In fact 26% of the girls "Strongly Agree" with this statement, while 24% simply "Agree" with the statement. 12% were uncertain and only 15% strongly disagree with this statement. In comparison to this, 60% of the boys indicated their disagreement with this statement. Table LI shows that significant differences between the responses of boys and girls occur on Item Numbers 20, 22, 31, 32, 35, 40, and 45 as well as on the total scores on this scale. 59% of the boys enjoy the challenge which a difficult new topic presents in mathematics, as compared to 43% of the girls. 43% of the boys can stick to maths work for over an hour as compared to 30% of the girls. 25% of the girls agree that being average students, there is no point in striving for something beyond them (in this case good marks in mathematics, although this was not specified in the item). Only 15% of the boys agree to this statement. Only 18% of the boys will admit to defeat in the easiest of questions in mathematics as compared to 28% of the girls. Even more interesting are the findings on items 40 and 45. 51% of the girls think that their friends seem to do better than them at maths. On what basis they make the comparisons is not clear, nor does the item specify this. Presumably this decision is based on scores on mathematics tests in the classrooms. However, this possibly indicates the greater sensitivity of girls to what others think of them and vice versa. Only 31% of the boys agree with statement number 40. Finally, more girls (46%) get disheartened and give up easily when faced with something too difficult than boys (24%). The implications of these significant findings will be considered in Chapter Five.

4.60. Sex Differences on the Reading Ability Scores

A Close test containing four passages randomly chosen from S.M.E.A. Books One and Two was used to obtain reading ability scores of boys and girls. In all, pupils were required to supply missing words, symbols, operators etc. to fill in 76 blanks on the test. Pupils were given 35 minutes to complete this test. The mean scores of girls and boys are recorded in Table LII which also gives the standard deviations and t-test values for comparison. The t-test shows that the differences between boys' and girls' scores on the cloze test are not significant.

Table LII: Means, Standard Deviations and t-values for comparisons between boys and girls on their scores on the cloze Test.

Sex	Number	Mean	S.D.	Differences	t-value	p
Boys	382	45.296	8.034	0.164	0.207	n.s.
Girls	204	45.132	8.452			

Hence the null hypothesis of no differences between the scores of girls and boys on their reading ability of passages from their mathematics texts is accepted.

4.70. Mutiple Regression Analysis

The aim of performing a multiple regression analysis was to establish for each sex group regression relationships between their scores on the dependent variable, i.e. mathematics achievement scores and the independent variables being considered in this study.

4.71. Correlations between Mathematics achievement and the other Independent Variables.

Table LIII presents the correlations between mathematics achievement scores and the independent variables under study. To determine if the differences between the correlations of the independent variables and the mathematics achievement scores for the sexes were significant Fishers' Table of Z transformations was used. The only case of significant differences between the correlations for boys and girls is for reading ability. The z-test showed that the differences

Table LIII: Correlation Coefficients between Mathematics Achievement scores and the other independent variables in this study for boys and girls.

Independent Variable	Correlation(Boys)	Correlation(Girls
1. Knowledge	.747	.810
2. Comprehension	.699	.758
3. Application	.755	.768
4. Analysis	.675	.586
5. Enjoyment of Maths	.360	.354
6. Value of Maths	.161	.197
7. Difficulty of Learning Maths.	.067	.211
8. Educational Aspirations	.157	.041
9. Vocational Aspirations	.108	-.080
10. Motivation	.299	.322
11. Reading Ability	.268	.453
12. Age	-.182	-.175
13. Numbers of hours devoted to homework	.085	.047

Number of boys = 381

Number of girls = 204

between the two correlations for the sexes are significant at .01 level of significance. Thus the achievement test scores of girls are more higly correlated to reading ability scores than those of boys.

The correlation between mathematics achievement and the attitude subscales are fairly low for both boys and girls. However, in all cases it was positively related to scores on the mathematics achievement test. Of the three attitude scales the highest correlation was between scores on the Enjoyment of Mathematics scale and mathematics achievement scores (correlation coefficient was between .36 to .38 for both sexes.) Thus boys and girls who obtain high marks on mathematics tests enjoy mathematics more than the poor achievers . This is to be expected and need not surprise us. The educational and vocational aspirations were found to have very low correlations with achievement in mathematics. In fact it appears that the achievement of girls who aspire to technical and professional courses in which they will be required to study mathematics further, is poorer than girls aspiring to non-technical and professional or general vocations. This is indeed contrary to expectations. A possible explanation could lie in the fact that the educational and vocational plans of boys and girls of Form III are not definite and are out of touch with reality. The age of pupils showed a low and a negative correlation with achievement in mathematics. Thus older boys and girls seem to do less well at mathematics than their younger peers.

4.72. InterCorrelations of Mathematics Total Scores and Cognitive Level Subscore Totals.

Table LIV and LV record the intercorrelations between the total scores of boys and girls respectively on the mathematics achievement tests and cognitive level subtests scores.

Table LIV: Intercorrelations of Mathematics total scores and subscores on cognitive variables for Boys.

Variable	1	2	3	4	5
1. Total scores	1.000	0.747	0.699	0.755	0.654
2. Knowledge		1.000	0.358	0.475	0.348
3. Comprehension			1.000	0.373	0.293
4. Application				1.000	0.325
5. Analysis					1.000

Number of boys = 381.

Table LV: Intercorrelations of Mathematics achievement scores and subscores on cognitive variables for girls.

Variable	1	2	3	4	5
1. Total scores	1.000	0.810	0.758	0.768	0.586
2. Knowledge		1.000	0.504	0.473	0.338
3. Comprehension			1.000	0.473	0.208
4. Application				1.000	0.345
5. Analysis					1.000

Number of girls = 204.

From Tables LIV and LV it is evident that the intercorrelations between the cognitive level subscores are fairly low, between 0.3 and 0.5 indicating clearly that the four subtests are measuring different abilities and certainly not making the same demands on pupils. Table LV shows that for girls the correlation between Knowledge and Comprehension scores is the largest, while that between Comprehension and Analysis scores is the least.

This means that girls who obtain high scores on Knowledge subtests do well on the Comprehension subtests and obtain high scores on them. Girls who do well on Comprehension subtests do not do as well on the Analysis subtests.

On the other hand for boys the correlation between Knowledge and Application is the largest while it is the least between Comprehension and Analysis. This means that boys who score high marks on Knowledge subtests also do well on Application subtests while the inter-relation between Comprehension and Analysis scores is very small.

This possibly implies that girls concentrate more on understanding the mathematical principles, rules, facts, algorithms etc. while for boys the application aspects of the principles, rules, facts is more important. For both boys and girls the correlation between comprehension and analysis is the least, a finding which is very difficult to explain. One would have expected to find that girls and boys who are competent in translation, interpretation and extrapolation of mathematical relations should do as well on making generalizations and solving non-routine problems, all of which are important elements of the Analysis level of ability. A possible explanation may be that boys begin to apply their mathematical Knowledge while girls spend their energy in the comprehension of this knowledge, at which stage they remain stuck rarely passing beyond. While it would be highly inappropriate to regard these inter-test correlations as being "causative" in the sense that low scores on Knowledge items are the cause of low scores on application subtests etc. there is little doubt that the achievement test scores of girls on Knowledge items are substantially related to their scores on Comprehension items while for boys the scores on Knowledge items are substantially related to scores on application items.

4.73. Regression Equations for Boys and Girls.

At the outset a regression analysis was carried out for each sex separately, fitting as many of the independent variables as possible to the regression equation. Thirteen variables were selected for study and were expected to influence significantly the mathematics achievement scores. The variables under study were grouped and laid out as in Figure 3.

Dependent Variable	Independent Variables
Mathematics Achievement	**Cognitive Ability**
	X_1: Knowledge
	X_2: Comprehension
Y_{Boys} or Y_{Girls}	X_3: Application
	X_4: Analysis
	Attitudes Towards Mathematics
	X_5: Enjoyment
	X_6: Value
	X_7: Difficulty
	Pupil Aspirations
	X_8: Educational Aspirations
	X_9: Vocational Aspirations
	X_{10}: Reading Ability
	X_{11}: Motivation
	X_{12}: Age of pupils
	X_{13}: No. of hours devoted to homework.

Fig. 3: The Dependent and Independent variables in the Regression Equations.

The first category contains Cognitive Ability Measures, namely Knowledge, Comprehension, Application and Analysis. It was assumed that pupils' cognitive potential will have a considerable influence on the overall pupils' achievement scores in mathematics. The second category of variables includes the attitude subscales scores. Thus value of mathematics, views about the difficulty of learning mathematics and Enjoyment of Mathematics were considered to be significant predictors of achievement in mathematics. The third category of variables considered in the regression equation were the aspirations of pupils.

This included the Educational and Vocational Aspirations of pupils. Besides these variables the Motivation scores, Reading Ability scores and age and number of hours pupils devoted to mathematics homework were also included in the regression analysis. The full regression equation with the regression coefficients for boys is as follows;

$$Y_{Boys} = \text{Constant} + 0.235\,X_1 + 0.256\,X_2 + 0.249\,X_3 + 0.255\,X_4$$
$$-0.006\,X_5 + 0.005\,X_6 - 0.028\,X_7 + 0.142\,X_8 + 0.075\,X_9$$
$$+0.009\,X_{10} - 0.003\,X_{11} + 0.038\,X_{12} + 0.057\,X_{13}\ .$$

The regression coefficients, the partial correlation coefficients and the t-statistics are recorded in table LVI.

Table LVI: Regression Coefficients, Partial correlations and t-statistics for each of the Independent Variables

Variable Code	Variable Name	Regression Coefficient	Partial Corr. Coeff.	t-value
X_1	Knowledge Cogn.Ability	0.235	0.89	36.85*
X_2	Comprehension Cogn.Ability	0.256	0.90	40.65*
X3	Application Cogn. Ability	0.249	0.90	39.50*
X_4	Analysis Cogn. Ability	0.255	0.88	36.02
X_5	Enjoyment of maths	-0.006	-0.02	0.32
X_6	Value of mathematics	0.005	0.02	0.42
X_7	Views on Diff. of Learning Math	-0.028	-0.06	1.25
X_8	Educational Aspirations	0.142	0.09	1.81
X_9	Vocational Aspirations	0.075	0.05	0.87
X_{10}	Reading ability	0.009	0.05	0.93
X_{11}	Motivation in Maths	-0.003	-0.01	0.14
X_{12}	Age of Pupils	-0.038	-0.02	0.45
X_{13}	Number of hours devoted to maths homework.	0.057	0.04	0.04

A minus sign indicates differences favour girls.
Number of Boys = 381, Degrees of freedom = 368

* Significant at .01 level.

In the column headed Partial Correlation coefficient are recorded values which give the relation between the variable under consideration with the dependent variable, when all the other independent variables are controlled or held constant. This column shows that when the effects of other independent variables are removed there is a high relationship between the four cognitive level variables and the dependent variable. The t-values for these four cognitive variables were all significant at the 1% level of significance. Thus for boys scores on Knowledge, Comprehension, Application and Analysis level abilities are good predictors of total achievement scores in mathematics. Next in importance are their scores on the Educational Aspirations Scales followed by Views about the difficulty of learning mathematics. Educational aspirations is not a significant predictor of achievement in mathematics. These are followed by reading ability scores and vocational aspirations of pupils which are not good predictors of achievement in mathematics for boys.

4.74. Proportion of total variance in Mathematics Scores Accounted for by the independent variables.

As pointed out, the four significant predictors of achievement in mathematics were the scores of the boys on the four cognitive levels. Table LVII gives the proportions of the variance attributable to each of the four cognitive ability variables and to Reading ability and Educational Aspirations.

Table LVII: Proportion of Variance Accounted for by the Four Significant predictors of Achievement and two otherVariables for Boys.

Independent Variable	Percent of Variance attributable to Var.
Knowledge	25.53%
Comprehension	24.68%
Application	27.14%
Analysis	19.85%
Reading Ability	0.18%
Educational Aspiration	0.29%
Total	97.67%

While Knowledge, Comprehension and Application each contribute about 25% of the total variance, the scores on Analysis level cognitive ability contribute to about 20% of the total variance in scores. The value of the Multiple correlation coefficient was 0.999 which is highly significant at 12 and 368 degrees of freedom. In fact the independent variables considered in this regression analysis turned out to be excellent predictors of total scores on the mathematics achievement tests. It was felt by the researcher that the inclusion of the cognitive levels as separate independent variables is not justified in this situation and could be responsible for the high value of the Multiple Correlation Coefficient (0.999). The regression analysis would have been more fruitful if each of the cognitive levels was treated as a dependent variable and only variables X_5, X_6, X_7 ... X_{13} had been included in the regression run as the independent variables. An attempt was made to improve this situation by using four of the variables, namely Enjoyment of Mathematics, Value of Mathematics, Difficulty of Learning Mathematics and Motivation in mathematics as independent variables and the total mathematics achievement scores as the dependent variable. Using Bert's method for calculating the multiple correlation coefficient it was found that for boys R was 0.3699, and the square of R was 0.1369. Since the square of the multiple correlation coefficient indicates the proportion of the variance accounted for by the independent variables it was possible to conclude that the four independent variables accounted for a total of 13.09% of the variance in the total scores in mathematics. Comparison with Table LVII shows that when all the 13 independent variables were included Enjoyment of mathematics, value of mathematics, views about difficulty of learning mathematics and motivation in mathematics account for less than 3 percent of the total variance. It is clear that the effect of throwing too many variables into the regression analysis has resulted in a less in the reliability of the regression coefficients. Thus some of the variables, especially the cognitive level variables, are redundant in the sense that they have quite high intercorrelations and therefore, for the purpose of regression analysis, measure similar abilities. The ideal would be to have correlations between the independent variables as near zero as possible so that there is little overlap between what the variables measure.

4.75. Regression Analysis for the Girls' Data.

A separate regression analysis was carried out for the girls' data. The full regression equation for girls using the regression coefficients was:

$$Y_{Girls} = \text{Constant} + 0.258\, X_1 + 0.256\, X_2 + 0.244\, X_3 + 0.237\, X_4 - 0.027\, X_5 + 0.002\, X_6 + 0.017\, X_7 + 0.025\, X_8 + 0.172\, X_9 - 0.012\, X_{10} + 0.019\, X_{11} - 0.058\, X_{12} - 0.037\, X_{13}.$$

The partial correlations, Regression Coefficients and the t - statistics are recorded in Table LVIII, for each of the independent variable. Hence for girls the scores on Knowledge, Comprehension, Application and Analysis level abilities are good predictors of their achievement scores in mathematics. Enjoyment of mathematics is a reasonably good predictor and is significant at the 0.10 level of significance. This is followed in order of predictability by Vocational aspirations, Reading ability and Motivation. Hence for girls Enjoyment of Mathematics came immediately after the cognitive variables in order of good predictors whereas for boys Educational aspirations came immediately after the cognitive variables followed by Reading Ability. Thus reading ability occupies the same position in the order of best predictors for both boys and girls.

Table LVIII: Regression Coefficients, Partial Correlation and t-statistics for the independent Variables for Girls .

Variable Code	Variable Name	Regression Coefficient	Partial Corr.	t-value
X_1	Knowledge Cogn. level	0.258	0.91	29.80*
X_2	Comprehension Cogn. level	0.256	0.90	27.97*
X_3	Application 6ogn. level	0.244	0.88	25.81*
X_4	Analysis Cogn. level	0.237	0.85	22.71*
X_5	Enjoyment of Mathematics	-0.027	-0.10	1.39
X_6	Value of Mathematics	0.002	0.01	0.10
X_7	Views on Diff. of Learn. mathematics	0.017	0.04	0.59
X_8	Educational Aspirations	0.025	0.06	0.28
X_9	Vocational Aspirations	0.172	0.08	1.11
X_{10}	Reading Ability	-0.012	-0.06	0.87
X_{11}	Motivation in mathematics	0.019	0.06	0.83
X_{12}	Age of Pupils	-0.058	-0.03	0.38
X_{13}	Number of hours devoted to mathematics homework	-0.037	-0.02	0.29

* Significant at .01 level

Degrees of freedom = 191

Table LIX gives the proportions of variance accounted for by the four significant predictors, and by Enjoyment and Reading ability for girls. The percentages for boys are also reproduced for purposes of comparisons. This table shows that for girls the largest proportion of variance (32%) is attributable to Knowledge level of cognitive ability. For boys the

Table LIX: Proportion of Variance accounted for by the Four Significant Variables of Cognitive Abilities and by Enjoyment and Reading Ability for Boys and Girls.

Independent Variable	Percent of Variance attributable (Boys)	Percent of Variance attributable (Girls)
Knowledge	25.53%	32.16%
Comprehension	24.68%	26.89%
Application	27.14%	25.47%
Analysis	19.85%	13.43%
Enjoyment	0.12%	0.72%
Reading Ability	0.18%	0.42%
Totals	97.50%	99.00%

variance attributable to Analysis level of cognitive ability is 19.85% as compared to only 13.43% for girls.

As in the case of boys a separate regression analysis was carried out using the four variables of Enjoyment of mathematics, Views on difficulty of learning mathematics and Value of Mathematics and Motivation as independent variables and the total mathematics scores as the dependent variable. For the girls the Multiple regression Coefficient was found to be 0.362, and its square is 0.1310. This means that the four independent variables above contribute about 13% of the total variance on the mathematics achievement scores.

4.80. OTHER FINDINGS

4.81. Coeducational Boys Versus Coeducational Girls

Comparisons were also made between the 63 boys and 30 girls in the single coeducational school used in the study. The total number of girls in this school was very small, and a complete set of measurements for all the variables were available for only 27 pupils. It was necessary to fill in the missing scores for some of the variables using the means of the remaining girls in this group, for whom a complete set of data was available. However, the rather small sample sizes rules out the possibility of generalization or application to all the coeducational schools in the country, but the comparisons provide some very useful information regarding sex differences between coeducated girls and boys, useful in the sense that both the boys and girls will have had the same instruction and teachers during their secondary school years. Hence effects due to variation in teaching will be considerably reduced. In a way this helps to control the teacher variable. In the single sex school comparisons,one would expect the level of instruction to vary from school to school depending on the qualifications and educational background of the teacher. Thus for comparisons between boys and girls variations due to level of instruction should have been regressed out of pupils' scores as was done in Husen's (12,1967) study. This was not possible because of the large number of variables being considered in this study.

Table LX presents the results of comparisons between boys and girls in the coeducational school for total scores on the mathematics tests and the cognitive level subtests. Table LX shows that the differences between coeducated girls and boys are small and insignificant. This finding applies to all the four cognitive level abilities as well as the total scores in mathematics. Table LXI presents the results of comparisons between girls and boys on the attitudes, aspirations, personality variable and reading ability scores of pupils.

Table LX: Comparisons between Coeducated Girls and Coeducated Boys on the Achievement tests and Cognitive level subtests.

Variable	Coed. Boys		Coed. Girls		d	t	p
	Mean	S.D.	Mean	S.D.			
Knowledge	44.30	16.04	38.17	18.97	6.14	0.602	n.s
Comprehension	44.49	13.28	39.33	10.84	5.16	0.688	n.s
Application	39.40	16.04	36.40	13.60	3.00	0.328	n.s
Analysis	29.40	13.49	24.20	9.62	5.20	0.703	n.s
Totals	39.75	10.52	34.53	10.05	5.24	0.847	n.s.

Table LXI: Means, standard deviations and t-statistics for comparisons between coeducated boys and girls on attitude scales and other variables.

Variable	Coed. Boys Means	Coed. Boys S.D.	Coed.Girls Means	Coed.Girls S.D.	d	t	p
Enjoyment	37.94	6.37	33.53	8.97	4.40	1.04	n.s.
Value	65.24	7.11	63.70	6.92	2.60	0.365	n.s.
Difficulty	22.18	3.69	27.30	3.43	-5.13	3.42	n.s.
Motivation	40.60	7.18	39.17	7.43	7.44	1.01	n.s.
Reading ability	47.10	6.06	45.33	7.59	1.59	1.77	n.s.
Educ. Aspirations	4.70	1.28	4.50	1.46	0.20	0.24	n.s.
Vocational Asp.	1.91	1.12	1.57	0.68	0.34	0.57	n.s.

On only one of the variables were significant differences between coeducated girls and boys found. This was on the total scores on the difficulty of learning mathematics subscale. Coeducated girls find mathematics easier to learn than boys. On all the other variables the differences between girls and boys were not significant. These are most unexpected findings. Previously, on comparisons between the total sample of boys and girls, it was found that boys did significantly better than girls on almost all the variables. Comparisons between coeducated girls and boys show that boys do better than girls but the differences are not significant at all.

To find out how coeducated girls compare with girls in single sex schools for the variables under study the t-test was used. The results of these comparisons are recorded in table LXII.

Table LXII: Means, standard deviations and t-values for comparisons between girls from single sex schools and coeducated girls.

Variable	Girls (Single Sex) schools		Girls(Coed.) schools				
	Mean	S.D.	Mean	S.D.	d	t	p
Knowledge	44.60	16.59	38.17	6.14	6.44	9.72	.01
Comprehension	41.78	15.95	39.93	5.16	1.85	3.09	.01
Application	36.19	15.36	36.40	3.00	-0.21	0.36	n.s.
Analysis	29.62	12.14	24.20	5.20	5.41	11.75	.01
Total maths. scores	38.20	11.19	35.50	5.25	3.70	8.59	.01
Enjoyment	30.98	8.71	33.53	8.79	-2.50	7.47	.01
Value of maths	63.86	8.61	63.70	6.92	0.16	0.50	n.s.
Difficulty of Learning maths	26.17	5.08	27.30	3.43	-1.13	5.95	.01
Motivation in maths.	39.76	7.14	39.17	7.43	0.59	2.10	.01
Reading ability	45.10	8.61	45.33	7.59	-0.24	0.71	n.s.
Vocational aspiration	1.43	0.86	1.56	0.68	-0.14	4.34	.01
Educational aspirations	4.24	1.45	4.50	1.46	-0.27	4.72	.01

A minus indicates differences favour Coeducated girls.

Number of girls in Single Sex Schools = 174

Number of girls in Coeducational school = 30

In brief, girls in single sex schools do significantly better on the achievement test totals as well as on the cognitive level subtest totals except for application subtests on which slight but insignificant differences favour the coeducated girls. On all the other variables except for the personality variables, the differences are either not significant or are in favour of coeducated girls significantly. Thus coeducated girls enjoy mathematics more than girls from single sex schools. Coeducated girls value mathematics significantly more than girls in single sex schools. Besides this, coeducational girls have higher educational aspirations and their vocational aspirations are more favourably inclined to vocations in which it may be necessary to study more mathematics. It is most interesting to note that girls who are educated alongside boys do better than girls in single sex schools on the application subtests. We have already seen from table LXI, that none of the differences between girls and boys within coeducated schools on all the variables were significant.

Finally comparisons were made between all the boys and the coeducated girls. The results are recorded in table LXIII.

Table LXIII: Means, standard deviations, and t-values for comparison between coeducated girls and all the boys.

Variable	All Boys		Coed. Girls		d	t	p
	Means	S.D.	Means	S.D.			
Knowledge	47.88	15.96	38.17	18.97	9.73	17.8	.01
Comprehension	45.44	15.44	39.93	10.94	5.50	9.5	.01
Application	40.19	15.85	36.40	13.60	3.79	8.3	.01
Analysis	31.25	13.48	24.20	9.62	7.05	15.8	.01
Total maths score	41.40	10.96	34.50	10.05	6.90	18.84	.01
Enjoyment of maths.	36.68	7.08	33.53	8.79	3.15	12.98	.01
Value of maths	66.80	7.61	63.70	6.92	3.10	12.19	.01
Difficulty of learning	26.60	3.83	27.30	3.43	-0.70	5.51	.01
Motivation	43.66	6.44	39.17	7.43	4.49	19.95	.01
Educational Aspiration	4.98	1.20	4.50	1.46	0.48	11.68	.01
Vocational aspiration	2.07	1.01	1.57	0.68	0.50	15.16	.01

A minus indicates differences favour girls.
Total Number of Boys = 382

Number of Coed girls = 30

As table LXIII shows there is now a swing back to male superiority found earlier on for the main comparisons between boys and girls, i.e. using the total research samples of boys and girls. However the coeducated girls still view mathematics as being easier to learn than the total sample of boys. The differences on the total scores on the Difficulty of Learning Mathematics attitude subscale are significantly in favour of coeducational girls.

In general it is possible to draw the following conclusions from the comparisons between coeducational and single sex school samples.

1. There are no significant differences between the performance of coeducated girls as compared to coeducated boys on total scores or scores by cognitive levels in mathematics.

2. There is no difference between coeducated boys and coeducated girls on their total scores on Educational and Vocational Aspirations or on the Enjoyment of Mathematics and Value of Mathematics subscales. The only significant differences found were between the total scores on Views about Difficulty of Learning Mathematics, on which girls scored significantly higher.

3. Comparisons between single sex school girls and coeducated girls show that the performance of girls from single sex schools is significantly better than that of coeducated girls on Knowledge, Comprehension and Analysis levels of cognitive abilities and on the total scores in mathematics. However, coeducated girls have more favourable attitudes towards mathematics and also score higher on the other variables such as Educational and Vocational Aspirations and Motivation.

4. Overall Comparisons between all the boys and the coeducated girls show that boys are superior on all the variables under study except on the Difficulty of Learning Mathematics scale in which coeducated girls have indicated that they find mathematics easier to learn.

CHAPTER FIVE

SUMMARY AND CONCLUSIONS

5.0. Introduction

This chapter consists of 5 sections. Section 5.1 presents an outline of the objectives and aims of the study and of the methods and procedures used for data collection and analysis. Section 5.2 presents a summary of the findings and decisions in relation to each of the hypothesis tested in this study. This section also includes a summary of other findings on sex differences in mathematics achievement. Section 5.3 gives an account of the interpretations of the findings. The last section (5.4) considers the implications of the findings of this study followed by concluding remarks in section 5.5.

5.1. Summary

The present study was carried out to find out if there were significant differences between the proportions of boys and girls taking mathematics after their primary schooling No attempt was made to investigate the history behind the gap (if any) between the sexes in the primary schools. After establishing that women were considerably under-represented in courses requiring extensive study of mathematics at the University of Nairobi, the hypothesis that girls do not do as well as boys in mathematics examinations to gain admission to these courses was explored. An analysis of the results at the school certificate levels for Nairobi schools gave support to this hypothesis. The proportion of girls failing the East African School Certificate examinations in mathematics in schools in Nairobi was found to be significantly higher than that of boys in both the traditional and the modern mathematics syllabi. It was shown that differences between the performance of girls and boys in mathematics become apparent as early as Form One. Evidence for this came from the results of Parkar's study reviewed in Chapter Two, in which form one girls began to lag behind the boys on achievement in mathematics and on their scores on the attitude towards mathematics scales, by the end of the first year in secondary school. In an attempt to explain the discrepancies in the performance of boys and girls in mathematics a large number of factors or variables were isolated and their relation to the achievement of boys and girls examined. The inclusion of a large number of variables was necessary as no previous studies had been carried out in Kenya examining the role of different factors and their impact specifically on mathematics achievement. Thus the directions for the choice of variables for inclusion in this study came mainly from the findings of researchers in the West.

The present study started by examining sex differences in mathematics achievement of about 600 pupils who had completed the first two years of secondary school and had just entered the third form. Initially 25 achievement tests were constructed to span as much of the content areas of S.M.E.A.

Book One and Two as was possible. In this respect the present study could be said to have played a dual role; one of evaluating the mastery of topics from the S.M.E.A. Books One and Two, and secondly of examining the nature of differences between the performance, attitudes, aspirations and motivation of boys and girls of Form III. It was felt by the researcher that examining sex differences on overall scores in one or two tests covering the entire contents of S.M.E.A. would be highly inadequate to reveal the subtle differences between the sexes. This was supported by the findings of this study. While overall significant differences were found between boys and girls, the differences were often small and insignificant when the performance of the sexes was compared by tests. Further it was decided to test the performance of the sexes on items at four levels of difficulty. In this respect Bloom's hierarchical classification by cognitive level abilities proved to be most useful. Thus items in each test were placed into four cognitive levels viz: Knowledge, Comprehension, Application and Analysis. This would have enabled the researcher to locate the levels of difficulty of items at which the performance of girls differs significantly from that of boys. Again in this respect the findings of the study were most useful and highly informative.

As standardized achievement tests were not available it was necessary to ensure that the tests used were appropriate for use in the study. The pilot study showed that a large number of the tests were poor and inadequate in many respects. This made it necessary to revise and reconstruct these tests. As severe limitations were imposed by the amount of testing time available in each of the six secondary schools it was necessary to cut down the number of tests used to a minimum. The only other way out would have been to increase the number of schools being tested and share the tests between them. This was out of question due to financial constraints, the amount of time available for completion of the study and the enormous amount of extra labour that would otherwise have been involved for data analysis. Finally seventeen achievement tests were used. The reliabilities of the tests range from 0.5 to 0.8, certainly not as satisfactory as one would have liked to have. Depending on the number of testing sessions available in each school, pupils sat between three to six of the seventeen tests randomly. Besides this each pupil sat for the General Questionnaire, the attitude scales and the Cloze test. For each pupil scores were recorded on the following variables:

1. Total mathematics Achievement scores.
2. Scores on each of the four cognitive level subtests i.e. knowledge, comprehension, application and analysis.

3. Reading Ability Scores.
4. Scores on each of the three attitude scales i.e. enjoyment of mathematics, value of mathematics and views on the difficulty of learning mathematics.
5. Educational aspirations of pupils.
6. Vocational aspirations of pupils.
7. Number of hours pupils devote to homework everyday.
8. Scores on the personality variable of motivation in mathematics.

Analysis of variance was used to test for differences between the performance of boys and girls on the seventeen achievement tests. As most of the findings turned out to be significant an enormous amount of additional analysis was carried out mechanically. The t-test was used to make comparisons between girls and boys on a large number of the independent variables. The regression analysis carried out was not as successful as the researcher would have liked it to be. One of the factors contributing to this was the overenthusiasm of the researcher. Far too many of the independent variables were included in the regression analysis although there were sound reasons for not doing so e.g. intercorrelations between some of the independent variables were too high implying that they were measuring similar abilities. However attempts were made to correct this situation. Far more data analysis was possible than was actually carried out. Infact data analysis was restricted to testing hypotheses as originally set up and rarely going beyond the testing of sex differences. For example, comparisons could have been made between schools, classes within schools, arts and science groups, high and low achievers or within sexes comparing girls with high educational aspirations, high motivation etc. to girls with low motivation and so on.

5.2. SUMMARY OF SIGNIFICANT FINDINGS

A summary of the major findings in relation to the hypotheses as originally stated in Chapter One of this / Dissertation follows. The variable name appears first and is underlined followed by the statement of the hypothesis and the decision on the hypothesis. Some of the hypotheses had not been originally set up. These were set up after data analysis and are reported in the separate section on summary of other findings (5.211).

5.21. Total mathematics score

Hypothesis: There is no difference in the overall achievement scores of boys and girls of Form III in mathematics.

Decision: The null hypothesis of no differences was rejected in favour of boys at the 1% level of significance.

5.22. Cognitive Level Performance.

Hypothesis: There is no difference between boys and girls of Form III on their achievement test scores in mathematics at each of the following cognitive levels; Knowledge, Comprehension, Application and Analysis.

Decision: Comparisons were made by levels for each of the tests. On Knowledge subtests no significant differences were found and the null hypothesis is accepted. On the test on 3-dimensional geometry boys were better than girls at the one percent level of significance. Girls were better on knowledge subtests on mappings and vectors.

On Comprehension subtests significant differences between boys and girls were found on only one test. This was the comprehension subtest on Pythagoras theorem on which, differences were found to favour boys. Thus the null hypothesis of no differences between the sexes on comprehension items is accepted.

On Application subtests significant differences in favour of boys were found on six tests in all. These were the application subtests on Equations, 3-dimensional geometry, rational numbers, vectors, Percentages and Regions and Statistics. On not even one of the tests was the performance of girls significantly superior to that of boys. The null hypothesis was rejected in favour of boys when total scores on application subtests were compared.

On Analysis subtests significant differences in favour of boys were found on four of the subtests. These were the tests on Sets, Area, Pythagoras theorem and 3-dimensional geometry. Girls' performance was significantly better than that of boys on the analysis subtests on natural numbers. Overall differences were also in favour of boys and the null hypothesis was rejected in favour of boys.

5.23. Content Areas of S.M.E.A.

Hypothesis: There is no difference between girls and boys of Form III on their achievement test scores in various content areas of S.M.E.A. Books One and Two.

Decision: Significant differences were found between the performance of boys and girls on five tests in all. The differences favour boys on the tests on Equations, Rotations, Rational Numbers and 3-dimensional Geometry. Girls performance was significantly better on only one test, the test on Percentages and Regions.

5.24. Reading Ability

Hypothesis: There is no difference between the reading ability scores of boys and girls of Form III as determined by the Cloze test constructed from a random selection of passages from S.M.E.A. Books One and Two.

Decision: The null hypothesis of no differences between the reading ability scores of girls and boys was accepted.

5.25. Attitude Subscale on Enjoyment of Mathematics

Hypothesis: There is no difference between girls' and boys' scores on Aiken's E scale on Enjoyment of Mathematics.

Decision: The null hypothesis was rejected in favour of boys at the one percent level of significance. Also on all the items in this scale significant differences were found to favour boys.

5.26. Attitude Subscale on Value of Mathematics

Hypothesis: There is no difference between girls' scores and boys' scores on Aiken's V scale on Value of Mathematics.

Decision: Null hypothesis of no differences was rejected in favour of boys. Boys have a significantly higher value attachment to mathematics than girls.

5.27. Views about the Difficulty of Learning Mathematics

Hypothesis: There is no difference between girls' and boys' scores on their views about difficulties of learning mathematics as determined by Husen's Scale.

Decision: The null hypothesis of no differences was accepted. Both girls and boys regard mathematics as being equally difficult. Significant differences favour boys on only one item and girls on one item in this scale, both at 5% level of significance. On all the other items in this scale no significant differences were found.

5.28. Personality Variable : Motivation

Hypothesis: There is no difference between girls' and boys' scores on motivation in mathematics as determined by the Entwistle-Nisbet Scale as used in this study in its modified form.

Decision: The null hypothesis of no differences between girls' and boys' motivation scores in mathematics was rejected in favour of boys at the 1% level of significance. On nine out of the thirteen items in this scale significant differences favour boys. On the remaining four no significant differences were found.

5.29. Aspirations of Pupils

Hypothesis: There is no difference between the educational and vocational aspirations of boys and girls of Form III.

Decision: The null hypothesis of no differences between girls and boys was rejected in favour of boys at the 1% level of significance. Significantly more boys aspire to do their A levels, take mathematics as a subject for study at A levels and attend University than girls. Significantly more boys aspire to the technical and professional category of occupations than girls.

5.210. Prediction

Hypothesis: The independent variables considered in this study will not be good predictors of achievement in mathematics for boys and girls of Form III.

Decision: Only pupils' scores on the four cognitive level abilities were found to be significant predictors of achievement scores of boys and girls in mathematics. Separate regression analysis were carried out for boys and girls. For boys, the four cognitive level abilities accounted for 97.20% of the total variance on the achievement test scores. For girls the corresponding figure was 97.95%. The order of good predictors for boys were first the four cognitive level abilities with the largest proportion of variance attributable to Application scores and least to Analysis scores, followed secondly by Educational Aspirations and then Reading ability. For girls the order was the four cognitive level abilities with the largest proportion of the variance attributable to Knowledge scores and least to Analysis. After these came Enjoyment of mathematics and Reading ability. Reading ability occupies the same position in the order of good predictors for both boys and girls.

Summary of Other Findings.

5.211. Cognitive Levels

Hypothesis: Originally no hypothesis was set up although this hypothesis could easily have been tested without further computation. A statement of the hypothesis is as follows;

There is no difference in the performance of Form III pupils (girls and boys considered together) at the following cognitive levels, i.e. Knowledge, Comprehension, Application and Analysis.

Decision: Significant differences between the performance of Form III pupils at the four cognitive levels were found. The differences between the means of Knowledge and Analysis levels were largest. Those between knowledge and comprehension were the smallest. Further all the pairwise comparison between the means of the four cognitive levels were significant. This finding lends further support to Bloom's hierachical classification of cognitive abilities. However, as noted on page 152 it does not follow that boys and girls pass through the same stages on their way to abstract or analytical thinking in mathematics. There is some evidence (though weak) from the data gathered in this study that for boys the application level follows Knowledge and scores on knowledge and application are significantly related while girls follow the normal order as proposed by Bloom and his associates from knowledge to comprehension to application and so on. However further research is necessary to verify this finding.

5.212. <u>Coeducational Versus Single Sex Comparisons</u>

Hypothesis: Again no specific hypothesis were set up prior to data collection. The statement of the hypothesis could have been set up as follows;

There is no difference between the

performance of girls from single sex schools and coeducated girls on their scores on mathematics tests or subtests and on the independent variables considered.

Decision: The hypothesis of no differences between cognitive abilities was rejected in favour of girls from single sex schools. The differences on application subtest totals were not significant. However coeducated girls obtained significantly higher scores on views about Difficulty of learning mathematics and on the educational and vocational aspirations scales.

5.213. <u>Coeducated Boys versus Coeducated Girls</u>

Hypothesis: There is no difference between the performance of coeducated boys and coeducated girls at the four cognitive levels or on total mathematics scores and on the other independent variables in this study.

Decision: The null hypothesis of no differences was accepted. The differences between girls and boys were all insignificant except on the Views about Difficulty of Learning mathematics scale on which coeducated girls scored significantly higher than coeducated boys.

5.214. Coeducated Girls Versus All Boys.

Hypothesis: There is no difference between the performance of coeducated girls and all the boys at the four cognitive levels or on total mathematics scores and on the other independent variables in this study.

Decision: This hypothesis was rejected in favour of boys on all the variables except on the difficulty of learning mathematics scale on which significant differences favour the coeducated girls.

5.3. INTERPRETATION OF THE FINDINGS.

5.31. Mathematics Achievement and the Sexes

This study has shown that the sexes differ significantly in their performance in mathematics. In general boys showed superiority at the higher cognitive level abilities while the differences between girls and boys were not significant at the lower level subtests on knowledge and comprehension. Overall boys did significantly better than girls. Essentially what this means is that girls are as good as boys in remembering or recalling their knowledge of mathematical facts, terminology and algorithms. Not only that, girls are also as good in their performance on items requiring translation, interpretation and extrapolation of mathematical information. The last three represent the lowest levels of understanding. The gap between the performance of girls and boys of Form III widens when we examine their performance at the upper levels of understanding. Thus girls and boys differ significantly in their abilities of using mathematical knowledge and applying it to new situations, to break down information into its components and discover relationships, solve non-routine problems and to make generalizations. In Bloom's system of classification of knowledge all these form the basic elements of higher levels of thinking.

This study has provided some evidence regarding the nature of sex differences on performance at different cognitive levels. Thus the matrix of intercorrelations between various cognitive level abilities (Table LIV and LV) showed that for boys the correlation between knowledge and application scores was the highest while for girls the correlation between Knowledge and comprehension scores was the highest. Further evidence was provided by the regression analysis. For boys the scores on the application subtests were the best predictors of mathematics achievement. The correlation between application and mathematics achievement scores were as high as 0.755. Besides this, the application scores accounted for more variance in the mathematics achievement scores than any of the other cognitive level subtests (Approx.27%).

For girls the best predictor of mathematics achievement scores were their scores on the Knowledge subtests accounting for a staggering 32% of the total variance in total mathematics achievement scores. The correlation between application scores and mathematics achievement scores was less than that between knowledge and mathematics achievement scores.

We can interpret these findings as implying that boys who obtain high scores on knowledge items get high scores on tests on application items while girls who obtain high marks on knowledge subtests obtain high marks on comprehension items. It would appear from this as if boys begin to apply their knowledge of mathematical facts, principles, rules and algorithms to practical situations while girls ignore the practical aspects and instead concentrate on understanding, or to use the words of Piaget "Assimilating" the various bits and pieces of mathematical information they are given. This possibly explains why the correlation for boys was highest between their knowledge and application scores while for girls it was highest between knowledge and comprehension scores. The explanations for this could lie in the fact that boys have a wider general background experience which is more relevant to later abstraction of mathematical knowledge and concepts and their application to new situations. The other explanation proposed is that this could be due to differences in the school experiences provided by mathematics teachers; those of boys being more relevant to abstract thinking than those for girls. Both the possibilities are equally attractive and relevant to Kenyan secondary school pupils and are the subject of discussion for the rest of this section.

The first explanation above makes it necessary for us to consider the part played by earlier school experiences as well those outside the school and prior to schooling. Little is known about sex differences in mathematics during the primary school years for Kenyan Children. A study is at present being conducted by an M. Ed. colleague using primary school children on conservation tasks along the same lines as Piaget's experiments. Parkar's study, reviewed on page 55 of this thesis, showed that there were no sex differences on achievement tests as pupils entered the secondary school. There were no differences between the attitudes towards mathematics scores as well for his sample of students. Whether the long holiday between the Kenya Preliminary examinations and selection into secondary schools reduced the differences between the sexes on their performance is difficult to determine. However, in view of the findings of researchers in the West showing that sex differences during the primary school years are minimal and insignificant and in view of the fact that most if not all primary schools in Kenya are coeducational schools it is very unlikely that the school experiences of boys and girls in mathematics classes of primary schools differ very much. This search for differences in the experiences of boys and girls leads us to consider the role of experiences outside the school and right into the child's environment, his home background and the social set up in which the child finds himself. In fact a large number of diverse and varied factors enter into the picture at this juncture. There is the society with its beliefs, taboos and attitudes towards the place of men and women in it to be considered. The society will define, limit and even restrict the choices open to each sex and stereotype roles appropriate to each sex. The socioeconomic status of the family will decide which toys boys will play with and what activities girls will engage in. Not only that it will decide who gets priority in attending school. The education of parents will exert further influence on achievemer and attitudes and aspirations of pupils. Stafford's review (reported on page 50 of the thesis) has considered the role of environmental components and its effect on Quantitative reasoning i.e. verbal problem solving ability. Thus factors such as Sex Role identification, Father absence or presence in the home, ordinal position of child in the home as well as child rearing practices may all have their part to play in bringing about differential attainment in mathematics by the sexes and need to be investigated further using Kenyan Pupils. Also personality traits such as dependency-independency and conformity-passivity become all important determinants.

of the performance of girls and boys, especially at the higher cognitive levels. As Maccoby (55,1966) has pointed out the dependent, passive person is oriented towards stimuli from other people. He waits for stimuli to act on him and then reacts to them, with little initiative of his own. The present researcher finds this explanation most attractive although it does not necessarily follow that what is true for children in the West is applicable to the Kenyan situation. Societies in Kenya, as elsewhere in many parts of the world, expect girls to be obedient, dependent, passive and conforming to the social rules; agressiveness[32], is frowned upon if exibited by girls. Boys on the other hand are encouraged to hit back, are given greater freedom of activities and independence in the choice of activities. Little girls are given dolls and cooking utensils to play with while boys enjoy themselves going uphill and downdale on bicycles and playing with mechanical objects like tyres, cars, trolleys etc. Thus girls become accultured to become dependent and passive, which, it is hypothesised, restricts them in independent and abstract thinking necessary at the higher levels of cognitive thinking. Boys on the other hand do not wait for stimuli from the mathematics teachers to prompt them into action.

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32. As already mentioned agressiveness is regarded by some researchers as a desirable quality for problem solving and abstract thinking.

The other explanation put forward to discuss the poorer achievement of girls at the higher cognitive level abilities centres on the role of experiences provided by the mathematics teachers in the secondary schools. Two facts point an accusing finger in the direction of the mathematics teacher. One is the virtual absence of sex differences in the coeducational school and the other is the responses of pupils to an item in the attitude subscale on Views about Difficulty of learning mathematics. This item states; 'Almost any one can learn complex mathematics if properly taught'. More than twice the percentage of girls disagree or strongly disagree with this statement as the percentage of boys. The differences between boys and girls on this item were significantly in favour of boys. It appears as if girls do not have much faith in mathematics teaching or possibly the mathematics teacher. It is not being claimed by the researcher that pupil responses on a single item prove or disaprove defacto that teachers of mathematics are not doing enough in girls' schools. However at a time when there are acute teacher shortages, the girls' schools are particularly hard hit. The female graduate teacher in mathematics is an unheard of phenomenon in most secondary schools. As one of the headmistress in a girls' school pointed out, teachers who had not graduated in mathematics during their teacher education years end up "teaching mathematics just to keep the girls occupied.

The tragedy of the whole affair is that when a pure science teacher is missing we can switch over to general or physical science easily or ask a teacher who has some science background to help out but then mathematics is compulsory for E.A.C.E. and somebody has to teach it". Thus although the mathematics syllabus has been completely changed teaching methods have seen no changes at all. Often the conventional chalk-talk methods are used with little or no use being made of models, visual aids, charts etc. Teachers who have used conventional teaching methods "successfully" during the past decade or two continue to rely on the same methods without realising that another approach is necessary and called for i.e the discovery approach. Thus although the authors of S.M.E.A. strongly recommend the use of the "discovery" approach in the teaching of mathematics, in practice the conventional approach is the only one used. In the schools used in this study the only teaching aids in evidence in the mathematics lessons were the textbook, the blackboard ruler and the blackboard protractors. Besides this, the switch to a completely new syllabus, which has as yet not been evaluated since its inception ten years ago, has produced severe strains on teachers who have had to relearn some of their mathematics. Some of the topics like surveying, set and probability theory were met by these teachers in the university. Before a transition to the new syllabus intensive inservice training was necessary for those teachers who were inadequately prepared to teach the new syllabus. Further evidence that background experiences are lacking and inadequate among girls comes from the finding that boys did best on the test on 3-dimensional geometry i.e. test 10, while for girls this was one of the tests on which their performance was very poor. It appears as though boys are superior on measures of spatial ability i.e. ability to think about objects in two or 3 dimensions and to see relations of an arrangement of objects in space, and their experiences help them to visualize three dimensional space clearly. Girls on the other hand are handicapped by their lack of experience in space relations. In most girls' schools, pure science subjects are rarely taught or if taught restricted to a single class of bright pupils, the rest being indirectly told that they are no good for pure science subjects. There is little doubt that the study of subjects like physics and to a lesser extent Chemistry will reinforce pupils' learning in the mathematics classes. In boys' schools on the other hand General science is virtually absent even in the Arts streams. In girls' schools the science laboratories are often illequipped and visual aids in mathematics if any, have no room. In boys' schools there is some evidence of mathematical models, charts etc. usually in the mathematics teachers locker or cupboard. Often the chapter on models, 3-dimensional geometry are skipped. Projects in books are overlooked and considered as a waste of time when in fact they would provide valuable background experience lacking in girls and necessary for thought processes at the higher cognitive levels. To summarize, it is felt by the researcher that the poor performance of girls at the higher cognitive levels of thinking i.e. application and analysis, is attributable to their lack of suitable background experiences which are necessary for higher order cognitive processes. It is felt that the laboratory approach to teaching mathematics will provide the necessary background experience and has a lot to offer in that mathematics will be taught as a practical subject, related to every day life and problems with wide applications. The mathematics laboratory would bring girls into contact with models, and visual aids and at the same time provide the backing of concrete materials when their attempts at abstractions fail.

5. 32. <u>Sex Differences in Attitudes Towards Mathematics</u>

One of the findings of this study was that girls had significantly more UNFAVOURABLE attitudes towards mathematics on two of the three subscales used in this study. Thus girls enjoy mathematics far less than boys, and girls' value of mathematics is lower than that of boys. Typical findings were; 50% of the girls found mathematics dull and boring as compared to 14% of the boys, 32% of the girls dread mathematics as compared to 14% of the boys. Maths made 48% of the girls uneasy and confused as compared to 25% of the boys. Again, evidence that the school experiences in the mathematics classes have a lot to do with the negative feelings of girls comes from the sample of girls from the coeducational school, where no significant differences were found between boys and girls on their total scores on the enjoyment of mathematics and value of mathematics scales; and on the views about Difficulty of learning mathematics, girls scored significantly higher than boys. It is surprising to note that coeducated girls find mathematics easier to learn than boys in the same school. Again it is likely that the poor teaching in girls' schools is responsible for more than 48% of the girls indicating that maths is dull and boring and about 50% of the girls declaring that they feel uneasy and confused with mathematics. While mathematics lessons can be made enjoyable if related to the physical world and the interests of pupils or to problems affecting and relevant to pupils' lives, little is done by mathematics teachers to enliven their lessons by making use of teaching aids, audiovisual materials and charts as is done for example in Geography lessons and even in history classes. In fact in mathematics, which deals mainly in abstractions, the use of these aids is more necessary than in geography or history lessons where pupils are more in touch with the physical world about which they are learning. Again it is felt that the use of concrete materials will help to enliven the mathematics lessons and help pupils grasp the essential abstract ideas which bog down so many of the girls.

The attitude of teachers towards mathematics is also important. If a teacher has a low value attachment to mathematics and has never known pleasant and enjoyable experiences in mathematics lessons during his or her school days (when the fear of the cane was capitalised upon by the mathematics teachers to force mathematical knowledge into pupils), it is highly unlikely that he will make his own lessons any more lively than what he himself went through. In fact the present day mathematics teacher must be at a loss without the only 'Visual Aid' i.e. the stick, with which he is so familiar and of which he has had so much experience during his school days,so much so that he may be hesitant to use modern 'visual aids', the effectiveness of which he has every reason to doubt. Hence it is necessary to demonstrate through refresher courses, the use of visual aids in teaching mathematics. The mathematics teacher will unknowingly convey his own feelings and expectations or attitudes towards mathematics to his pupils. For example, if the mathematics teacher believes that mathematics is for boys he or she may unconsciously transmit her feelings to the pupils.

Besides teachers, the attitudes of parents and other members of the society will have a strong influence on pupils' attitudes and interest in mathematics. Most parents have themselves had nasty and dreadful experiences of mathematics during their own school years, when the cane decided all matters for once and all, including the learning of mathematics. The change to modern mathematics has not helped matters and has completely alinated parents from the content of the mathematics textbooks so that what little help they could have given their daughters (and sons) to reinforce their school learning is no longer available. Fear of what little parents knew in mathematics has now turned into the more drastic fear of the 'Unknown' by the switch over to the new syllabus for which he has as yet to be given sound reasons. We cannot expect parents' attitudes towards mathematics to become more favourable in the present circumstances for at least another generation or two when the present school going population will themselves become parents. Parental attitudes towards mathematics will inevitably affect the amount of encouragement their sons and daughters will receive in their study of mathematics, in discussion of mathematical problems and reading mathematical literature or entering careers involving mathematics. In these circumstances what is necessary is greater coordination between the school, educational authorities and curriculum designers so as to familiarize teachers and parents with the new syllabus.

5.33. Sex Differences in educational and Vocational Aspirations.

Significant differences were found between the educational and vocational aspirations of Form III boys and girls. Significantly more boys wanted to do their A levels, to take mathematics as a subject at A levels and to attend University. Also more boys wish to enter into technical and professional occupations. 31% of the girls wanted to go for the general category of vocations as compared to 12% of the boys. The general category of vocations includes all those vocations for which a pass in mathematics is not strictly a necessary pre-requisite for entry. For entry into the technical and professional class of vocations a pass at A levels in mathematics is absolutely necessary. It was found that only 7% of the girls aspired to this category of occupations as compared to 42% of the boys. It was originally felt by the researcher that as the entrance requirements for the technical and professional category of vocations were higher the educational aspirations of pupils aspiring to these vocations would also be high. However, this was disproved by the findings of this study. The correlation coefficient between educational and vocational aspirations scores was very small for both boys and girls showing that the relationship between the two was poor. Besides this the partial correlation coefficient between mathematics achievement scores and scores on the educational and vocational scales was not significant at all (.08 and .04 respectively for boys and .06 and .08 for girls). One possible explanation for this could be that Form III pupils are as yet uncertain or unaware of the period and length of training required for entry to the professions of their choices. Thus, although their vocational aspirations are high Form III pupils seem to underestimate the length of training and full time education they will be required to take. One reason for this could be that the career guidance services in schools are inadequate and as such pupils lack information on educational opportunities etc. Only one girl out of the research sample of 204 wanted to become an engineer. This can be compared to the figure for boys which is 97 out of a total of 382, almost a third of the boys. In this case it would be unfair to blame the career master who rarely enters into the picture till the Fourth Form. The influence of the home, society and culture is more important . The socio-cultural differences weigh more heavily on girls than on boys. Thus traditionally parents have higher achievement expectations of boys and encourage and expect them to choose the high status occupations. Often males have first claims to the family resources and educational priority is given to boys while girls are often kept at home to look after the kitchen. If any plans are made for girls they are more likely to be marriage plans than educational and vocational plans. Evidence from the regression analysis suggests that for boys, educational aspirations is the best non-cognitive variable for prediction on their achievement in mathematics. It is likely that boys are more realistic and definite about their future educational plans while girls are uncertain not only about their future educational but also vocational plans. Most often these are worked out for them by their parents, after a series of heated last minute arguments which are inevitable if a daughter declares that she wants to be an engineer. On the other hand if a boy made the same declaration the parents would be full of praise for their son. The school reinforces the beliefs of society at large by setting up separate cookery classes to prepare girls for good housekeeping and discouraging girls from making choices of professions traditionally reserved for 'males'.

5.4. Implications of the Findings for Further Research

The present study has found that significant sex differences exist at the higher cognitive level abilities for boys and girls of Form III in Nairobi schools. The differences are in favour of boys. Further research is necessary to find out if the findings for other categories of schools and provinces are similar.

Also research is necessary to show if the findings are applicable to other Forms in the Secondary Schools of Kenya.

There are indications that the achievement scores on knowledge and application levels of cognitive ability for boys are related while for girls, knowledge scores and comprehension scores are more strongly related than any of the other cognitive level abilities. Further research on a larger scale is necessary to verify this finding and to find out if this hinders the development of mathematical concepts for girls.

Significant differences were found between girls and boys on their attitudes towards mathematics. The influence of parents, teachers, and peer groups on the attitudes of girls and boys needs to be examined further.

Controlled experiments are necessary to examine the effect of different teaching methods on the sexes. Thus the discovery, the laboratory method and the Conventional Classroom approach should be used to find out if these have any strong influences on the performance of girls and boys at the higher cognitive levels.

Rural areas cling more strongly to past traditions than urban areas. It is hypothesised that the gap between the performance of the sexes in the rural areas will be wider. Research is necessary to test this hypothesis.

Little is known about sex differences in mathematics for primary school children. Further research is necessary to find out if sex differences exist in the primary schools for Kenyan Children.

It was hypothesised that background experiences of pupils exert a profound influence on the achievement of Form III pupils especially at the higher cognitive levels. Research studies should be conducted to examine the role of socioeconomic factors, cultural and traditional values and beliefs on the attitudes and achievement of pupils in mathematics.

Significant differences were found in the mastery of different content areas of S.M.E.A. Books One and Two, by Girls and boys of Form III. Further research is necessary to find out if the treatment of content areas in some of the chapters is inadequate. If necessary these chapters should be revised or enrichment materials added in. The objectives in a chapter are rarely stated in the S.M.E.A. Books often making it difficult for pupils to know if they have attained the overall objectives in a chapter. Thus each chapter should include clear statements of behavioral objectives towards which pupils can work.

One area of research in which promising results are likely is the personality differences between the sexes. Thus explanations for sex differences in mathematics achievement in terms of personality dimensions such as dependency, conformity, dominance, confidence, sociability, agressiveness etc. appear most promising. However, reliable instruments to obtain measures on personality factors for Kenyan pupils are lacking and these will have to be developed and tested before use. Further research is necessary to find out what effect the change over from the traditional mathematics syllabus has had on differential attainment of the sexes. However as this syllabus is in its final stages of being withdrawn, any research undertaking must commence as soon as possible.

5.5. CONCLUSIONS

The disparities in the enrolment of boys and girls for mathematics classes in the higher institutions of learning and for courses in which the study of mathematics is necessary are related to a large number of factors. Not all of them are under the control of mathematics educators or curriculum designers. Socio-cultural issues are just as important as the mathematics teachers and weigh far more heavily on girls than on boys. Until such time as there are changes in the attitudes and beliefs of society towards the role of women in Kenya the disparities in the enrolment rates are likely to persist. In the meantime mathematics educators should not sit back and hope that the situation will change. They can do much to improve mathematics lessons by bringing pupils into contact with the real world of concrete materials and to build the abstract concepts involved in mathematics from these. Besides this the mathematics teachers should always be in the search of better ways of presenting mathematical concepts and be in touch with the findings of research studies relevant to the teaching of mathematics. In fact it is about time that the mathematics teacher took an active part in developing new methods of presenting mathematical concepts and putting in a bit of colour, life and enthusiasm into his teaching. He will have to break away from the traditional Talk and Chalk approach to teaching mathematics and think of ways of inducing maximum participation of pupils rather than pouring mathematical knowledge into his pupils. He would have to be more flexible in his outlook and attitudes towards mathematics. All along his aim should be that of making the experiences of his pupils in the classrooms pleasant and rewarding so that mathematics lessons are no longer dreaded by as much as 50% of the girls as was found in the present research investigation.

APPENDIX I
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APPENDIX 11

Summary of ANOVA on random sample of 50 boys and 50 girls.

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Squares	F	P
Sex (A)	14.61	1	14.61	12.80	.01
Tests (B)	531.19	16	33.20	29.72	.01
Levels (C)	409.04	3	136.34	170.42	.01
Sex by Tests	75.92	16	4.75	4.17	.01
Sex by Levels	0.94	3	0.31	0.49	n.s.
Test by levels	576.46	48	12.09	15.11	.01
Sex by levels by tests	46.90	48	0.98	1.23	n.s.
Pupils within sex by tests	1894.34	1666	1.25		
Residual	4001.70	4998	0.80		

APPENDIX III

STUDENT QUESTIONNAIRE

This is not a test. The questions ask you about yourself, your interests and about your background. Answer the questions as honestly as you can. Your answers will help us find out what relation there is between student background and achievement in mathematics. DO NOT WRITE ANYTHING ON THE QUESTION PAPER.

1. What is your name?
2. What is your sex? A. Male B. Female
3. What is your age?
   - A. Less than 14 years
   - B. Between 14 and 15 years
   - C. Between 15 upto 16 years
   - D. Between 16 upto 17 years
   - E. Between 17 upto 18 years
   - F. Over 18 years.
4. Do you want to do your A levels after form four?
   - A. Yes
   - B. No
   - C. Uncertain
5. If you answered Yes to No. 4 above, would you like to attend University after form VI?
   - A. Yes
   - B. No
   - C. Uncertain
6. If you answered yes to No. 4 above will you take maths as a subject for your A levels?

A. Yes

B. No

C. Uncertain

7. Which job do you wish to enter after your schooling?

8. Approximately how many hours do you devote to mathematics everyday after school?

A. Less than $\frac{1}{2}$ hr

B. $\frac{1}{2}$ hr. to 1 hour

C. 1 to 2 hours

D. 6 to 7 hours

E. 3 to 4 hours

F. More than 7 hours

G. 5 to 6 hours.

Attitudes Towards Mathematics

This is not a test. There is no right or wrong answer. In each question you are asked to tell how you feel about each statement by selecting one of the responses, A, B, C, D or E. If you "strongly agree" with a statement circle A. If you "agree" with a statement circle B, if you are "uncertain" about your feelings to a statement circle C. If you "disagree" with a statement circle D. If you "strongly disagree" with a statement circle E.

Write your answers on the separate answer sheet.

1. Mathematics is dull and boring because it leaves no room for personal opinion.

2. Maths is needed in designing practically everything.

3. A thorough knowledge of advanced maths is the key to an understanding of our world in the 20th century.
4. I can get along perfectly well with everyday life without maths.
5. Any person of average intelligence can learn to understand a good deal of maths.
6. I sometimes wish I could choose another subject instead of maths.
7. It is important for me to do really well in maths here.
8. Maths makes me feel uneasy and confused.
9. Maths is a very worthwhile and necessary subject.
10. It is important to know maths in order to get a good job.
11. I can't see any relevance in the maths we do here.
12. Even complex maths can be made understandable and useful to every secondary school pupil.
13. Maths makes me feel nervous and uncomfortable.
14. I think my father uses maths in his job.
15. I usually tackle the easy things first and leave the more difficult ones to the end.
16. Maths is not important in problems of everyday life.
17. I have always enjoyed studying maths in school.
18. Maths is needed in order to keep the world running.
19. Very few people can learn maths.
20. I enjoy the challenge of a difficult new topic in maths.
21. An understanding of maths is needed by artists and writers as well as scientists.
22. It is not often that I can stick to maths work for more than an hour.
23. Maths has contributed greatly to science and other fields of knowledge.

24. I enjoy going beyond the assigned work and try to solve new problems in maths.
25. Maths is less important to people than art or literature.
26. Maths helps develop a person's mind and teaches him to think.
27. Almost anyone can learn maths if he is willing.
28. I do maths problems to get high marks not just for fun.
29. I have never liked maths and it is my most dreaded subject.
30. Only people with a special talent can learn maths.
31. I am an average student in maths; I will never be particularly good, so there is no point in striving for something beyond me.
32. I am willing and interested to acquire further knowledge of maths.
33. There is nothing creative about maths; it's just memorizing formulae and things.
34. Almost all pupils can learn complex maths if it is properly taught.
35. I hate admitting defeat even in the easiest of questions in maths.
36. Maths is very interesting and I have usually enjoyed courses in this subject.
37. In the near future most jobs will require a knowledge of advanced maths.
38. It is most unusual for me to be late in handing my maths homework.

39. I am interested and willing to use maths outside school and on the job.

40. My friends always seem to do better than me at maths.

41. Outside the school I would like to use maths.

42. I would like to develop my mathematical skills, and study this subject more.

43. Maths is not important for the advance of civilization and society.

44. Anyone can learn maths.

45. I get disheartened and give up easily if something is too difficult for me.

46. Maths is enjoyable and stimulating to me.

47. More of the most able people should be encouraged to become mathematicians and mathematics teachers.

APPENDIX IV

Reading Ability Test

Missing Words.

The passages which follow are taken from the school Mathematics of East Africa Books One and Two. When they were copied, some of the words were left out. There is a line under the space where a word is missing. Try to guess each missing word and write it in the space. DO NOT DO THE PROBLEMS. JUST TRY to fill in the missing words as best as you can. The first two are filled for you.

1. Look at each of the following pairs of sentences.

   In which pairs is ___the___ result of following the _instructions_ the same?

   (i) Add 15 __________ 7. Add 7 to __________.

   (ii) Hoe the ground and __________ sow the maize.

   Sow __________ maize and then hoe ________ ground.

   (iii) Turn right and __________ take one step forward.

   Take _________ step forward and then _______ right.

   (iv) Put on your ____________ and then put on ______shoes.

   Put on your ____________ and then put on ______socks.

   (v) Open the door ___________ then open the window.

   __________ the window and then __________ the door.

   (vi) Subtract 9 ___________ 15.

   Subtract 15 from ____________.

Do you agree that ________ and (v) give the __________result? The order in ________ we open the door _________ the window does not ________ a difference to the __________.

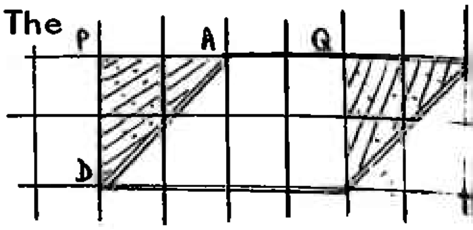
2. Consider once more the sequence (1,2), (2,4), (3,6), (4,8)....
Represent the ordered pairs ________ points on squared paper.
________ your points appear to ________ on a straight line?
________ is the relation between ______ two numbers in each ________ the ordered pairs?
Do ________ see that the y __________ is twice the x ________? We can write this ________ y = 2x.
Do your answers ________ section 1.2 (a) satisfy the ________ y = 2x?

We say that __________ is the equation of _____line through (1,2), (2,4), __________, (4,8). Does the ________ (7,4) lie on this ________? The line is the ________ of all points (x,y) ________ that y=2x.
This ______ written, using set notation ______ $\{(x,y): y = 2x\}$. Each of the _______ pairs (1,2), (2,4), (3,6), ________ is a member of __________.
We can write for ________, $(2,4) \in \{(x,y): y=2x\}$
We __________ refer to the line ___________ two ways:
(i) $\{(x,y): y= 2x\}$ or (ii) the _________ y = 2x.

---

3. In figure 24 the parallelogram has the same area as the red rectangle, PQCD because the shaded areas are equal. The width QC of _______ rectangle is the distance ______ of the parallel lines _________ and DC. If we ______

FIG. 24



QC the height of ______ parallelogram and DC the ________ then the rule giving _______ area of a parallelogram __________: area= height x __________. Redraw fig. 24 so _______ BC is the base. ________ is the height of ________ parallelogram?

---

4. <u>The difference of two squares</u>:

In section 4 we learned that $(a+b)(a-b) = a^2 - b^2$. $(a+b)$ and $(a-b)$ are ________ factors of $a^2 - b^2$. An ______ of the type $a^2 - b^2$ __________ called the difference of _______ squares. Other examples ____ p^2-9q^2, $4x^2 - y^2$ and $(a+b)^2 - c^2$. _______ factorize the difference of _____ squares it helps if ______ rewrite the expression to ______ what each term is _______ square of. For _______ $x^2 - 4y^2 = (x)^2 - (2y)^2$.

APPENDIX V

THE ACHIEVEMENT TEST BATTERY

TEST 01

NUMBER SYSTEMS

1. Fill in your Name, class and Roll Number in class on the answer sheet.
2. DO NOT write anything on the question paper.
3. Answer ALL the questions. Select the correct answer from the suggested ones and for each question circle one of letters A, B, C, D or E on the answer sheet.

Test Number 01

1. The four in the numeral 5042_{six} stands for

A. Ones
B. Sixes
C. Six sixes
D. Thirty six sixes
E. None of these.

2. 35_{eight} expressed as a numeral in base two is

A. 11101
B. 100011
C. 101011
D. 10111
E. None of these.

3. Which of the following represents the largest number?

A. 1011_{two}
B. 102_{three}
C. 23_{four}
D. 21_{five}
E. 20_{six}

4. Using t for ten and e for eleven if necessary find the product;

$$\begin{array}{r} 125_{12} \\ \times\ 6_{12} \\ \hline \\ \hline \end{array}$$

The correct answer is;

A. 740_{12}
B. 726_{12}
C. $t26_{12}$
D. $1t26_{12}$
E. None of these.

5. A number system in base three uses the symbols X, ł, θ, łX, łł, ... to correspond to zero, one, two, three, four .... in the base ten. In this

system five is represented by

A. XO D. OX

B. 01 E. 110

C. 10

6. Write $3 \times 6^3 + 4 \times 6^2 + 5 \times 6^1 + 3$ as a number numeral in base six.

A. 3450_{six} D. 3543_{six}

B. 3210_{six} E. 4335_{six}

C. 3453_{six}

7. Find the sum
$$\begin{array}{r} +101101_2 \\ +10001_2 \\ \hline \\ \hline \end{array}$$

The correct answer is;

A. 111110_2

B. 101101_2

C. 100101_2

D. 100001_2

E. None of these.

8. What is the base b if 12_b, 22_b, 34_b, and 51_b are all square numbers?

A. 3 D. 6

B. 4 E. 7

C. 5

9. If $p = 12_{five}$, $q = 24_{five}$ and $r = 24_{ten}$, then which of the following statements is/are true?

i) $q = 2p$ iii) $p + q = 30_{five}$

ii) $r = 2q$ iv) $p + q = 21_{ten}$

A. i and ii C. i and iv

B. i and iii D. ii and iii

10. Work out the division

$15_6 \quad 2050_6$ The answer is;

A. 13_6 rem. 2
B. 13_6 rem. 0
C. 21_6
D. 40_6
E. none of these.

11. The square root of the binary number 11001 in binary form is:

A. 1001
B. 1100
C. 100
D. 101
E. none of these.

12. If 102 = 201 then the numbers must be in different bases.
The base for 102 is seven. The base for 201 is:

A. 2
B. 3
C. 5
D. 6
E. 8

13. $12_{five} = 21_a$, $23_{seven} = 32_b$ and $34_{nine} = 43_c$; The values of the bases a, b, c, are

A. 3, 5, 7
B. 5, 6, 7
C. 5, 7, 9
D. 5, 7, 7
E. 3, 5, 9

14. Convert 1220_{three} into base six.

A. 100_{six}
B. 111_{six}
C. 121six
D. 123_{six}
E. None of these.

15. Arranged in order of decreasing size the numbers
1001, 1010, 1100, 1011, 1111 will appear as in

A. 1010, 1001, 1100, 1011, 1111

B. 1001, 1011, 1100, 1111, 1010

C. 1111, 1100, 1011, 1010, 1001

D. 1010, 1011, 1100, 1111, 1001

16. To multiply a binary number by 32_{ten} the decimal point must be moved

   A. three places to the right

   B. four places to the right

   C. five places to the right

   D. four places to the left

   E. five places to the left.

17. Which one of these statements is false?

   A. In the binary system any number ending in zero is even.

   B. Any number can be expressed in any base.

   C. If the last two digits of a number in base six are odd then the number itself is odd.

   D. For any positive whole numbers a and b, $a_b = b_a$ (e.g. $8_{10} = 10_8$)

18. Simplify;

$$\begin{array}{r} 7326_{eight} \\ -423_{eight} \\ \hline \\ \hline \end{array}$$

The correct answer is;

A. 4123_{eight} C. 703_{eight} E. none of these.

B. 2034_{eight} D. 6703_{eight}

19. The square of 12_{three} is;

A. 221_{three} C. 22_{three} E. none of these.

B. 122_{three} D. 12_{three}

20. The base five number which when squared is 1034_{five} is;

A. 21_{five} C. 23_{five} E. none of these.

B. 22_{five} D. 12_{five}

21. Which one of the following expressed in base 7 is both prime and odd?

A. 11 C. 13 E. 15.

B. 12 D. 14

TEST 02.

SETS

1. Fill in your Name, class and Roll Number in class on the answer sheet.

2. DO NOT write anything on the question paper.

3. Answer ALL the questions. Select the correct answer from the suggested ones and for each question circle one of letters A, B, C, D or E on the answer sheet.

1. $\{1, 3, 5\} \cap \{3, \_\_\_\_, 4\} \cap \{\_\_\_\_, 4, 5\} = 3, 5$

   The missing members respectively are;

   A. 1 and 3　　C. 3 and 4　　E. 1 and 5

   B. 5 and 3　　D. 2 and 3

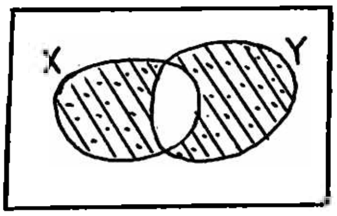
2. If $X = \{a, e, i, o, u\}$

   $Y = \{a, b, c\}$　　Then $X \cap Y$ is the set

   A. a, b, c　　C. a, c　　E. empty set

   B. a, b　　D. a

3. The shaded region in the diagram is the set;



   A. $X' \cap Y'$

   B. $(X \cap Y') \cup (X' \cap Y)$

   C. $X \cup Y$

   D. $X' \cap Y$

   E. $X \cap Y$

4. In a class of 44, boys, 28 play tennis, 20 play football and 6 do not play any game. The number of pupils who play both tennis and football in the class is;

   A. 6　　C. 8　　E. 12

   B. 7　　D. 10

5. Which one of these statements is incorrect?

   A. $\{1, 4, 3\} = \{3, 4, 1\}$

   B. $\{1, 3, 1, 2, 3, 2\} \subset \{1, 2, 3\}$

   C. $\{4\} \in \{\{4\}\}$

   D. $\{4\} \subset \{\{4\}\}$

   E. $\emptyset \subset \{\{4\}\}$

6. L = {-1, 0, 1, 2} Then L U (M N) is the set

M = {-1, 0}

N = {0}

A. {0} C. {0, 1, 2} E. {-1}

B. {-1, 0, 1, 2} D. {-1, 1, 2}

7. A = 2, 4, 5 , 4 Which of these statements are correct?

i. {4, 5} ⊂ A

ii. {4, 5} ∈ A

iii. 5 ∈ A

A. i only C. iii only E. all three.

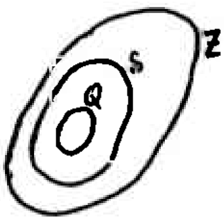
B. ii only D. i and ii

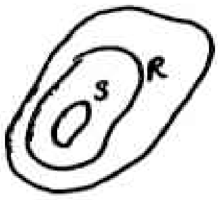
8. R = {all rectangles}

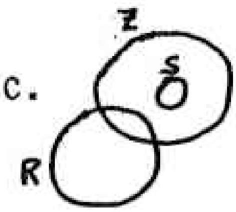
S = {all parallelograms}

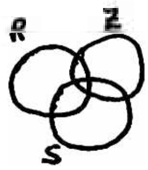
Z = {all quadrilaterals}

A Venn diagram which shows the relation between the three sets is;

A. 

B. 

C. 

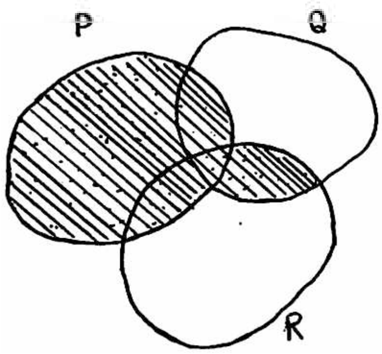
D. 

9. L = {x, y, z} The number of all possible subsets of L is;

A. 3 C. 6 E. 10

B. 4 D. 8

10. Which of the following sets represents the shaded part in the diagram?



A. $\{(P \cap Q) \cup R\}$

B. $\{P \cup (Q \cap R)\}$

C. $\{P \cup (Q \cup R)\}$

D. $\{P \cap (Q \cup R)\}$

E. $\{P \cap Q \cap R\}$

11. $X = \{3, 7, 5\}$
$Y = \{5, 7, 9, 11\}$
$z = \{2, 15\}$

Then $n(X \cup (Y \cap Z))$ is ;

A. 3
B. 4
C. 5
D. 6
E. 8

12. A and B are two sets.

$n(A) = 20$
$n(B) = 15$

The number of members in the Universal set is 30. What is the least possible value of $n(A \cap B)$?

A. 4
B. 5
C. 7
D. 8
E. 10

13. If $X = \{2, 3, 4\}$ & $Y = \{-4, -2, 0, 2\}$ the greatest possible value of $p^3 - q^3$ (where $p \in X$ and $q \in Y$) is:

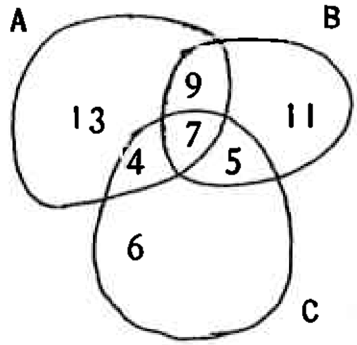
A. 16
B. 64
C. 128
D. 172
E. none of these.

14. In the diagram the numerals represent the number of members in each area.

Find $n(A \cap B \cup C)$

A. 4 C. 11 E. 31

B. 7 D. 20



15. If $n(A \cap B) = 8$

$n(A) = 10$

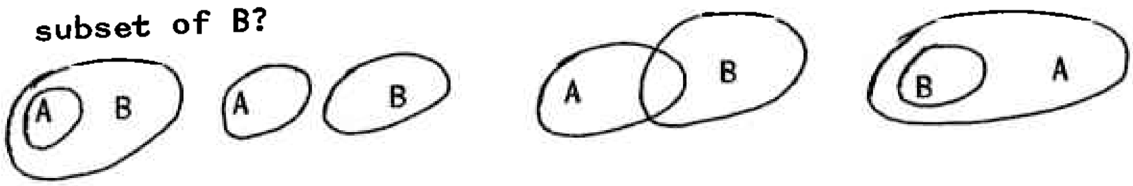
$n(B) = 19$

$n(A') = 20$ the number of members in the universal set is;

A. 28 C. 38 E. none of these

B. 30 D. 57

16. In which of the following Venn diagrams is A a subset of B?



I II III IV

A. I only C. III only E. II and IV only

B. II only D. I and II only

17. If U is the universal set, $\emptyset$ is the empty set and A is a set which has at least one member, which one of these statements is true?

A. $U \cap A = U$ C. $A' \cap A = U$ E. $A' \cup A = \emptyset$

B. $\emptyset \cup A = \emptyset$ D. $A \cap A = A$

18. A survey of 200 homes in a town gave these results;

T; 160 homes had water supplied in taps

E; 120 homes had electricity supplied

R; x homes had both electricity and water supplied.

What is x if all the homes had either water or electricity supplied?

A. 20 C. 80 E. 160

B. 40 D. 120

19. The operation \$ between two sets P and Q is defined as follows;

P \$ Q is the set of all members of P which are not members of Q. If X = {4, 5, 6} and Y = {5, 6, 7, 8} then X \$ Y is the set

A. {4} C. {4, 7, 8} E. none of these

B. {4, 5, 6} D. {5, 6, 7, 8}

20. A shopkeeper reported faults in 50 radio sets as follows;

fault A occured 25 times

fault B occured 20 times

fault C occured 22 times

fault A and B occured 4 times

fault B and C occured 10 times.

If faults A, B and C never occured together how many times did faults A and C occur?

A. Once

B. 2 times

C. 3 times

D. 4 times

E. 5 times

TEST 04

FRACTIONS

1. Fill in your Name, class and Roll Number in class on the answer sheet.

2. DO NOT write anything on the question paper.

3. Answer ALL the questions. Select the correct answer from the suggested ones and for each question circle one of letters A, B, C, D, or E on the answer sheet.

1. In the figure PS = 36cm. The distances from P to Q is one fourth of the distance from P to S and the distance from P to R is two thirds the distance from P to S. What part of the distance from P to S is the distance from R to S?

A. $\frac{1}{3}$ C. $\frac{3}{4}$ E. $\frac{1}{4}$

B. 5/12 D. 7/12

2. Fractions can be written as ordered pairs of integers, for example: $\frac{3}{4}$ = (3,4) and 5/6 =(5,6). Simplify:

$$\frac{(5,7) \times (14,\ 15)}{(2,3)}$$

using the ordered pair notation given above. The answer is:

A. (1,1) C. (4,9) E. (1,4)

B. (9,4) D. (1,2)

3. Compute the difference in base 2.

$$\begin{array}{r} 10.010 \\ -1.011 \\ \hline \end{array}$$

The answer is: ________

A. 1.011 C. 10.011 E. 0.111

B. 10.11 D. 1.111

4. Add $.204_{eight}$ and 1.325_{eight}. The answer is:

A. 1.531_8 C. 2.029_8 E. 2.016_8

B. 1.231_8 D. 1.651_8

5. If to the numerator of a fraction we add 2:

   A. the fraction becomes smaller

   B. the fraction becomes bigger

   C. the fraction remains the same

   D. it is not possible to say what happens to the fraction.

6. The exact value of $3\frac{4}{5} \times 3\frac{3}{19} \div 60$ is:

   A. 1/5 C. 1/12 E. none of these.

   B. 1/76 D. 1/36

7. x/y is a fraction with both numerator and denominator positive integers. When y is divided into x the decimal obtained is:

   I. terminating eg. 1.25

   II. repeating eg. 2.777

   III. neither terminating nor repeating.

   Which of these is true?

   A. I only C. III only E. I or II

   B. II only D. I or III F. II or III.

8. If the numerator and denominator of a fraction is multiplied by the same number:

   A. the fraction becomes smaller.

   B. the fraction remains the same.

   C. the fraction increases in size.

   D. the fraction equals one.

9. If 1/3 of a string is cut off and then $\frac{1}{2}$ of what is left is cut off, 4 cm remain. How long was the original piece?

A. 9 cm. C. 24 E. 48

B. 12 D. 36

10. Which of these fractions lies between $\frac{3}{4}$ and 5/6?

A. 2/3 C. 19/24 E. none of these

B. 17/24 D. 16/24

11. Which of the following cannot be written as a decimal fraction:

I. 2/3 II. 15/20 III. 165/140?

A. I only C. I and II E. II and III

B. II only C. I and III only.

12. The difference between the largest and the smallest of the three fractions $\frac{15}{18}$, $\frac{23}{27}$, $\frac{7}{9}$ is:

A. 5/81 C. 3/162 E. none of these.

B. 2/27 D. 7/152

13. Simplify: $1\frac{5}{6} + \frac{2}{3} - 1\frac{7}{12}$ The answer is;

A. $1\frac{3}{4}$ C. $1\frac{4}{5}$ E. none of these.

B. $1\frac{2}{3}$ D. $1\frac{11}{12}$

14. Which one of the following numbers is the square of an improper fraction?

A. $20\frac{1}{6}$ C. $5\frac{4}{9}$ E. $7\frac{1}{4}$

B. $3\frac{2}{5}$ D. $15\frac{6}{7}$

15. In the numeral 21.003_{four} the three stands for:

A. fourths C. tenths E. fortieths

B. sixteenths D. sixty-fourths.

16. $\frac{a+b}{a-b} - \frac{b}{a-b}$ equals:

A. $\frac{a}{(a-b)^2}$ C. $\frac{a-2b}{a-b}$ E. $\frac{b}{a-b}$

B. $\frac{a+2b}{a-b}$ D. $\frac{a}{a-b}$

17. In binary notation $\frac{7}{8}$ is equivalent to:

A. $\frac{111}{10001}$ C. $\frac{100}{1000}$

B. $\frac{110}{1000}$ D. $\frac{111}{1000}$

18, 0.03_{four} written as a fraction in base 10 is:

A. 3/16 C. 3/10

B. 3/100 D. 3/4

19. How many fifteenths does $2\frac{1}{3}$ equal?

A. 15 C. 75 E. 105

B. 30 D. 135

20. 5/16 expressed as a decimal equals:

A. 31.25 C. 3.12 E. .03125

B. 3.120 D. 0.3125

21. With two of the four digits 1, 3, 5, 7 on top and the other two on the bottom the greatest possible fraction we can form is:

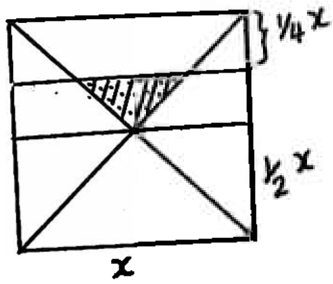
A. 57/13 C. 75/13 E. 17/35

B. 75/31 D. 35/17

22. What fraction of the square does the shaded area represent of the square ?

A. $\frac{1}{4}$ B. $\frac{1}{8}$ C. $\frac{7}{8}$

D. $\frac{1}{16}$ E. $\frac{1}{32}$.



TEST 08

STATISTICS

1. Fill in your Name, class and Roll Number in class on the answer sheet.

2. DO NOT write anything on the question paper.

3. Answer ALL the questions. Select the correct answer from the suggested ones and for each question circle one of letters A, B, C, D or E on the answer sheet.

1. In seven successive games a player/scored 3, 5, 7, 4, 3, 4, 6, 7 His median score is:

   A. 3 C. 4 E. 6

   B. 3.5 D. 5

2. Find the sum of the mode and the median of 2,3,9, 4,4,7,2,1

   A. 4 C. 8 E. 13

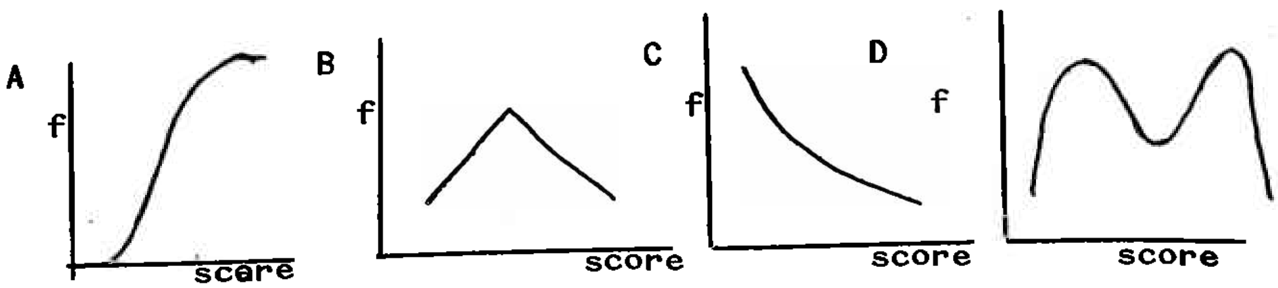
   B. 6 D. 11

3. The following salaries were received by a group of employees in a factory in a certain year;
   4,000 Sh., 6000sh., 12,500sh., 5,000sh., 7,500sh.
   How many of these salaries were greater than the mean?

   A. 3 C. 5 E. 1

   B. 4 D. 2

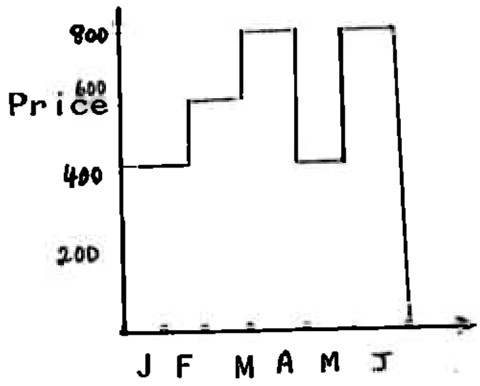
4. The Form III's in a 6 stream school were given the same mathematics paper. Three of the classes had not covered the syllabus thoroughly and did very poorly. The other three did very well. A frequency diagram which most probably represents the score distribution is:



5. The most frequently occuring score in a set of measurements is called the

   A. mean C. Median
   B. mode D. frequency

6. The bar chart gives the price of a bag of maize during the first 6 months of 1975. The price of maize was 800 shillings in:-



   A. January and February.
   B. March.
   C. May.
   D. April and June
   E. May and April.

Months

7. Five arithmetic tests were given to John's class. Each test has a value of 25 marks. John's average for the first four tests is 15. What is the lowest score he can get on the last test to have an average of at least 16?

   A. 15 C. 20
   B. 16 D. 25

8. The mean of the numbers 99, 102, 97, 98, 103 and 101 is:

   A. 97 C. 99 E. none of these.
   B. 98 D. 100

9. The mean weight for a class of 14 boys and 16 girls was 52 kg. The mean for girls alone was 50 kg. The mean for boys alone is:

A. 50 kg. C. $54\frac{2}{7}$ E. none of these.

B. $52\frac{1}{7}$ D. 60

10. The table gives the ages of boys entering a school.

Age	12.6 - 13.00	13.00 - 13.6	13.6 and over
Number of boys	8	32	46

The class interval in which the median age lies is;

A. 12.6 - 13.0 C. 13.6 - & over

B. 13.0 - 13.6 D. cannot be determined

11. The mean of 1/2, 1/3 and 5/12 is

A. 1/3 C. 5/12 E. none of these.

B. 1/2 D. 3/72

12. The trend graph shows the average daily profit for a week made by a bus company. The mean for the week is;

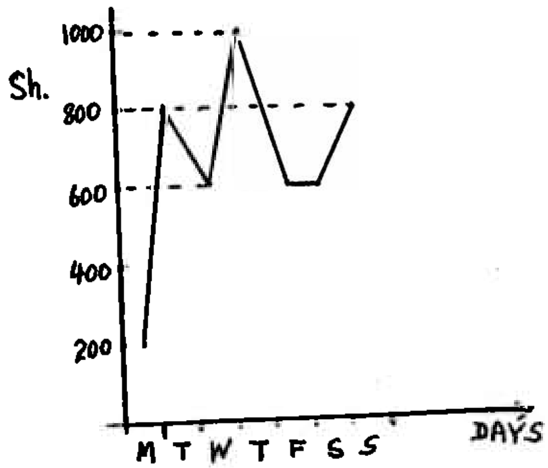
A. $600\frac{2}{7}$

B. $720\frac{2}{7}$

C. $325\frac{2}{7}$

D. $657\frac{1}{7}$

E. $659\frac{1}{7}$



13. The mean of a set of/ numbers is 13. When 37 is /n
added to the set the new mean is 15. Then n is:

A. 11 C. 13 E. 25

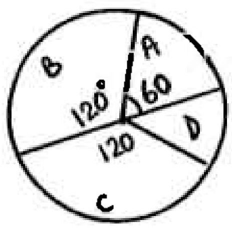
B. 12 D. 15

14. The mean number of grains on three ears of corn is 172. The mean number on the larger two is 181. The number of grains on the smallest is;

A. 136 C. 154 E. none of these.

B. 145 D. 163

15. In a given year 600 cars were bought by a dealer. The pie chart gives the different makes of cars he bought. The number of type D cars he bought was;



A. 50 C. 100 E. 160

B. 60 D. 120

16. The mean weight of 30 girls in a class is 52 kg. The mean for the ten oldest girls is 56 kg. What is the mean weight of the other 20 girls?

A. $33\frac{1}{3}$ C. 50 E. none of these.

B. 48 D. 54

17. The mean of the numbers 3, 7, 9, 1, 4, 13, 18, 9 is m. The mean of the numbers 3, 7, 9, 1, 4, 13, 18, 9, x is m+1

Then the value of x is;

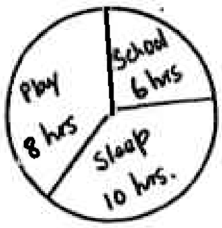
A. 8 C. 17 E. 24

B. 9 D. 18

18. The pie chart shows how a boy spends his time. What is the angle in degrees represented by the sector for play?

A. 90 C. 110 E. 150

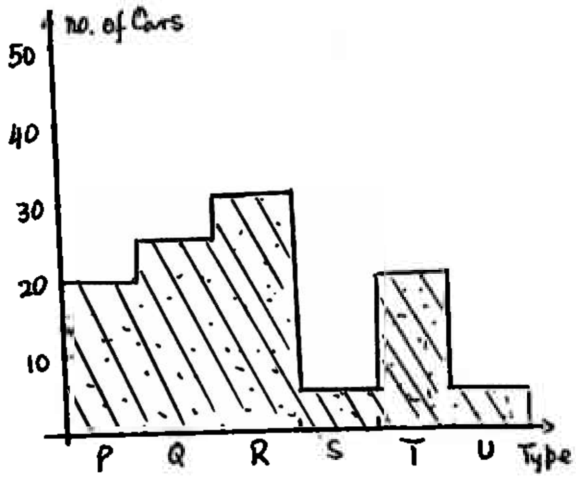
B. 100 D. 120



19. A survey of vehicles passing a school was carried out by Form III pupils. The results of the survey carried on for 30 minutes are shown in the bar chart. The type of cars passing the school most frequently is

A. P C. R E. T

B. Q D. S



TEST 16

3-DIMENSIONAL GEOMETRY

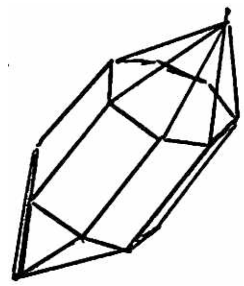
1. Fill in your Name, class and Roll Number in class on the answer sheet.

2. DO NOT write anything on the question paper.

3. Answer ALL the questions. Select the correct answer from the suggested ones and for each question circle one of letters A, B, C, D or E on the answer sheet.

1. The figure shows a solid. The number of faces it has is:

Fig. 1.



A. 14

B. 15

C. 16

D. 18

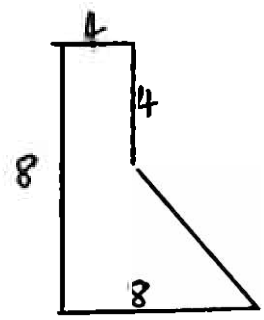
E. 20

2. The number of vertices in fig. 1 is:

A. 2 C. 12 E. 20

B. 10 D. 14

3. The figure shows the cross-section of a prism 12cm long. What is it's volume?



A. 360 cu.cm

B. 480 cu.cm

C. 552 cu.cm

D. 600 cu. cm

E. none of these.

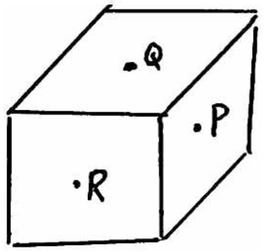
4. A certain solid has exactly 4 vertices and its surface consists only of triangular regions. The number of edges it has is:

A. 2 C. 6 E. 12

B. 4 D. 8

5. Figure 2 shows a cube with centres of three faces, P and Q and R. The triangle PQR:

Fig. 2



A. is right angled at P

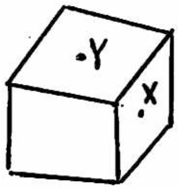
B. is an equilateral triangle

C. has an obtuse angle at R

D. is isosceles with P = Q = 45^o

E. has only two sides PQ and PR equal.

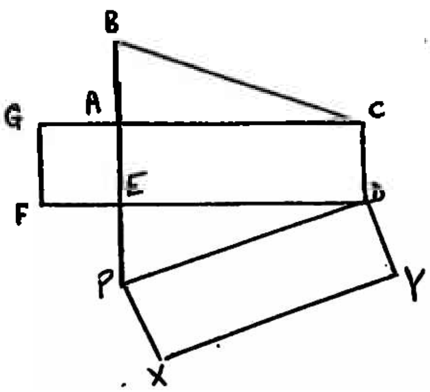
6. X and Y are the centres of two adjacent faces of a cube of side 4 cm. What is the length of XY



A. $2\sqrt{2}$ C. $3\sqrt{2}$

B. $\frac{1}{\sqrt{2}}$ D. $\frac{3}{\sqrt{2}}$

7. The figure shows a net for a wedge. The part corresponding to Δ ABC was cut along AC and joined to the net in a different position. We may obtain the same wedge by placing Δ ABC



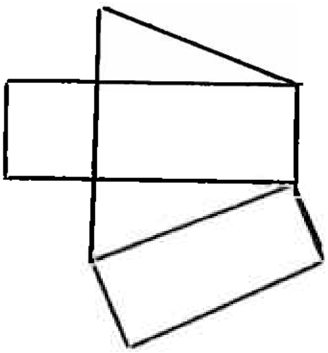
A. along XY with X touching A and Y touching C.

B. along XY with X touching B and Y touching C.

C. along DC with A touching D and B touching C.

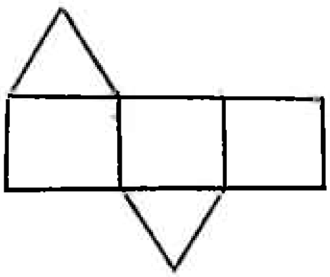
D. along GF with A touching F and B touching G.

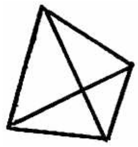
8. The number of vertices in a solid constructed from the net shown is:

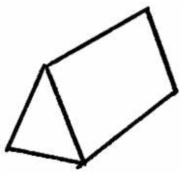


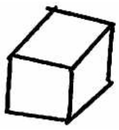
A. 4 B. 8 C. 6 D. 10 E. 12

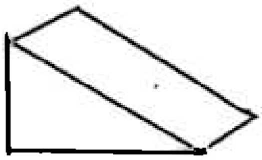
9. Which of these solids can be made using the net on the left?



A. 

B. 

C. 

D. 

E. none of these

10. The volume in cubic cm of the solid made from the net is:

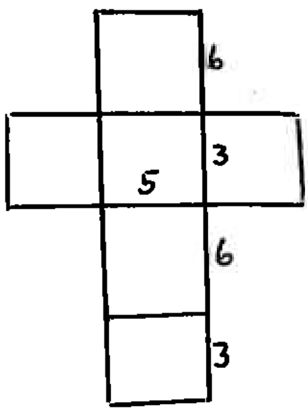
A. 45 c.c.

B. 90 c.c.

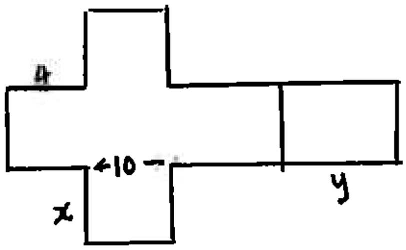
C. 135 c.c.

D. 150 c.c.

E. none of these.



11. The diagram shows the net for a cuboid. The lengths of x and y respectively are:



A. 4 and 10

B. 4 and 6

C. 6 and 10

D. 6 and 4.

12. A solid constructed from the net shown here will have x vertices, y edges and z faces, where x, y, and z are respectively;

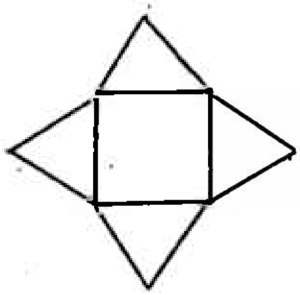
A. 3, 8, 5

B. 5, 8, 3

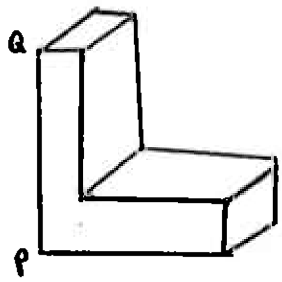
C. 5, 8, 5

D. 3, 8, 5

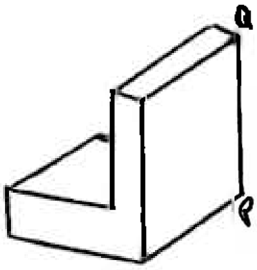
E. 5, 5, 5.



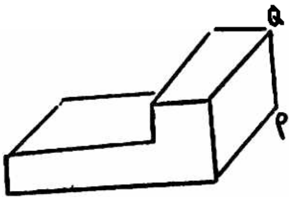
13. In the diagram the edge PQ is vertical. When turned through 180^{o} anticlockwise about PQ its new position is shown in;



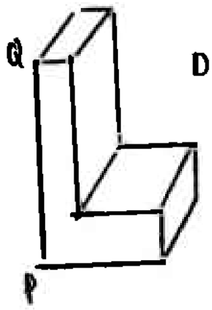
A.



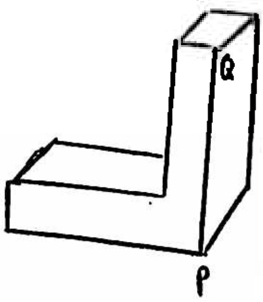
B.



C



D.



14. A prism has a volume V cm^3 and a uniform area of cross-section of A cm^2. If its length is h cm the equation relating V, A and H is;

A. $V = A h^2$ C. $V = \frac{A}{h^2}$ E. $\frac{A^2}{h}$.

B. $V = A h$ D. $V = A^2 h$

15. The volume of the solid shown at the right is;

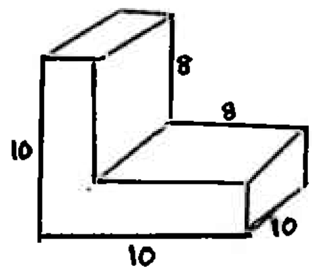
A. 360 cm^3

B. 640 cm^3

C. 800 cm^3

D. 1000 cm^3

E. None of these.



16. Eight cubes of side 1 cm can be arranged in 3 different ways so as to form a rectangular block. The diagram shows one possible way. The area of cardboard needed to make a closed box to hold this block is:

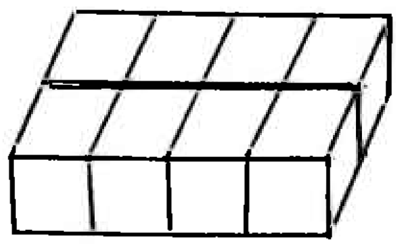
A. 12 cm^2

B. 16 cm^2

C. 28 cm^2

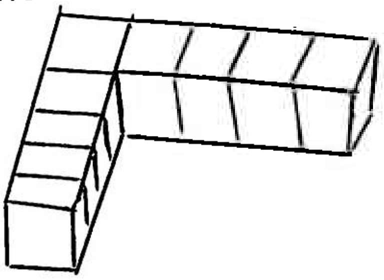
D. 56 cm^2

E. 72 cm^2

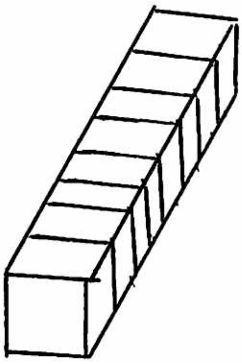


17. For the 8 cubes of Q 16, above which of these diagrams shows another arrangement of the cubes so as to give a rectangular block?

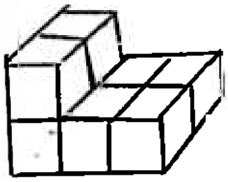
A.



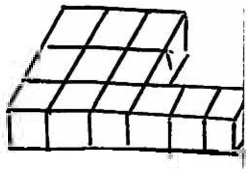
B.



C.



D.



APPENDIX VI

LIST OF SOME FORMULAE USED IN THIS THESIS

1. For Reliability coefficients;

$$r = \frac{k}{k-1} \left(\frac{\sum o_i^2 - \sum p\, q}{\sum o_i^2} \right)$$

where k : total number of test items.

o_i^2 : Variance of the scores on item i.

p : Propotion of pupils who gave correct answer to item

q : Propotion of pupils who gave incorrect answer to an item.

2. For difference between two means;

$$t = \frac{\overline{X}_1 - \overline{X}_2}{\sqrt{\left[\frac{(n - 1)\, s_1^2 + (n_2 - 1)\, s_2^2}{n_1 + n_2 - 2} \left(\frac{1}{n_1} + \frac{1}{n_2}\right)\right]}}$$

Where X_1, X_2 : means of sample 1 and 2 respectively

s_1^2, s_2^2 : Standard deviations of sample scores.

n_1, n_2 : sizes of samples 1 and 2 respectively

3. For differences between two propotions;

$$Z = \frac{p_1 - p_2}{\sqrt{\left[\overline{p}\,(1 - \overline{p}) \left(\frac{1}{n_1} + \frac{1}{n_2}\right)\right]}}$$

where $\overline{p} = \dfrac{n_1 p_1 + n_2 p_2}{n_1 + n_2}$

and p_1 , p_2 : propotions of pupils in groups 1 and 2 respectively

n_1 , n_2 : Number of pupils in group 1 and 2 respectively.

APPENDIX VII

CLASSIFICATION OF ITEMS IN THE ACHIEVEMENT TESTS INTO COGNITIVE LEVELS.

Test	Item Numbers																					
Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1.	k	k	c	p	p	k	n	c	n	c	k	n	p	c	p	c	n	p	c	p	p	
2.	k	k	c	p	p	k	n	c	n	c	k	n	p	c	n	c	n	p	c	p		
3.	k	p	p	p	n	c	k	p	p	c	c	p	n	c	n	n	k	n	k			
4.	c	n	k	k	c	k	n	c	p	p	p	p	k	c	k	k	c	k	c	c	n	c
5.	k	c	p	k	p	n	n	c	p	nn	c	k	k	p	n	k	p	n	p	c		
6.	k	k	c	c	n	p	p	p	n	p	k	k	c	n	k	c	p	c	n	c		
7.	k	c	c	n	c	k	n	c	k	c	k	c	n	n	c	p	c	p				
8.	k	k	c	c	k	c	p	k	p	c	p	n	n	n	p	p	n	c	c			
9.	c	p	p	p	n	p	p	k	p	p	c	c	p	k	k	n	c	n	p			
10.	k	k	k	n	k	p	p	p	n	n	n	n	c	c	n	c	c	p				
11.	c	c	c	c	k	k	c	p	c	n	p	n	p	p	p	n	k	k	n	c		
12.	c	k	n	p	c	n	k	k	n	n	p	–	c	k	p	c	p	p	k			
13.	k	k	c	c	p	p	k	k	c	n	n	k	k	k	k	k	k	c	c	p		
14.	k	k	c	c	c	p	n	n	n	c	n	n	c	k	p	p	n	k				
15.	k	n	c	n	p	c	c	k	n	c	c	p	c	k	p	p	p	k				
16.	k	k	p	n	n	p	n	c	p	p	n	c	n	k	p	p	k					
17.	k	k	k	c	c	p	n	n	p	k	c	c	c	p	p	k	n	n				

Code: k : item classified as Knowledge

c : item classified as Comprehension

p : item classified as Application

n : item classified as Analysis.