EFFECT OF CLASSROOM INTERACTION AND GENDER ON MATHEMATICS PERFORMANCE AND ATTITUDES TOWARD MATHEMATICS OF SECONDARY PUPILS IN MOZAMBIQUE

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Effect of Classroom Interaction and Gender on Mathematics Performance and Attitudes Toward Mathematics of Secondary Pupils in Mozambique

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A thesis submitted to the Faculty of Science, University of the Witwatersrand, Johannesburg, in fulfilment of the requirements for the degree of Doctor of Philosophy

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DECLARATION

I, Bhangy Cassy, declare that this thesis is my own, unaided work. It is being submitted for the Degree of Doctor of Philosophy in the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in any other University.

28th day of February 2002

ABSTRACT

In Mozambique, the main aim of the National Education policy is to promote, among others, gender equity in the access to all levels of education. However, there are more females than males, who do not benefit from this aim. This gender discrepancy increases over the education levels, and particularly in mathematics and its related fields. Mathematics is taught as a compulsory subject at the beginning of primary school to the lower secondary school and it becomes an optional subject at the beginning of the upper secondary school. Although pupils are encouraged to take mathematics until the end of secondary schooling, they tend to choose social studies, perceiving it as apparently easier. An associated problem arises because mathematics is the basis of Engineering and Applied Sciences fields, in which few females participate. This is subsequently reflected in the number of new entries to universities, leading to their virtual exclusion from the technical and scientific professions in the country. The present investigation involved 1221 secondary pupils (531 boys and 690 girls) of grades 9 and 10 and their mathematics teachers from 4 co-educational schools in Maputo City. Applying both quantitative and qualitative methods, it explored possible gender differences in the patterns of mathematics classroom interactions, pupils' performance and attitudes toward mathematics and if these differences could be related to the gender discrepancies in the participation in courses requiring more Advanced mathematics. Albeit gender differences are small, they exist but by themselves are not large enough to justify the gender disparities in participation. Teachers' attitudes were found to contribute to the gender differences observed. Other school and socio-cultural factors might play a role in creating or reducing these gender differences. It is imperative that any strategy designed to produce gender equity in mathematics and related fields should focus not only on encouraging more female pupils to take mathematics, but also to promote classroom active learning (student-centred approaches), and by recruiting more female educators. A more qualitative study should also be done to explore potential causes of the observed gender differences by analysing classroom interactions, teacher's guide and pupils' textbooks for possible gender bias.

To:

Sheyla,

my oldest daughter, hoping that she could reach the plane of being a good Mathematician,

Dalila & Danilo,

my twins who undoubtedly strengthen my dream of developing a strong base in Mathematics Education.

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ABREVIATIONS

ACP	Partial Control Activities
ACS	Sistematic Control Activities
ESG-1	Lower Secondary Level
ESG-2	Upper Secondary Level
ESP-1	Lower Primary Level
ESP-2	Upper Primary Level
FIAC	Flanders' Interaction Analysis Category
INE	National Statistics Institute
MAS	Mathematics Attitude Scale
MINED	Ministry of Education
MINED-PEE	Ministry of Education-Education Strategic Plan
PEE	Education Strategic Plan
SAREC	Swedish Agency for Research Cooperation
SADC	Southern African Development Countries
SNE	National Education System
UEM	University Eduardo Mondlane
UEM-PE	University Eduardo Mondlane -Strategic Plan
UNDP	United Nations Development Programme

CHAPTER I

INTRODUCTION

"Although there have been a number of famous female mathematicians throughout history, students of Mathematics sometimes are unable to name any."

Luchins and Luchins (1980:14)

1.1 BACKGROUND TO THE STUDY

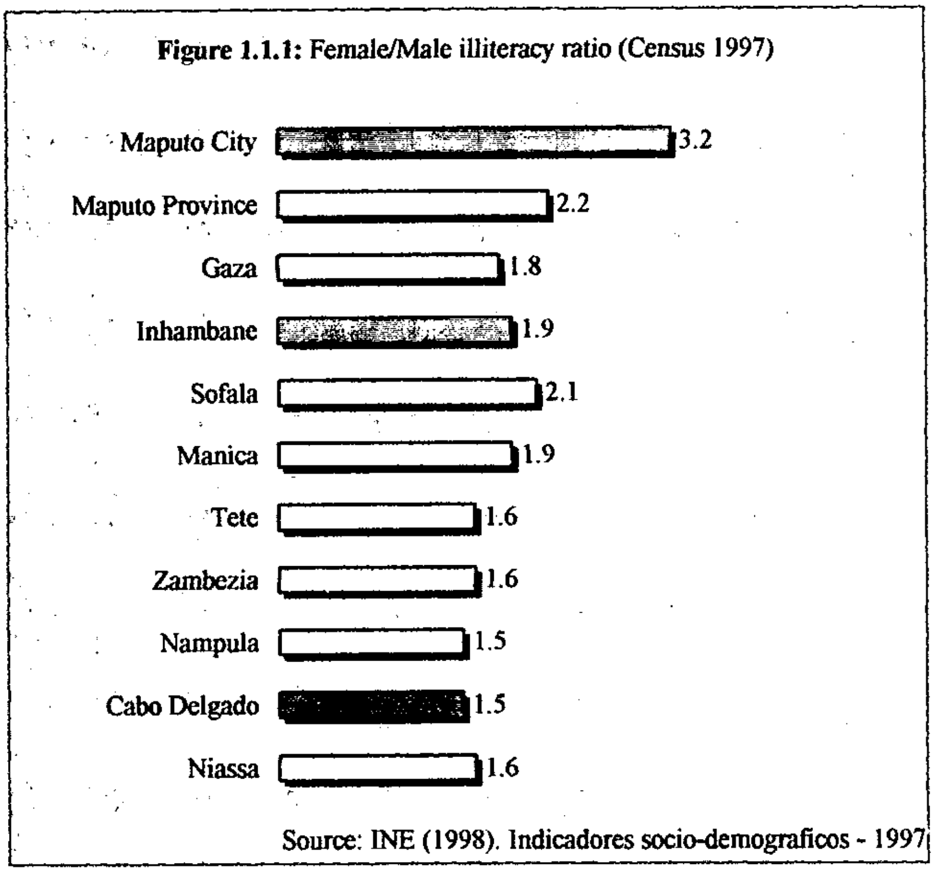
1.1.1 The General Overview of the Context - Mozambique

If the above quotation is assumed as the truth then, it is not surprising to find female under-representation in mathematics and its related fields in undeveloped countries like Mozambique. Apparently, while females are certainly under-represented in these areas, it is not solely because of a lack of qualified candidates but also as a consequence of a lack of encouragement or recognition since the mathematics pupils do not identify even the females' references.

Mozambique is a country situated in Southern Africa that became independent from Portugal in 1975. In 1997, the population was estimated at about 16 million inhabitants spread out over an area of 799 390 square kilometres, which yields a population density of 20 people per square kilometre with a masculinity index of 0.92. The official language is Portuguese although there are another 13 indigenous African languages that are generally relegated to the domains of family relations, traditional social life, religious rituals, etc.

In the twenty-five year period since independence, the index of illiteracy (the proportion of people who can neither read nor write) has dropped from 90% to 60%, and the number of pupils in formal education increased at all levels compared with that before independence, (Mozambique, UNDP-report, 2000). As a force for promoting knowledge, the formal education bore the responsibility of ensuring access to the accumulated technical and scientific knowledge of humanity, as a fundamental and decisive instrument in the fight against misery, a conditional sine qua non for the promotion of development.

Despite a substantial reduction in illiteracy, Mozambique continues to have the lowest literacy rate of the fourteen member countries of the SADC (Southern African Development Countries). The illiteracy remains particularly acute among women, where illiteracy is 74.1% (Mozambique, UNDP-report, 2000). An illustration of this situation is demonstrated in Figure 1.1.1, where the proportion ratios of illiteracy between females and males are presented, (INE, 1998-Census of 1997), by Province.



From Figure 1.1.1 it is evident that the incidence of illiteracy varies from province to province but all the provinces have one thing in common, that is, there are always more illiterate females than males. The extreme case is seen in Maputo Ccity where the proportion ratio between females and males is 3.2:1. There are many factors that one may associate with this gender discrepancy, which varies along the National System of Education established in 1983. Mozambican schools in general, remain without roots in the communities where they are physically located, who still regard schools as something strange, and that they transmit world visions and values far different than that of the local culture.

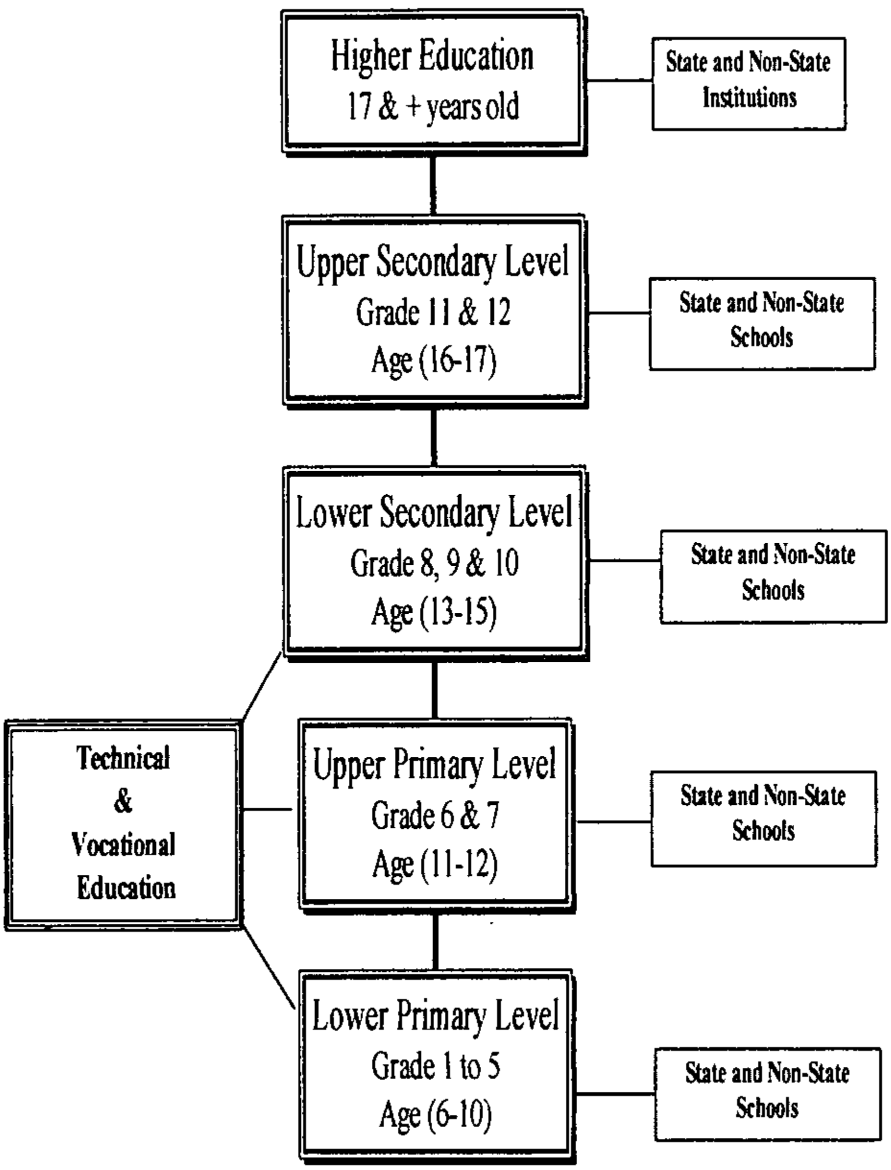
1.1.2 The National System of Education

The educational programme of independent Mozambique intended not only to broaden access but also to create equity of opportunity to enter the formal education system for different social, cultural, gender and age groups. The National Education System (SNE) is structured into pre-school education, school education, and trade professional education. Figure 1.1.2 shows that school education consists of General Education, Technical and Professional Education and Higher Education.

General Education includes the primary and secondary levels. The primary level, which is compulsory covers the first seven grades divided into two cycles being the first cycle from grade 1 to 5 (EP-1) and the second being grades 6 and 7 (EP-2). Secondary education provides preparation for mid-level employment and post-secondary education training, including training for teachers (MINED, 1998) and it covers the further 5 years also distributed into two cycles, the lower secondary cycle (ESG-1) of 3 years duration and the upper secondary cycle (ESG-2) of two years duration. Technical and Professional Education follows the same format.

Higher Education is available to those who have graduated with 12th grade of general education, or its equivalent, and is undertaken in universities or other higher institutions, (higher schools and academies). Mozambique has nine such institutions providing this level of education and they are responsible for providing training, (at the highest possible level), for technical staff and specialists in various fields of scientific knowledge, and it takes place in direct combination with scientific research.

Figure 1.1.2: National School Education System



Apart from the education provided in the educational establishments mentioned earlier, the Education System also includes Special Education, Vocational Education, Adult Education, Distance Learning and Teacher Training, as integral parts and governed by special provisions.

In the Mozambican Education System, all schools are co-educational and as the language of business and government is Portuguese, the medium of instruction at all levels of schooling is the official language, Portuguese. The school year for the general primary and secondary levels starts on February 1, and it is divided in two semesters: the first semester covers the period from the beginning of February to the end of June and the second semester runs from the last week of July to the end of November followed by a period of examination.

In 1999, 96% of the school population was concentrated in the two levels of primary education. The two cycles of secondary education between them account for 3% of the school population, while technical and professional education account for just 0.8% and 0.4% respectively (Mozambique, UNDP-Report, 2000). According to the statistics of the Ministry of Education, there is a substantial difference in the number of male and female pupils enrolled at the primary and secondary school levels, with males in general outnumbering females. The gap increases further at the tertiary level. This gender disparity starting with the low presence of girls in education at the lowest levels is worsened by both drop out and repeat rates (MINED-PEE, 1999). This picture is exacerbated in secondary education where the levels of repeating are even higher. In this phase the levels are approximately 53.5% among girls and 46.5% for boys.

Together with interrupted schooling these high repeat rates cause wide age-differences among pupils in class. The modal age in grades 8, 9 and 10 is 16, 17 and 19, rather than 13, 14 and 15 as recommended and intended. In grades 11 and 12 it is 20 and 21, compared to the 16 and 17 years old theoretically defined as the appropriate age for schooling at that level.

1.1.3 Secondary Education and Mathematics in Mozambique

Real demand for secondary education is defined by the number of grade 7 graduates who want to proceed to ESG-1, since there are many more graduates than grade 8 places available. This expansion has been partially absorbed in the cities by the non-state schools. Thus, there are two types of schools provisions in Mozambique: the state schools and the non-state schools (commercially provided and voluntary – Non-Governmental Organizations and communities). Similarities between these types of schools are in general session-based, with certain classes being taught in the morning and others in the afternoon. Thus, pupils only attended a half-day, and teachers in general teach only one session at that school. In many non-state schools, the teachers are on contract, and are employed by the state to teach in the state schools in the other session. The teacher populations in both type of schools overlap. However, in this study teachers were only observed in one type of school.

Pupils cover the same curriculum, and have the same number of hours of teacher contact in every subject during the teaching year. Testing and examining follow the same set of procedures. Both types of school offering secondary level, function under the rules and the supervision of the Ministry of Education (MINED). The fees charged in the non-state schools are far too expensive for the average salaried citizens. This particular aspect makes one of the differences between this type of school and the state schools. Thus, the class size varies from 23-25 pupils in the non-state to 45-55 in the state schools.

The ESG-1 curriculum is in general composed of eleven subjects, while ESG-2 comprises 3 streams designed **A**, **B** and **C**, of seven subjects each hence in Mozambique, Mathematics has been taught as compulsory subject from the beginning of primary school to the lower secondary level (ESG-1). It becomes an optional subject for the first time in grade 11, in the beginning of the upper secondary level (ESG-2). These upper secondary streams have subject combinations according to the requirements that will follow at the tertiary education. It means that the pupils who have done the **Stream A** can follow the social sciences courses; those who have done **Stream B**, can continue their further study in life sciences courses while the pupils who have finished the **Stream C**, with a more Advanced Mathematics, can follow Engineering and Science related courses.

Although in most of the schools, particularly in the non-state sector, all pupils are encouraged to take mathematics until the end of secondary schooling, they tend to choose social studies, perceiving it apparently to be easier. For many lower secondary school leavers, mathematics is a closed system of knowledge and it is one of the major problem that cause failure at schools from primary through to secondary education in Mozambique. Perhaps this could be related to the fact that the majority of the population (71%) live in rural areas (INE, 1998) far removed from urban requirements of accounting, measuring and calculating. For the most part, the role of mathematics in people's daily lives is limited to elementary arithmetic.

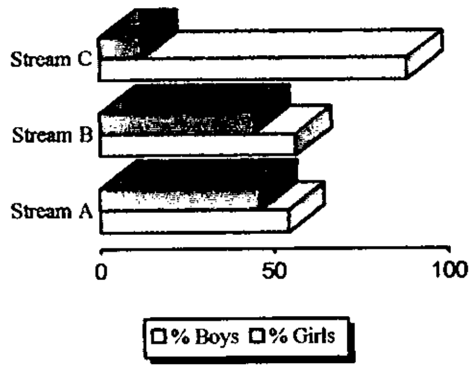
On one hand, this secondary pupils' attitude could be explained by factors inherent to the system itself, such as the quality of teaching and teachers, the availability of teaching aids and the high teacher- pupil ratio. Besides being of a questionable quality, teaching aids are in short supply. ESG-1 teachers may have books, but pupils often cannot afford them. At ESG-2, learning materials have not been developed for the revised curriculum, and pupils and teachers have had none for some years. Where libraries exist, they have few new resources or the resources are just non-existent.

On the other hand, mathematics and related subjects (physics, chemistry and other technical subjects) are socially viewed to be hard and therefore more suitable for boys than for girls. This is supported by the fact that the majority of incoming students at University Eduardo Mondlane (UEM) in the academic year of 1998/99 were males in all the courses/faculties with the only exception, medicine, where the percentage of girls was 50% (UEM-PE, 1998). This situation is particularly evident in science and engineering courses with 3%, 10.9% and 18.7% in engineering, architecture and informatics respectively. It means that girls are found to be underrepresented in engineering and science fields and better represented in arts and social sciences.

An associated problem arises because mathematics is the basis of fields such as engineering and the applied sciences. All these domains in which few females currently participate lessen the possibility of developing a critical mass of mathematics and science female pupils. This is subsequently reflected in the number of new entries to university, particularly of girls. If such trends should continue they would lead to the virtual exclusion of women from the technical and scientific professions in the country. However the pupils' performance did not reflect the belief that mathematics is more appropriate for males than for females as presented in Figure 1.1.4, where boys and girls performed similarly within the same stream.

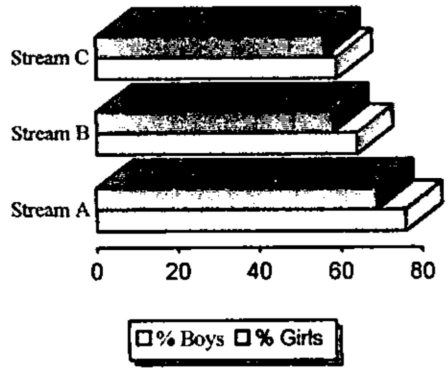
From Figures 1.1.3 and 1.1.4, it is evident that although there are more boys than girls taking further studies in the stream with advanced mathematics (**Stream C**) the pupils' pass rates are similar within the streams. It might suggest that in Mozambique, the pupils' performance in the ESG-2 is not the substantial cause of the gender disparity in mathematics participation. One possible explanation for the relatively low participation rate of girls is the scarcity of female teachers. In secondary education the number of female teachers is small (15%). Only 12% of the mathematics teachers are females.

Figure 1.1.3: Percentage of ESG-2 pupils' enrolment by gender and streams in 1998



Source: MINED-Estatística da educação, 1998

Figure 1.1.4: Percentage of ESG-2 pupils' pass rates within gender by streams in 1998



Source: MINED-Estatística da educação, 1998

On the other hand, mathematics is taught mostly in a teacher-centred style with the teacher either giving a presentation, i.e., traditional lecturing, or engaging in teacher-pupil interactions, by solving mathematics exercises and problems at the desk as well as on the board. The exercises/problems are selected by the teachers from the textbooks, recommended books or another sources, to be solved during the practical lessons or as homework. It is evident that these teachers' procedures do not contribute to the engagement of individual pupils in the process of developing the knowledge, hence it is used basically as a deductive method. Therefore the teaching approaches could be interpreted as meaningful in developing a competitive environment in the classroom than in promoting a co-operative learning environment.

Another important aspect of the teaching-learning of mathematics at the secondary education level in Mozambique is the characteristics of the assessment system, which in the two cycles of secondary education comprises the official format of assessment procedures including:

a) Three Systematic Control Activities (ACS)
b) Three Partial Control Activities (ACP)
c) The **National Examination** at the end of each school cycle

All the marks are given on a **0 - 20** scale, with 10 as a pass mark for each subject. the school teachers of all disciplines marked all the assignments including the National Examination.

The ACS are to be considered as classroom tests, and they are set by the class teacher with the intention to determine the achievement level of the pupil, in a small section of the mathematics programme. It is done usually in the class before the introduction of a new topic and does not exceed 45 minutes duration (the time of a class lesson). There are six ACS per annum.

The ACP is a longer test defined as a standardised test and set up by the school subject committees with the intention to ascertain the achievement level of the pupil in a larger body of work and has duration of double that of the ACS. There are usually six ACP per annum.

At the end of each semester, the marks achieved in the ACS and ACP tests are combined for obtaining the pupil's semester mark by weighting them using the following formula:

$$Semester\ mark = \frac{mean\ of\ the\ ACS + 2 \times mean\ of\ the\ ACP}{3}.$$

At the end of each grade, the average mark of each pupil per subject is obtained by calculating the mean of the two semester marks. For a pupil to be promoted to the next grade the pupil must average at least 10 (out of 20), pass Portuguese (at least 10 out of 20) and mathematics (10 out of 20) and only 2 other subjects at most may score between 8 and 10 (out of 20). No marks are condoned below eight, and to pass, all pupils must pass Portuguese and mathematics.

At the end of each school cycle, the cycle mark is determined by calculating a weighted mean of the averaged marks obtained in each of the grades (8, 9 and 10), using the following formula:

$$Cycle\ mark = \frac{grade\ 8 + grade\ 9 + 2 \times grade\ 10}{4}.$$

The Ministry, centrally designs the National Examination at the end of the school cycle, which aims to certify and assess knowledge, skills and abilities developed in each school cycle, and contributes to the pupils' final achievement in the subject and grade.

The state schools have their pupils admitted to write the National Examination if they have attained an achievement mark between 10 and 13, and those pupils achieving above 13, pass without writing the examination. The non-state school pupils cannot pass without sitting the examination. This aspect constitutes the major evaluation difference between the state and non-state schools. The same criteria of passing from grade to grade are used when considering a pupil's passing from one cycle of education into the next one.

The final mark, which is credited in the academic certificate at the end of each cycle, is a mean of the combination of the marks of the continuous assessment and the examination. In the state schools, the final mark is 2/3 of the continuous assessment and 1/3 of the examination mark, and the reverse is true for non-state schools. These are then averaged to give a grade/score, and pass/fail.

Those pupils who did not achieve a final mark of 10 fail in mathematics and have to repeat all the science subjects if they are in the first secondary schooling cycle or to repeat the subject if they are in the second secondary schooling cycle. Those who fail a second time are excluded from the state schools.

It is recognised worldwide that a multitude of social and cultural customs combine to influence gender differences in education (Fennema and Leder, 1990; Volmink, 1994; Willis, 1995 and Fennema, 1996) since there are also socio-cultural obstacles that girls face in growing up, which not only contribute to their poor performance, but also militate against their advancement, and in general discourage the education of girls.

Among the cultural barriers is the tension between formal and traditional education systems which plays a great role since:

a) Traditional education prepares boys and girls for adult life in groups separated by gender while formal education prepares pupils in heterogeneous groups (co-educational schools).

b) Traditional education shapes girls to be submissive and obedient, a fact which is sometimes seen as incompatible with the effort of investing in the education of girls.

The social differences between males and females are reflected in the choices they make at school and university. Female pupils are expected to be docile and retiring in an environment, which generally equates boldness and flair with success. The ramifications of this are particularly serious in mathematics and science. Often the contradictions of being a female in science or mathematics is so overwhelming that, females opt in favour of arts or social sciences related subjects.

The traditional society places limitations on the spheres of activity in which females are permitted to develop, although a competitive spirit creates different lifestyles for each gender with females' views as subordinate to that of males. However, in the cities there is evidence that the gender-related differences are diminishing. It is particularly emphasised by the higher participation of females in schools in the cities than in the rural areas (INE, 1998).

1.1.4 Rationale for the Study

In general, females' under-representation in science occupations can be traced back to their participation in education. While it is true that females are officially encouraged to play an active role in the development of the country, the majority of them do not even have the opportunity to obtain a secondary education. Although mathematics is an interesting and valuable subject considering that, a strong mathematical background is a prerequisite to many career and job opportunities in this technological world of today, it is in this field that lower female participation is seen. Thus, mathematics may be viewed as a subject that filters women out of opportunities in later life.

On the other hand, this exclusion of women from education in Mozambique is extremely worrying particularly if it is taken into account the social benefits of females' education that are universally recognised. Thus, looking into the new millennium, Mozambique one of the poorest countries in the world would not be able to gain a better position among the nations in the world in terms of scientific and technical development without attracting more people into technical careers, such as science and engineering courses, including also the greater participation of qualified females.

Fennema (1984) has argued that without mathematical knowledge and skills, females will never be able to achieve equity in society. In order to begin to address this situation, it is necessary to understand the obstacles that females face entering science and technology occupations.

As a corollary, gender disparities in the teaching and learning of mathematics in Mozambique are mostly related to the:

a) Low participation of female pupils in all levels of the education system and particularly in the ESG-2 courses, which require extensive mathematical training.

b) Very traditional ways of teaching, based on a didactic method (basically a teacher-centred approach with pupils passively receiving the information) in an evidently competitive atmosphere.

c) Lack of basic teaching aids (textbooks, learning aids) reinforced by the fact that particularly the contents of the mathematics textbooks are also possibly gender biased.

1.2 AIMS AND IMPORTANCE OF THE STUDY

In this context it is viewed as crucial, for understanding the influence of factors in the gender disparities in school participation particularly at secondary level, to explore the classroom environment (classroom interactions) and the academic factors (pupil performance and attitudes toward mathematics and the mathematics' teachers) involved there. To this end, the following questions were addressed:

1. ***Do teacher-pupil and pupil-teacher interactions in mathematics classrooms show a typical pattern based on gender?***

2. ***Does a relationship exist between classroom interactions, pupil's attitudes toward mathematics and pupil's mathematics performance? If so, how is it affected by gender?***

With these questions it is expected to provide quantitative and qualitative information related to the influence played by classroom interactions and gender on mathematics education in the secondary school in Mozambique, for the possible reduction of gender-related differences. Thus, the research results will give a more solid insight to the learning problems of pupils, and are expected to lead to better ways of dealing with teaching and learning problems found in mathematics classrooms.

It is also expected to provide statistical information related to gender differences in mathematics education at the secondary school level. Further outcomes are expected to:

a) Produce recommendations for secondary education as regards pupils' mathematics learning and as regards to the assessment procedures that might benefit both boys and girls equally, and for teaching staff as how to teach more effectively by using successful gender neutral examples and explanations.

b) Contribute to the improvement of teaching techniques and teaching materials with respect to the promotion of gender equity

The knowledge that should be gained from this study could help in keeping the Mozambican education authorities aware of the "mathematics education and gender" issues in order to improve the participation of girls in technological and scientific careers, which traditionally are still being viewed as a male domain. . It has been hoped that, with the findings of the present research it may be possible to contribute to the debates about the roles of decreasing the gender differences in mathematics enrolment and in attitudes toward mathematics.

In addition, the scientific community in general, and mathematical and educational professionals in particular should also use the expected findings of the study, for uncovering and reducing gender inequities wherever they might appear at every stage of mathematics training by adjusting the teaching process. It should also suggest a need for attention to be given to the improvement of pupils' attitudes toward mathematics and achievement based on how mathematics should be taught and learned.

1.3 LIMITATIONS OF THE STUDY

Certain limitations of the present study need to be noted. The results of this study cannot be generalised to pupils who do not have the same background in mathematics or from other academic levels in Mozambique or in other countries. In terms of this research this is not considered a limitation, because this study was specially aimed, at secondary school pupils in Mozambique.

Socio-cultural factors could also have contributed to the limitations of the generalisation of the findings from this study even within the Mozambican society, since there are different cultural patterns, which could directly influence traditional education and strengthen the tensions within formal education.

CHAPTER II

LITERATURE REVIEW

"Demystifying Mathematics does not mean merely making it accessible to all, but also to mean that those who have been marginalized, disinvited and under-represented, will come to see that they too can share in the creation of Mathematics and its ownership, beauty and power."

(Volmink, 1994:52)

2.1 INTRODUCTION

From Volmink's quotation it is possible to understand that mathematics should be open to, and used by, everybody since it plays an important role in our daily lives. A thorough grounding in mathematics is essential for all boys and girls during their education and training. Therefore, as stated by Kaur (1990), a strong mathematical background is a pre-requisite to many career and job opportunities in this technological world of today. However, during the preceding 25-30 years much has been written about the low participation of females in advanced mathematics courses, college majors and careers, that involves mathematics stressing that gender has a very substantial effect on students' career choices (Fennema and Carpenter, 1981).

Megarry (1984) argued that the well-documented under-participation of girls and women shows that despite a worldwide increase in female participation in higher education, the total number of females continues to lag behind that of males, especially in the university level. In Australia for example, according to Leder and Forgasz (1992), for the most demanding elective mathematics courses in the post-compulsory years of schooling and at the tertiary level, females' participation rates have persistently remained lower than those of males.

Sells (1980) identified mathematics as a filter that gives women the possibility to get access to prestigious and lucrative occupations, meaning that gender differences are smaller in countries with high rates of female employment. Some authors, (Fennema and Sherman, 1977; Armstrong, 1985, Fennema, 1985; De Boer, 1986; Leder, 1990a; Dick and Rallis, 1991; Maple and Stage, 1991), stated that this situation is evident as soon as students have the opportunity to select their own courses that fewer females choose to continue studying science subjects and hence mathematics.

According to some authors (e.g., Eccles, 1986; Dick and Rallis, 1991), it is impossible to consider the female under-representation issue without examining gender differences in mathematics performance and attitudes toward mathematics.

In this regard, Forgasz (1995) argued that the study of gender differences could be focused in attitudes toward mathematics, classroom environments and mathematics performance. Meanwhile, Linn and Hyde (1989) underlined that the development of gender differences in career choices occurs independently of girls' achievement levels. Their findings showed that girls begin to lose their interest in science even when they perform as well, or even better, in the subject as their classmate boys.

A similar point of view is had by other authors (e.g., Hanna 1989 and Solar 1995) who argued that females are succeeding as well as males in mathematics, yet they participate much less in mathematics-related careers. For them, just because females can succeed in mathematics does not ensure that females will choose to pursue careers in this field.

On the other hand, there are authors (e.g., Casserly, 1980; Meyer and Koehler, 1990; Willis, 1995; Forgasz and Leder, 1996 and Norton and Rennie, 1998) citing gender differences in attitudes toward mathematics as one factor that has contributed to lower enrolments of girls compared to boys in mathematics and science courses and less success in those courses. Indeed, these authors believe that interest in mathematics is a significant predictor of pupils' experiences in class, their grades and the level of mathematics they choose.

Woolnough (1994) and Catsambis (1995) underlined that gender differences in mathematics and science career choice cannot only be explained by differences in achievement levels, attitudes toward mathematics/science, or social background characteristics but, as stated by Marr and Helme (1990), there are also the historical, cultural and educational forces, which combine to discourage females from continuing with these subjects.

From these arguments it is clear that the issue of gender and mathematics is extremely complex, as pointed out by Fennema and Hart in 1994. According to Fennema (1996), research on gender and mathematics must be concerned with an issue much broader than that which is usually considered the domain of scholarship and that issue is the role of women and girls in our world, in particular as this role is influenced by mathematics.

This is reinforced by the number of studies examining issues related to the learning of mathematics including gender differences in cognitive and affective variables, spawned during the last half of the 20th century. In reviews that covered many publications, authors such as Reliech, (1996) and Fennema (1996), noted that it is widely believed that mathematics gender differences vary by socio-economic status, ethnicity, school and the teacher who in general tend to structure their classrooms in ways that favour male learning.

However, Fennema and Sherman (1977) stated that sometimes the gender differences are attributed to underlying ability and other times they are attributed to a social climate that does not encourage girls to study mathematics.

2.2 PUPILS' GENDER AND THE ATTITUDE TOWARDS MATHEMATICS

Differences in attitude towards mathematics between boys and girls were evaluated in several studies carried out in many countries over the world involving pupils of different grades and levels of different educational systems. The findings from the study of Weinburgh, (1995) suggested that over the last 21 years, boys have consistently shown a more positive attitude towards science and mathematics, than girls. This has not appeared to change over time if the date of publication of the studies is used as an indicator.

In this regard, Tressou-Milonas (1990) said that no serious differences were detected in the attitudes of boys and girls toward mathematics since both boys and girls exhibited the same enthusiasm when faced with the same difficulties on certain topics and showed common preferences for particular pieces of apparatus or certain activities. According to Oakes (1990), it could be expressed by the fact that there are a number of factors influencing pupils' attitudes toward mathematics/science, which could mask the gender differences.

However, in different studies other researchers, (e.g., Fennema and Sherman, (1977) and Leder, (1990a)), stated that when comparing the two genders, females have been noted to have more negative attitudes and that these differences increase as pupils progress in school.

The influence of schools on the attitude towards mathematics have also been analysed (e.g., Mallan 1993) and the findings showed that girls have a more positive attitude towards mathematics and higher opinion of their mathematical ability in monastic schools than do girls in co-educational schools since they do not have males to compete with for the mathematics teachers' attention and do not have boys to discourage them in their mathematics lessons, contributing to their higher motivation to study mathematics. Similarly, Norton and Rennie (1998) have noted that Australian studies indicated that monastic school environments tend to be more closely associated with positive attitudes toward mathematics, particularly among girls.

2.2.1 Confidence in Learning Mathematics

As argued by many authors (Fennema and Sherman, 1977, 1978; Armstrong, 1981; Shaughnessy, Haladyana, and Shaughnessy, 1983; Norton and Rennie, 1998), confidence in learning mathematics, or the degree to which a person feels certain of his or her ability to do well in mathematics, has consistently emerged as an important component of gender-related differences.

Sherman (1980), has stressed that not only is confidence in learning mathematics important because of its relationship to mathematics performance, but also perhaps even more important because of its role in deciding whether or not to take further mathematics courses. Further evidence by Tartre and Fennema (1995) supported Meyer and Kohler (1990) who have argued that since girls tended to be less confident in their ability to do mathematics than boys are, it is reasonable to hypothesise that confidence may be an important variable to investigate. The results of several studies (e.g. Fennema and Carpenter, 1981; Kaiser-Messmer, 1993 and Bohlin, 1994) arrived at the conclusion that, from the beginning of the secondary school stage, females perceive their mathematical ability to be lower than that of males. Middleton and Spanias (1999) noted that, students who like mathematics tend to report that they started liking mathematics and begin to perceive mathematics to be a special domain in which smart students succeed and other students merely "get by" or fail, at or about the 7th grade.

According to Eccles (1986) in the United States of America for example, gender differences in mathematics ability start to appear in junior high school and at this point girls have lower estimates of their abilities than do boys. Moreover, Norton and Rennie (1998) in a review of the literature noted that there is possibly a similar pattern in Australia, with some findings suggesting that girls tended to have lower Confidence in mathematics by grade 7, although girls more than boys, in monastic or in co-educational schools, believe that females are able to participate and perform as well in mathematics.

Authors such as Sherman (1980); Bohlin (1994); Kaur, (1995); Seegers and Boekaerts (1996) and Relich (1996), stated that females' attitudes declined, as measured on the Confidence in Learning Mathematics Scale and that, males are significantly more confident of themselves as learners of mathematics. This pattern is supportive of the results of Joffe and Foxman (1986) and Solar (1995), who concluded that females are more unsure of their mathematical ability than males and frequently the girls showed less confidence to cope with jobs requiring a strong mathematical background, although they claim to have good grades in this subject while many boys may overrate their abilities.

According to Fennema et al. (1981), females tend to attribute success more to hard work than to their abilities and believed their failure related strongly to their lack of ability. More often than females, males attributed their success to ability, and as Norton and Rennie (1998) noted, boys were found to have a greater tendency to blame failure on external factors, such as luck. Similar results were reported by Boekaerts, Seegers and Vermeer (1995) when stating that boys attribute their (positive) result more frequently to capacity and to invested effort, but only the difference between boys and girls in the degree to which positive results were attributed to "pleasure" was statistically significant. Boys more frequently mentioned that the "pleasure" they experienced in working on the task explained their positive result.

Kaur, (1995) has found that, the younger boys were more likely to attribute their success in mathematics to effort than were the girls. Older students more than younger students, and irrespective of their gender, attributed their success in reading and in mathematics to external factors, such as luck and ease of task. Girls, more readily than boys believed that failure in mathematics was the result of low ability. Failure in reading and in mathematics was attributed to poor effort more by the older students than by the younger ones. In addition, the older pupils were likely to view such failures as more the result of external than internal circumstances.

Fennema (1985) stated that girls underestimate their level of performance more frequently than boys and that girls far more than boys feel that their failures are due to a lack of ability in mathematics and this attributing style may lead them to believe that success in mathematics is unattainable. She continues arguing that, if a girl likes mathematics, but feels that the amount of effort it will take to do well is not worthwhile because it decreases the time she will have available for more preferred activities (i.e., activities more consistent with her personal values), she will be less likely to continue taking mathematics.

If a girl stereotypes mathematics or careers involving competency in mathematics as masculine and not consistent with her own sex role, she will be less likely to value mathematics learning and less likely to continue her mathematical studies, especially if she does not expect to do well (Fennema, 1985). This is confirmed by Becker (1990b), who reported that male and female graduate students in both mathematics and computer science expressed similar reasons for liking their disciplines but females generally had less confidence in their abilities in both fields. Apparently, this contributes to lack of ambition for more advanced mathematics degrees. Males expressed confidence in their abilities, and usually denied ever having any difficulties in coursework or other aspects of their graduate programme. The females were much more likely to spontaneously mention difficult points in their programmes, and their coping mechanisms. There was no evidence from grades or degree attainment that females were less successful; they just seemed to feel that they were.

As Kaiser-Messmer (1993) stated, girls tend to be more open-minded about mathematical ability and gender roles than boys, but this does not appear to become established in most girls' self-images. Thus, the self-image of girls is dominated by factors such as self-confidence in their own mathematical competence, remaining within "socially acceptable" role expectations and increased self-assertiveness areas. On the other hand Boekaerts, Seegers and Vermeer (1995) argued that girls might, more than boys, believe that doing mathematics is applying a set of rules. When they are not sure that they know "the necessary" rule they may want to protect their ego by lowering their efforts and expectations.

2.2.2 Mathematics as a Male Domain

In 1972, Horner concluded that females have a motive to avoid success in mathematics since traditionally it has been viewed as more of man's interest or occupation. In 1973, Stein and Bailey arrived at a similar conclusion when they stated that females have lower achievement motivation in academic areas not considered gender-appropriate. More recently, Forgasz, Leder and Gardner (1996) stated that, although gender differences in perceptions of mathematics as a male domain had declined during the 1980's, they were persistent and still evident in current work.

Certainly, as Norton and Rennie, (1998) argued, despite the fact that large gender differences remain, this variable may not be as significant as it may have been 20 years ago when the original scale was used. It could justify the findings obtained by Kaur (1995), that only males of the high achievers group believed in the common stereotype of mathematics being a male domain subject.

Indeed, Fennema (1996) stated that it became clear that while boys did not strongly stereotype mathematics as a male domain, they believed much more strongly than did girls that mathematics was more appropriate for males than for females. Further, Sherman (1980) argued that girls' more positive attitude towards success in mathematics appear to be a function of an increased maturity.

Of particular importance is the view point of Fennema and Sherman (1977), who stated that many females have as much mathematical potential as do males, contradicting in this way the generalised belief, that, females cannot do well in mathematics. This is reinforced by the consistent findings of the study by Kaiser-Messmer (1993) that involved different courses and levels, where it is reported that although the belief in females being equally as talented as males is held by both the majority of boys as girls it is the girls who hold this belief significantly more than the boys.

Norton and Rennie, (1998), argued that girls are more likely to regard mathematics as that of a male domain and it remains stronger in monastic schools but declines in co-educational schools, although in senior grades, these school type differences become more apparent. The impact of this girls' attitude is stressed by Sherman (1980) when she noted that the stereotyping of mathematics as a male domain negatively affects girls' mathematics learning.

2.2.3 Perception of the Teacher's Attitude

In a review of relevant research reports regarding the affective variables Middleton and Spanias (1999) concluded that the findings of the majority of these studies suggest that the decline in positive attitudes toward mathematics can be explained in part as a function of teacher supportiveness and the classroom environment. Other studies (Midgley, Feldlaufer and Eccles, 1989 and Relich, 1996) tended to confirm the findings that a teacher's effect on students is more directly related to his or her personal efficacy and qualities as a teacher than whether they were male or female although the gender of the teacher necessarily influenced the treatment of the students or the way that either boys or girls related to the teacher.

Of the variety of factors frequently invoked to help explain gender differences in participation and performance in post-compulsory mathematics courses, the influence of the teacher as argued by Leder (1990a) was particularly singled out in research carried out over the world.

This role of the mathematics teachers was widely examined in several studies (Fennema and Hart, 1994; Fennema, 1996 and Middleton and Spanias, 1999). Most of the results lead to the conclusion that students tend to attribute their feelings about mathematics to their identification with influential teachers or to their reactions to bad experiences for which they blame teachers. Despite that, Sherman and Fennema (1977) reported little evidence that, females more than males perceived their teachers as less positive toward them as learners of mathematics.

Eccles et al. (1985) found that the students' reasons for liking or disliking mathematics seem to focus on the transition from elementary to middle school instructional patterns, especially the perceived supportiveness of the teacher and new rules for determining success in mathematical tasks. In fact, a study carried out in Australia (Forgasz, 1995) examined the link between students' attitudes to mathematics and their perceptions of classroom environmental factors in co-educational schools and found that teacher variables were stronger indicators of mathematics attitude for males than for females.

Personalisation was found to be more critical for female than for male class cohorts. Fisher and Rickards (1998) supported this when arguing that mathematics teachers are likely to promote favourable student attitudes in their classes if they monitor and adjust their interpersonal behaviour accordingly.

According to Rodgers (1990) many of the students regarded the encouragement, support or enthusiasm of particular teachers as the most important factor, which was influential in their career choice. For this author it was clear that the individual personality and style of each teacher played a unique role in the students' experience of mathematics and the mathematics classroom. Isaacson (1990) reinforced this when reporting on a transcript of a female pupil's self-reported perception on a mathematics teacher's attitude:

> *"The mathematics teacher had 12 pupils, 5 of whom were girls. I do not know how exaggerated my memory has become, but I do remember him saying that girls had no place in his field. By the end of the term, there were only two of us girls left and he did make life hard for us. In the end I dropped maths and was told not to worry, because my aptitude lay in languages anyway."*
>
> *(Isaacson, 1990:23)*

As Isaacson (1990) stressed it was evident that although the female student could have attributed her failure to difficulty of the course, but her attitude, enjoyment and commitment to the subject had obviously suffered as a result of her perception of the teacher's opinion of her as a person and her potential. Thus, another recurrent view of the teacher's role is the way the teacher either did not encourage, or even actively discouraged, girls from doing mathematics – often rationalising this by saying that the student was better at other subjects.

Students in the study of Luchins and Luchins (1980) also voiced this opinion and gave it as a reason for not majoring in mathematics and explain some of the discouragement and different treatment that girls received, since teachers, advisers, and counsellors seemed to have the impression that there were few career opportunities in mathematics for females. Luchins and Luchins (1980) reported female mathematicians felt that they were treated somewhat differently than males and that they received more discouragement from teachers and colleagues during the process of their development than was typical of successful male mathematicians.

It is still in accordance with Isaacson's (1990) view when arguing that girls need to be told that they are capable of doing mathematics – even if this, to the teacher, seems obvious. Girls need to be made aware of the many potential uses of mathematics in their own lives. Females' career options need to be opened up so as to include many traditionally male areas of work where mathematics is needed – science, banking and insurance, technology, engineering, etc. In particular, the potential contribution of these fields to human welfare needs to be emphasised.

This is supportive of Marr and Helme (1990) who argued that the attitude that girls do not need mathematics has resulted in large numbers of adult women who, having not succeeded in mathematics in the past, have very little confidence in their ability.

In the study by Forgasz and Leder, (1996) the results of the large scale survey suggested that individual students who perceive their mathematics teachers to be interested in them as individuals, who feel classroom participation is promoted and that emphasis is placed on investigative skills, are also likely to have more functional beliefs about themselves as learners of mathematics.

Indeed, Fennema and Peterson (1985) have proposed the Autonomous Learning Behaviour model (ALB), as an explanation of gender differences in mathematics. This model hypothesises a relationship between teachers' beliefs and gender differences. In fact, in the studies by Fennema et al. (1990) and Fennema (1996) it was pointed out that differential teachers' expectations of the girls and boys lead teachers to overrate the boys' mathematical ability and to correspondingly underrate the girls' ability.

2.2.4 The Usefulness of Mathematics

Toomey and O'Donovan (1997) stated that there is a conventional wisdom about the importance of mathematics in western and other societies, for most people, the grounds for its special importance include, amongst many other things the role that it plays in developing logico-deductive thinking skills and its contribution to improving the nation's economic competitiveness. Thus, as Fennema (1996) noted, the beliefs about the usefulness of mathematics were identified as critical affective variables.

According to Kaur (1995), regardless of the gender, a majority of the students believed in the practical utility of mathematics, but did not know whether mathematics would be useful to them in their future studies. However, Barnes and Coupland (1990) argued that many more females than males see mathematics as neither relevant to their interests and experiences nor useful to them in their future lives and careers.

The study of Catsambis (1995) confirmed that females continue to have limited participation in science-related extracurricular activities and restricted views about the usefulness of science for their future. Nevertheless Fennema, (1985) and Armstrong (1985) considered a positive attitude towards mathematics and belief in its usefulness in later life as the most important influential factors on gender related differences. Still taking into account the study by Fennema (1985), one can arrive at the conclusion that females do not perceive the usefulness of mathematics for their future as clearly as males do, particularly in the case of the mathematically precocious.

Toomey and O'Donovan (1997) supported this when stating that girls still perceive mathematics as an area of study relatively unrelated to their lives and to how they seek to live their lives. While other authors (e.g., Leder, 1993; Tartre and Fennema, 1995 and Forgaz, 1995) noted that males agreed more strongly than females that mathematics is useful.

Maccoby and Jacklin (1974); Fennema and Sherman (1977) and Tartre and Fennema (1995) found that the pupils' perceptions about the usefulness of mathematics showed minimal if any differences between males and females, and showed this to be independent of the other attitudinal variables.

Despite this in their study carried out in 1977, Fennema and Sherman stated that the perception of the value of mathematics or mathematics-related careers had emerged as significant predictors of both achievement and course plans. In opposition, Forgasz (1995) concluded that students' beliefs about the usefulness of mathematics might not be as strongly implicated in gender differentiated mathematics learning outcomes as was earlier believed.

2.3 THE PATTERNS OF CLASSROOM INTERACTION

Research in classrooms has proliferated during the past three decades. A range of techniques – both qualitative and quantitative – have been used to monitor classroom behaviour. This has shown the importance of teacher practices and beliefs as at least partial explanation for gender differences in educational performance and participation, particularly in the areas of mathematics and the physical sciences, (Leder, 1990a). It could explain the fact that the patterns of interactions in the mathematics classrooms are also considered an important factor in the examination of gender related differences in pupils' attitudes toward mathematics as well as in their mathematics performance (Armstrong, 1985; Fennema and Sherman, 1977, 1978 and Joffe and Foxman, 1986).

However, according to Forgasz and Leder, (1996), the literature reveals inconsistent findings about the relationship between classroom factors and students beliefs about themselves as learners of mathematics. Wood (1994) reported that opinions of those interested in mathematics education have suggested that variations in the classroom culture and the nature of the patterns of interaction that occur between the teacher and the students create quite different settings for enhancing learning.

Meanwhile, Kimball (1989) argued that gender differences in mathematics are related to teacher behaviour and classroom climate. It is supported by Peterson and Fennema, (1985), who concluded that girls' mathematics performance related negatively with a competitive atmosphere and positively with a co-operative classroom climate. According to Fennema, (1996), competitive activities encouraged boys' learning and had a negative influence on girls' learning, while the opposite was true of co-operative learning.

In addition, Fennema (1996), argued that since competitive activities were much more prevalent than co-operative activities in the observed classrooms it appeared that these mathematics classrooms were often more favourable to boys' learning than to girls' learning.

Fisher and Rickards (1998) referring to results of a Dutch study investigating teacher's behaviour in a classroom from a systems perspective noted that in the communications processes it is assumed that the behaviours of participants mutually influence each other. That is the behaviour of the pupils is influenced by the behaviour of the teacher and vice-versa and thereafter a circular communication process develops that not only consists of behaviour, but also determines behaviour.

Meanwhile, Fennema et al. (1990), stated that one component of the external influences, which may affect the development of gender related differences in mathematics would be the teacher influence on both students' internal motivational beliefs and on students' participation in classroom learning activities. Still according to Fennema et al. (1990), there is some evidence that teachers hold different beliefs about appropriate learning experiences for boys and girls.

It is particularly important to acknowledge that the traditional school mathematics classes are usually teacher-centred (Wood, 1999). In these classes the patterns of classroom interactions, both behavioural and mathematical, that take place are both limited and restrictive allowing the pupils little divergent (but correct) mathematical thinking. Instead they need only to be able to carry out the appropriate mathematical behaviour in response to the teacher's actions.

Clearly, the attitude of teachers is of great importance. Thus, Owens (1981), as referred to by Barnes and Coupland (1990), stated that the teaching methods used in mathematics could also create barriers to females' participation. It is well known that females under perform in learning environments that are individualistic or competitive and perform well in learning environments' that are co-operative.

In general, the traditional style of mathematics teaching, as Isaacson (1990) argued is authoritarian and teacher-centred, and tends to encourage a competitive atmosphere. The confident, assertive student thrives in such a classroom, while the more reticent and less confident, are disadvantaged. There is an abundance of research results showing that females are more likely to come into the latter category (Fennema et al., 1990; Levin, Sabar and Libman, 1991 and Fisher and Rickards, 1998).

Accumulating evidence Gerdes (1985), from his work in Mozambique, reinforced the view that a competitive style of learning is destructive for a lot of students who change their view of mathematics, and of their potential to learn the subject when placed in a climate which encourages them to work together listen and learn from each other, explore and respect different perspectives. The same viewpoint was also expressed by other authors such as Webb (1991) and Leikin and Zaslavsky (1997), who advocate that small group co-operative learning methods have been shown to increase learners' participation in general and facilitate student interactions in particular.

Leder (1990a) reported that the overall impression conveyed by the data suggests that boys and girls are treated differently in mathematics lessons. In fact, there has been further work (Koehler, 1990; Leder, 1993 and Forgasz and Leder, 1996) indicating that males and females are not treated equally in the mathematics classroom, with females being disadvantaged, as mathematics teachers interact more with boys than with girls. Compared with females, males have been found to receive more assistance and have their work monitored more often (Koehler, 1990; Leder, 1990b; Leder, 1993 and Forgasz and Leder, 1996). The same authors underlined the evidence that teachers have interacted more frequently with students for whom they held positive expectations.

As Middleton and Spanias, (1999) argued it seems that teachers attributions of their students successes and failures are reflected in the ways in which they interact with boys and girls in their mathematics classes. Supporting this, Becker (1981; 1990a) argued that, during lessons, females in co-educational schools are at a quantitative and qualitative disadvantage regarding the attention given to them by their teachers.

Guzzetti and Williams (1996) pointed out that despite a teacher's intentions to be gender fair, the culture of the classroom might subvert or override these attempts. The teacher in this study tried to be equitable by calling on equal numbers of males and females, and by approving female skills in refutational discussion. Despite these interventions, this form of discussion still favoured males.

Becker, (1981) and Reliech, (1996) found evidence suggesting the existence of patterns of the teaching practice based on the gender of the pupils, since they reported that both male and female teachers were found to encourage boys more than girls in mathematics classes.

The study of Atweh and Cooper (1995) also showed that mathematics teaching is a gendered practice. According to Fennema, et al. (1990) females have many more lessons in which they do not interact at all with teacher and males initiate more contacts with teachers than do females. Although modest, Taber (1992) reported differences between the numbers of teacher–boys' interactions and teacher–girls' interactions. These modest differences, according to Taber (1992) might have happened because the observations were undertaken as part of an action–research project, in which teachers were aware of the purpose of the observation and were given feedback on their performance.

Taber (1992) also reported that boys were involved in significantly more interactions in the full class setting with their teachers, than girls. In particular, boys were involved significantly in more interactions related to the science content and received more lesson administration interactions as well as more control/discipline interactions.

Leder, (1990a) arrived at the same conclusion with boys dominating the interactions in the full class setting and being involved in more disciplinary exchanges than were girls hence as this author reported, teachers asked boys more questions and although girls volunteer answers as often as do boys, the boys were called upon to respond more frequently than were girls. Boys received a little more individual instruction and social interactions. Acknowledgement, praise, encouragement, and corrective feedback were given slightly more to boys than to girls.

However, Fennema et al. (1990) noted that boys were perceived as volunteering answers to problems more often, enjoying mathematics more, and more independent in mathematics than were girls. Jungwirth (1991), reported that males called out answers more often than did females and were much more active in initiating informal contacts with the teacher while females tended to ask more questions of the teacher with the class as passive participants than males.

According to Leder, (1990a) boys consistently sought and received teacher attention more frequently than girls, since boys themselves initiated more interactions, and publicly asked more cognitive questions. Effectively, boys were spoken to more often than girls particularly by asking more questions.

In addition Taber (1992), has also noted that, although there were very few “call–outs”, boys achieved more interactions because they called out answers more than girls and boys were more often selected from the volunteers. As referred to by Jungwirth (1991) Becker’s analysis (1981) of ten high school geometry courses (each with an equal male–female ratio), showed that teachers asked males more questions, particularly more process questions, gave them more feedback after a partially incorrect answer, initiated more non-academic contacts and directed toward them about two thirds of their encouraging comments and the females students received nearly all of the non-encouraging or discouraging comments that the teachers made.

Solar (1995), also noted that sexism in the classroom interaction is evident in gender differentiating feedback, differentiating when giving attention and the opportunity to speak in the classroom or by asking males the more complex and difficult questions.

Meanwhile, Boli, Allen and Payne (1985) argued that having had female mathematics teachers in high school, led to better performance in tertiary level science courses by females with mathematics ability. Indeed there are other authors (e. g. Dale, 1974 and Mallan, 1993) arguing that females attending co-educational schools taught by female mathematics teachers demonstrated more positive attitudes toward mathematics than females attending all-girls' schools taught by female mathematics teachers.

Sharp (1975) referred to by Mallan (1993) argued that having male teachers could discourage females from studying mathematics. According to Mallan (1993) this could be a contributing factor to the lower mathematics attitude mean obtained by secondary school females taught by male Mathematics teachers and more positive attitudes toward mathematics were demonstrated by the females taught by female teachers.

Jungwirth's findings (1991) about the behaviour of female and male teachers stated that although female teachers tend to be more student centred indirect and supportive of students than male teachers, in general, female and male teachers are more similar to each other than different. A similar result was found by Solar (1995), who reported that boys were involved in a significantly higher proportion of interactions in both mathematics and science and with both male and female teachers.

However, as Fennema (1996), stated, the impact of this differential treatment from the teacher to the boys and girls is still unclear and difficult to ascertain and it does not support the premise that differential teacher treatment of boys and girls causes gender differences in mathematics enrolment. This conclusion was also found by Eccles and Blumenfeld, (1985); Koehler, (1990) and Leder (1982a), who claim that there still is not sufficient evidence to conclude that interacting more or differently with girls than boys is a major contributor to the development of gender differences in mathematics performance.

As Leder, (1990a) pointed out, it is noteworthy that the differences in teacher treatment of boys and girls were still found in contemporary classrooms. The differences identified seem to precede gender differences in performance in mathematics and that the link between teacher treatment and student achievement is suggestive, indirect, and probably further reinforced by the gender-linked expectations and beliefs of the wider society.

Finnaly, according to Leder (1990a) it could be argued, in fact, that the teacher behaviours quantified are symptomatic of wider social expectations and beliefs. Schools function within a cultural context, reflect it, and continue to reinforce the notions that being competitive in mathematics is more important for boys than for girls.

2.4 GENDER RELATED DIFFERENCES IN MATHEMATICS PERFORMANCE

A review of the relevant literature reveals that, studies into gender differences in mathematics performance have been carried out, especially in English speaking countries. Most of them arrive at diverse conclusions as was reported by Kaiser-Messmer (1993), who noted an inconsistency in the research findings of several studies, with males performing better in some studies and females in others, and that these patterns varied considerably both within and between countries.

This is reinforced by Forgasz, (1995), who stated that there were several factors that may influence the levels of performance of males and females, and Fox and Cohn, (1980); Fennema, (1985); Kaiser-Messmer, (1993) and Bohlin, (1994), who have also stated that there are many factors responsible for gender differences in mathematics performance. According to Relich (1996), some differences in mathematical achievement, albeit small do seem to exist, but vary from culture to culture.

Many other studies (e.g., Maccoby and Jacklin, 1974; Meece, et al., 1982 and Fennema, 1985) also indicated that boys' achievement in mathematics is higher than girls at some point in high school but that the size of this difference varies a great deal.

In a later study Brandon, Newton and Hammond (1987) have partially supported these earlier findings, stating that gender differences in mathematics achievement worldwide vary by ethnicity along a range from moderate differences favouring girls to large differences favouring boys. However, according to authors such as Friedman, (1989) and Hyde, Fennema and Lemon, (1990) research favouring male attainment found that differences in performance are decreasing as a function of the grade level.

Though, as Becker (1990a) argued the absence of mean differences in the performance of both gender groups is not sufficient evidence for a conclusion that such differences do not exist. On the whole, Feingold, (1992) found that males were more variable than females, in test performance. As Leder (1992) stated, there is much overlap in male and female performance with between group differences overshadowed by within gender group differences. This is in accordance with Norton and Rennie (1998) who stated that the nature and extent of gender differences in mathematical performance remains a controversial topic, because there are many influencing variables. From this it is possible to infer that gender-related differences in achievement may vary considerably according to specific context of countries, schools environment, and cultural, social and economic dynamics.

For Leder (1992), the extent and direction of the gender differences might depend on the age of students, and on the type, the format, and the content of the measures administered. Various other authors (e.g., Fennema and Peterson, 1985; Hall and Hoff, 1988; Kimball, 1989; Battista, 1990; Leder, 1990b; Bohlin, 1994; Mji and Glencross, 1996; Cronjé, 1995 and Barnard and Cronjé, 1996) argued that male superiority in mathematics is found especially in performance on tasks of high cognitive complexity that have not been explicitly taught such as true problem solving, and they were non-existent, or even to the advantage of girls, for algorithmic problems reflecting the classroom content.

Indeed, in one meta-analysis carried out by Hyde, Fennema and Lamon (1990) it was concluded that while gender differences in mathematics achievement might be decreasing, they still existed in tasks that required functioning at high cognitive levels where males generally achieve better than females. Furthermore according to Benbow (1988) at the high ability end of the spectrum, gender differences favouring males appear to have remained constant. That is, gender differences are particularly apparent in problem-solving tasks and applications (Swafford, 1980 and Friedman 1989).

Fennema and Sherman (1978), Armstrong (1981), Fennema and Carpenter (1981), Marshall (1984), Tartre (1990), Tartre and Fennema (1995) and Seegers and Boekaerts (1996) have noted that when differences are found, they favour boys, especially in more complex abilities such as problem solving and applications of mathematics. Thus, it has been hoped that differences in achievement between females and males would disappear when there was equal enrolment in elective mathematics courses (Fennema and Carpenter 1981, Fennema, 1996). However, as these authors stated, even when females and males reported they had been enrolled in the same mathematics courses, males' performance was higher than that of females', and differences were greatest on the more complex tasks.

Similar findings were reported by Kaur (1990) who found that the few questions in which girls surpassed boys were generally of the type that call for recognition or classification, application of techniques, substitution of numbers into an algebraic expression and so forth, just the kinds of operations that are most susceptible to drilling. These questions mainly centred on the topics arithmetic, sets, algebra and graphs, vectors in two-dimensions, trigonometry, and matrices and transformations. The fact that these questions were from any particular topic or group of topics might be irrelevant.

However, Hanna (1986; 1989) has argued that gender differences are limited to certain areas of mathematics (e.g. geometry, problem solving, spatial visualisation, arithmetic, algebra, and statistics). Leeson (1995) has supportive evidence to these findings with boys tending to perform better on topic areas including rates, percentage and estimation while girls achieved better in number patterns, reflection and identifying geometrical shapes within a larger picture.

Some studies (Fennema and Carpenter, 1981; Cheung, 1989; Fennema, et al., 1990; Hanna, Kundiger and Larouche, 1990; Fennema and Hart, 1994 and Tartre and Fennema, 1995) have found that there are no significant differences among gender groups in mean percent correct for algebra, arithmetic and statistics, while such differences were observed in geometry and measurement.

A significantly different gender-pattern of results was found by Fennema and Carpenter (1981) on geometry and measurement exercises. For them, a possible explanation for females' relatively poor performance on geometry and measurement exercises is that a substantial number of these exercises may involve spatial visualization skills. Cronjé, (1995) on the other hand, stated that even though there were some contradictions, gender differences in geometry performance, are seldom found and, when they are found, they are relatively small.

Fennema and Sherman (1977) found that their data did not support either the expectations that males were invariably superior to females in mathematics performance or the idea that differences between genders increase with age.

Maccoby and Jacklin, (1974) and Hilton and Berglund (1974) stressed that it has been commonly believed that gender differences in mathematics learning are not usually evident in first grades school, and are thought to emerge during adolescence. This is supported by Hall and Hoff (1988), Kaelley (1988), Hanna, Kundiger and Larouche (1990), Hyde et al. (1990), Levin, Sabar and Libman (1991) and Kaiser-Messmer (1993) who all stated that there are no gender differences in elementary or middle schools, and only small differences in favour of the males in high schools and in higher education. For Leder (1985), there is a substantial body of evidence suggesting that by the beginning of secondary school, males frequently perform better than females in mathematics, and this is more evident among precocious adolescents, the differences favouring males are larger and appear earlier than in a normal population.

On the other hand, contrary findings exist. For example, Linn and Hyde (1989) have demonstrated that although gender related differences in mathematics achievement are visible as early as late childhood, they are more marked in older students.

2.5 PUPILS' MATHEMATICS ATTITUDE AND PERFORMANCE

In an attempt to explain differential achievement in mathematics, Reyes and Stanic (1988) drew attention to five different factors, which are: societal influences, school mathematics curricula, teacher attitudes, students' attitudes and achievement-related behaviours and classrooms processes. However, these authors have pointed out that although knowing that the 5 factors are important, little is known about the casual connections among the factors.

According to Burton (1994) it seems that in order to account for the differential willingness of certain groups to engage with mathematics and their varying competency when so doing it must be examined not only how mathematics is perceived but also the impact of all of these factors on the experiences and attitudes of learners.

As Meece et al. (1982), Gamoran (1987), Meece, Wigfield and Eccles (1990) and Catsambis (1995) noted, differences in mathematics performance may be caused in part by the gender related differences in attitudinal and motivational variables. In other words, this means that, as Ma and Kishor (1997) stressed, it is impossible to separate the cognitive from the affective domain in any activity and the most important is that, there is a cognitive component to every affective objective and vice-versa.

Aiken in 1976 noted that the relationship between attitude towards mathematics and performance in mathematics is usually positive and meaningful at the elementary and secondary school levels, but may not always reach statistical significance. Middleton and Spanias, (1999), supported this point of view saying that when the students attribute their success to ability they tend to succeed; when they attribute their failures to lack of ability they tend to fail.

Little consensus exists in the research literature concerning this relationship. It has been stressed by some researchers (e.g., Seegers and Boekaerts, 1996 and Ma and Kishor, 1997) that there is a complex set of relationships between cognitive and affective variables in learning mathematics. Ma and Kishor (1997) reported that previous studies have identified a number of factors as having important effects on these complex relationships and performance in mathematics and gender. Grade and culture are the most common variables described as influencing them.

Moreover, Fennema (1996) stated that the negative attitudes toward mathematics are the strongest barrier to girls' success in mathematics and science. Leder (1982b) investigating the relationship between fear of success and mathematics performance found no relationship for males; while for females, high achievement was associated with high fear of success. However, Reliech (1996) found that, although boys and girls have similar performance, there is considerable evidence that males are more positive about personal abilities in mathematics when compared to females.

In a study carried out in Mozambique at the post-secondary level by Cassy (1997), it was reported that gender performance in mathematics and attitude towards mathematics tended to be similar and the gender inequalities found were more evident in the participation in mathematics related careers. According to Relich (1996), differences in the cognitive domain seem to appear at later ages than do differences in the affective domain with regard to mathematics.

Seegers and Boekaerts (1996) have argued that the greatest differences between males and females can be found in their attitudes to mathematics and self-confidence rather than in their mathematical achievement. To support the existence of gender differences in confidence, authors such as Fennema and Sherman (1977); DeBoer (1986) and Leder (1992) have noted that boys rated themselves higher than girls in science and mathematics courses even in the absence of superior course performance on their part. Other researchers (Mura, 1987; Thomas and Costello, 1988 and Leder, 1987, 1990a) have also provided evidence of boys perceiving superior competence and girls undervaluing their achievements in mathematics.

Meece, et al., (1982) and Tartre and Fennema, (1995) concluded that prior mathematics performance is the strongest single predictor of future mathematics achievement and that confidence in learning mathematics is the affective variable most consistently related to mathematics achievement. Marsh, Smith and Barnes (1985), in an Australian study with fifth-grade students found that although the girls outperformed the boys on a standardised mathematics test they nevertheless had lower mathematics self-confidence than did the boys. Fennema and Sherman (1977) and Tartre and Fennema (1995) have noted that confidence in one's ability to learn mathematics is strongly correlated with mathematics achievement.

However, Midgley; Feldlaufer and Eccles (1989) argued that high perceived competence is in itself not enough to guarantee that students will put in a sufficient effort since when they see themselves as capable of doing well in mathematics they tend to value mathematics more than students who do not seen themselves as capable of doing well.

A particular aspect was established by Fennema and Sherman (1977), who stated that mathematics has traditionally been viewed as more of a man's interest or occupation and consequently one might expect that males would score higher than females on tests of ability and achievement in mathematics and on scales of attitude towards mathematics. They found mathematics as a Male Domain correlating significantly, but modestly, with achievement for girls, but not for boys.

Peterson and Fennema (1985) concluded that high confidence males interact at higher levels with their teachers more often than do high confidence females. Thus, traditional classrooms, (Forgasz and Leder, 1996), may also be implicated in differentially influencing the affective beliefs of male and female students.

Jungwirth (1991) reinforces this view when stating that the gender differences in patterns of interaction between teachers and girls or boys is based on the fact that the pattern of interaction practised by boys is more likely to make them appear more competent in mathematics and the results on competence and incompetence in mathematics, of boys and girls might also be related to their modes of participation as well as to the corresponding practices of their mathematics teacher.

According to Weinburgh, (1995) the correlation between attitudes toward science and achievement in science are comparable for boys and girls. This author found that, in general, the correlation between attitude towards science and achievement in science was moderate, but this correlation was somewhat stronger for girls than for boys, indicating that a positive attitude is more necessary for girls in achieving high mathematics and science scores.

Indeed, as Kenway and Gough (1998) argued, some authors question the popular assumption that girls largely perform inadequately in the 'non-traditional' subjects. They do so by pointing out the ways in which assessment practices are gendered or by questioning the very notion of performance itself. In girls and mathematics, Walden and Walkerdine (1985) showed that, in the United Kingdom, many teachers work with a masculine model of a good learner. This permits them both to define girls' achievements negatively and discourage their progress along esteemed mathematical pathways. In short, teachers' perceptions actually produce gendered patterns of success and failure.

In examining the correlations for the affective variables with mathematics achievement Tartre and Fennema, (1995) have found a strong pattern of positive correlations between mathematics achievement and confidence for both males and females. Neither gender showed consistent patterns of correlations between mathematics achievement and the effect of the teacher or the perceived usefulness of mathematics. However, there appeared to be differences between genders in the pattern of the correlations between mathematics achievement and the stereotyping of mathematics as a male domain. The Male Domain sub-scale was not related to mathematics achievement for males. Although for females there was less stereotyping, the Male Domain sub-scale was positively correlated to mathematics achievement.

In addition, Catsambis (1995) also argued that, the relatively low interest of girls in mathematics and science courses could mean that high mathematics and science achievement is a necessary, but not sufficient, condition for increasing females' participation in technical careers. Attitudinal and socio-cultural factors play an equally important role. Indeed, inequities in the science-related attitudes and orientations of male and female pupils in the middle grades could affect their achievements and learning opportunities during high school, then, interventions for increasing women's motivation to pursue science-related careers should occur early on in adolescents' academic careers, (Catsambis, 1995).

The choice of this target population for intervention attempts is explained by Fox (1980) when he stated that it would be young women and girls who have not yet completed high-school or college, for whom the choices of careers and course-taking are still open or reversible.

As a remark, Fox (1980) suggested that if we believe that gender differences in mathematics course-taking in high school, college, and graduate training and the pursuit of careers in fields that require high-level mathematical skills are at least partially caused by socio-environmental and educational factors, then strategies for change must seek to reduce or eliminate the gender-typing of mathematics and related careers as masculine domains and to provide more encouragement and support for female achievement in the classroom and on the job. It appears that such support must, as early as possible, involve not only the parents but also it must be reinforced in the schools and by society at large.

2.6 DEFINITION OF IMPORTANT TERMS

Since the study is on education, some definitions related to the concepts involved in the study need to be considered.

2.6.1 Attitude

Although there is no standard definition of the term **attitude**, in general it refers to a learned predisposition or tendency on the part of an individual to respond positively or negatively to some object, situation, concept or another person (Aiken, 1970). Attitude towards some significant part of pupils' world is a composite expression of what they think, feel and do with respect to that aspect of their world, (Oppenheim, 1992).

According to Thomas (1984) an attitude has three components:

i) A **cognitive component**: based on what people know, think or believe about their world or any specific aspect of it.

ii) An **affective component**: the feeling that an individual experiences in relation to any discriminable aspect of their world: physical, material, abstract, other pupils, events, institutions, etc. This aspect is often referred to as an individual's affective orientation to some object, concept or value.

iii) A **behavioural component**: a predisposition to behave in a particular way toward the object of the attitude.

For the purpose of scientific study as Oskamp (1977) stated, attitudes must be classified into categories or measured on a quantitative scale using attitude statements. Thus, an attitude statement is a single sentence that expresses a point of view, a belief, a preference, a judgement, an emotional feeling, and a position for or against something.

2.6.2 Achievement Tests

In most educational research involving pupils' performance the indices or tools that are used to measure attainment are achievement tests (Ebel and Frisbie, 1991; Gronlund, 1993). An **achievement test** is a systematic procedure for measuring a representative sample of learning tasks, meaning that it is simply the measure of one's performance at a given set of tasks.

In the normal classroom situation, mathematics performance is measured by classroom tests and standardised tests (including the examinations conducted, either by the class teacher or external examination bodies). Indeed, in the Mozambican context, **classroom** tests are the achievement tests that reflect classroom content, while **standardised** tests are those tests that reflect curricular content-tasks.

CHAPTER III

MATERIAL AND METHODS

"There are sex-related differences in the final outcome of Mathematical Education due in large part to females' reluctance-if not refusal- to elect to study Mathematics"

(Fennema, 1980:88)

3.1 INTRODUCTION

Fennema's argument quoted above, although relative to a certain population, could be extrapolated to a broader population since there is a worldwide convention that girls are not interested in participating in mathematics and its related fields. Therefore it was considered crucial not only to understand what is taking place within the girls' decision making framework, but also to find the way for increasing the number of females involved in these fields which constitute the basis of the technological world of today.

The present study intended to explore possible gender patterns of teacher-pupil interactions in Mozambican mathematics classrooms and if these differences influence the pupils' performance and attitude towards mathematics. The study applied both quantitative and qualitative approaches since, "they are necessary and complementary components of any system of research in the mathematics and science education and social science fields" (Malone, 2001, pg. 20). The research was carried out during the January 1999 – December 1999 school year, in natural school environments.

Four schools, in Maputo City were chosen, being two state-schools and the other two non-state schools. All four schools are co-educational using Portuguese as the instructional language.

The procedure for carrying out school-based research in Mozambique requires that the researcher initially gain permission from the Provincial Directorate of Education. Only when this Directorate grants permission may the researcher approach the head teacher of any school. The head teacher would then allow the researcher to speak to teachers and approach the governing body, which comprises among others, parents of the pupils. Only when all these groups agree can classroom based-research be carried out. All of these procedures were followed for carrying out the present research.

3.2 SAMPLE

Pupils of grades 9 and 10, from 4 different secondary schools were invited to participate on a voluntary basis knowing that refusal in participating would not result in any penalty. A total of 1221 pupils, (531 boys and 690 girls), distributed in 33 classes of grades 9 and 10 of both types of schools (states and non-state schools) and their mathematics teachers were involved in the study. The classes varied from 45 to 55 in the state schools and from 23 to 25 in the non-state schools. In all classes, regardless of the school type, there were more girls than boys. All of the teachers (2 women and 7 men) involved in the study had the necessary qualifications (academic and professional training), for teaching mathematics at that secondary level. One of the female teachers resigned from the school during the second period of the study as she was awarded a full-time bursary to continue studying toward a higher degree.

3.3 MEASURING INSTRUMENTS

This study was done in an attempt to understand which school factors influence the differences in gender participation in mathematics and its related fields. Thus, it was decided to explore the role of gender in the patterns of mathematics classroom interactions and the possible relationship between these patterns and the pupils' attitude towards mathematics and their mathematics performance. In this context, it was clearly necessary to obtain relevant data on the pictures of the mathematics classroom interactions, the pupils' attitude towards mathematics and the school mathematics performance. In order to gather these data the following developed instruments and techniques were used:

a) Mathematics Attitude Scale – MAS (Appendix A-1),
b) Classroom Observation Schedule (Appendix A-2) and
c) Achievement Tests (Continuous Assessment tests and the National Examination)

The decision to use an attitude scale, observational methods and achievement tests was supported by the research methodology of previous studies (Schumacher and McMillan, 1993; Cohen and Manion, 1985) where these types of instruments have been used to carry out effective data collection.

3.3.1 The Attitude Scale

The pupils' attitude, in this study, was measured by using a researcher developed Mathematics Attitude Scale (MAS) covering five components of the affective domain that have been established in the literature as likely to be important aspects of pupils' attitudes toward mathematics.

Schumacher and McMillan (1993) and Cohen and Manion (1985) consider that attitude scales are very common techniques for collecting data in educational research and that the data obtained from these type of instruments are more consistent than the information obtained by means of interviews. According to these authors this is based on the fact that by using scales in the study of attitudes to each respondent the same set of questions as everybody else in the same sample was given, phrased exactly in the same way.

The **MAS** initially included 47 items of a Likert-type format, ranging from 1 (Strongly Disagree) to 5 (Strongly Agree) and they were taken from the "Modified Fennema-Sherman Attitude Scale" for mathematics and science (Doepken, Lawsky and Padwa, 1998). A fluent Portuguese-English translator translated the scale into Portuguese, and another independent fluent Portuguese-English translator, translated the initial Portuguese version back into English. The English versions were then compared. There were a few minor differences, usually in the technical language, which were then agreed. Hence a Portuguese version was now available for piloting.

The items of the MAS could be aggregated in 4 different sub-scales regarding pupils' perceptions about "Pupils' **Confidence** in learning and performing well in mathematics tasks"; "mathematics **Teacher Attitude** towards the pupils"; "mathematics as a **Male Domain**" and the "**Usefulness** of mathematics". For each sub-scale half of the statements was positively worded while the remainder were negatively worded.

Although many studies involving aspects of this research have been done (e.g. Fennema and Sherman, 1977; Sherman, 1980; Forgasz, 1995; Tartre and Fennema, 1995; Forgaz and Leder, 1996; Doepken, Lawsky and Padwa, 1998 and Norton and Rennie 1998), the **MAS** which was based to a large extend on the Fennema-Sherman Mathematics Attitude Scale (Fennema and Sherman, 1977):

(a) has not been translated or used in Portuguese; and,

(b) specifically not used in Mozambique.

It was therefore necessary for a pilot study to establish the reliability and applicability of this instrument, getting also a contextual validity before carrying out the research. The pilot of the translated **MAS** was carried out in one school in February 1999, over the three grades of the lower secondary level. This school was not used in the main study and the standard procedure for conducting classroom-based research in Mozambican schools was followed (see Section 3.1, page 63).

The subjects participating in this phase of the pilot study consisted of 461 secondary school pupils, similar to but mutually exclusive from the target sample. The percentage of girls in the pilot was 53% (n= 246). The pupils were asked to participate, and this participation was voluntary. All the available scales were returned and many comments and/or suggestions were made, not only by the pupils involved in the pilot phase but also by their mathematics teachers.

The internal consistency for the **MAS** and of each of the sub-scales separately, was computed. In Table 3.1.1 the values of Cronbach's Coefficient Alpha and the mean scores (and standard deviations) for the **MAS** and each of the 4 sub-scales are presented.

Table 3.1.1: Cronbach's Coefficients Alpha, means and standard deviations of the attitudes toward mathematics by gender

Scale/Sub-scale	α			Boys		Girls		t
	All	*Boy*	*Girl*	*Mean*	*SD*	*Mean*	*SD*	
Confidence	0.78	0.75	0.78	3.84	0.69	3.52	0.78	4.51^{b}
Usefulness	0.70	0.68	0.71	4.25	0.59	4.10	0.67	2.51
Teacher Attitude	0.61	0.59	0.63	3.62	0.59	3.58	0.63	0.68
*Male Domain**)	0.59	0.60	0.54	3.44	0.65	3.77	0.60	-5.47^{b}
MAS	0.83	0.79	0.85	3.57	0.39	3.36	0.36	5.84^{b}

*) Low scores imply less stereotyping/gender neutral; a) $p<0.01$; b) $p<0.001$;

The **MAS** had an internal consistency of α =0.83 for the total sample, α = 0.79 for boys and α = 0.85 for girls. These values are regarded as good (Anastasi and Urbina, 1998). Although similar satisfactory results were found, only for two of the sub-scales, "**Confidence**" and "**Usefulness**", since the other two sub-scales, the "**Teacher Attitude**" and "**Male Domain**" showed values below 0.70. The pilot study showed that the full Portuguese Fennema-Sherman MAS version was sufficiently reliable for use in Mozambique. The connotation in the wording of some of the "**Male Domain**" sub-scale statements may well have contributed to the lower values of the internal consistency of this sub-scale.

The female pupils particularly suggested improvements to the language in the scale, as they considered the **Male Domain** sub-scale's language as being of an offensive nature. As an example, the majority of the girls did not like the connotation of the items:

a) *"When a woman has to solve a mathematics problem, she should ask a man for help".*

b) *"It is hard to believe a female could be a genius in mathematics"*

c) *"I would have more faith in the answer for a mathematics problem solved by a man than a woman".*

Thus, on the basis of the criticisms and suggestions like these, some statements were rephrased to avoid double-meanings and biased statements and/or terms arising from the translation from English into Portuguese. In addition, as the mathematics teachers suggested, five new items developed by Forgasz (1995), were included to cover anxiety, enjoyment and motivation in studying mathematics. These items were subjected to a translation-back translation procedure and met the agreement of pupils, teachers and other professionals that they were clear and understandable, before the scale was administered to the target sample.

The 52 items comprising the **MAS** used in the main research aimed to gather data related to the pupils' attitude towards mathematics, which were grouped in the following 5 sub-scales:

a) ***Confidence***: For measuring pupils' confidence in their ability to learn and perform well on mathematics tasks (Fennema-Sherman, 1977).

b) ***Teacher Attitude***: For measuring pupils' perception of how their teachers feel about them as learners of mathematics (Fennema-Sherman, 1977).

c) ***Usefulness***: For measuring pupils' beliefs about the usefulness of mathematics currently and in relationship to their future education, vocation, or other activities (Fennema-Sherman, 1977).

d) ***Male Domain***: For measuring the extent to which mathematics is viewed as a male domain - low scores imply less stereotyping or gender neutral domain, (Fennema-Sherman, 1977).

e) ***Anxiety***: For measuring the feelings of anxiety, dread, nervousness and associated bodily symptoms related to doing mathematics (Forgasz, 1995).

Each sub-scale contained items with two or more statements assessing similar aspects and, in order to minimise the effects of rote responses, half of the items were worded negatively. According to Oskamp (1977), the simplest way of reporting a group's attitudes is to give item response percentages separately for each item. However, several items on the same general topic must be classified into categories or combined to form a scale with a single score for the group of items computed for each respondent. He also argues that scales give a broader range of scores than a single item and including more items can increase the reliability of the overall score.

In this study, the negatively worded items were then reverse-scored. In each sub-scale, item scores were summed to give a sub-scale score. According to Nunnally (1978), the use of summative scales has a number of advantages over all other known methods, because, summative scales:

a) follow from an appealing model;
b) are rather easy to construct;
c) are usually highly reliable;
d) can be adapted to the measurement of many different kinds of attitudes;
e) and, have produced meaningful results in many studies to date

Although, one of the major limitations that can be recognised in the use if this type of attitude scale is that the respondent's attitude score does not have a unique meaning.That is, any given score can be obtained in many different ways. For instance, on a Likert-type scale, a mid-range score can be obtained by giving mostly "undecided" responses or by giving many "Strongly agree" responses balanced by many "Strongly disagree" responses.

3.3.2 The Classroom Observation Schedule

With the intention to find out whether the teacher-pupil and pupil-teacher interactions occurring in mathematics lessons in lower secondary schools in Maputo show a typical pattern based on gender, the researcher developed an observation schedule. Stallings and Mohiman (1990) stated that there are many ways of attempting to quantify what happens in the classroom. In some cases, researchers in classroom observations use rating scales, others prefer some kind of category system, but as Wragg (1994) pointed out, the usefulness of a particular observation system depends on specific goals.

According to Schumacher and McMillan (1993), observational research methods allow for recording behaviours as they occur naturally and refer to a more specific method of collecting information that is very different from interviews or questionnaires. There is a very important advantage for research designed to study what occurs in real life as opposed to highly contrived or artificial settings.

As a technique for gathering information, the observational method relies on a researcher's seeing and hearing things and recording these observations, rather than relying on subjects' self-report responses to questions or statements. However, it should be noted that the observers might affect the behaviour of the subjects by being present in the setting (Estrela, 1986; Good and Brophy, 1991, Schumacher and McMillan, 1993). To minimise this aspect, teacher trainees were involved in the classroom observation and they usually sat at the back of the class with only paper and pencil.

Taking into account these considerations, the researcher designed a grid based on the combination of the well known, FIAC (Flanders' Interaction Analysis Category) system (Flanders, 1970) and the Brophy and Good Dyadic Interaction Observation System (Good and Brophy, 1991).

The reason for not using either one or the other of the two systems, was mostly concerned with the fact that both systems were developed for teacher training purposes, which is not the case of this study. The FIAC system allows a record of what is taking place in the classroom but includes categories that are inappropriate for most lessons in mathematics and sciences. FIAC was designed to show and analyse the type of teacher-pupil/pupil-teacher interaction within a time interval framework, it was not designed to elicit and analyse the quality and individuality of pupil and teacher responses. It does not give information either about the quality of the teacher's questions and the pupil's answers or about the nature of the teacher's feedback reaction to the pupil (Wragg, 1994).

The Brophy and Good Dyadic Interaction Observation System is not designed for continuous usage and it is tailored for use in specific situations with certain forms being used when a teacher is lecturing, others are used when the teacher is giving directions or dealing with management problems, when the pupils are seated or working in small groups, and also some of the categories defined in this system have few application in mathematics and science lessons. The characteristics of the grid (Appendix A-2) allowed the researcher to distinguish classroom interactions into two types, namely:

a) **Teacher** action and,

b) **Pupil** action.

The **teacher action** comprised those aspects of the teacher's behaviour during the mathematics lessons, while the **pupil action** referred to those aspects related to the behaviour of the pupils in lessons and includes mainly the pupil initiated talk and/or pupils setting up answers to the teacher. In the initial grid the information needed could then be easily recorded by entering check marks in appropriate places on the coding sheet. No writing or note taking was required.

The grid was organised to follow the time sequence of each lesson, so that, to code a given interchange, the observer ticked the appropriate spaces moving from left to right across the observational sheet. It means that, when the teacher selected a pupil to respond, the observer recorded the pupil's position in a class map and the pupil's gender by entering a check mark under B or G. Then after noting the pupil's response and the teacher's reaction to it, they coded the quality of the response by entering a check mark under "+", "-", "±", or "**0**".

Finally, the teacher's feedback reaction was also recorded in the appropriate teacher reaction columns. For example, if the teacher simply affirmed that a correct response had been given and then went on to another question and another pupil, observers would enter a check mark in the "+" column. However, if the teacher had praised the response and then asked the same pupil another question, observers would have entered check marks in both the "+ +" and the new question-columns.

Thus, the observational grid was developed in such a way that allowed the observers to code information about the gender (boy or girl) of the pupil interacting with the teacher; the mode in which the teacher posed the questions; the quality of the pupil's responses, and the nature of the teacher's feedback to the pupil.

3.3.2.1 Training of Observers

To collect data related to the classroom observation scheduled it was necessary to use four observers. The decision to use this number of observers is supported by Ebel and Frisbie (1991) arguing that, in classroom observation gathering the use of multiple observers is ideal because it could allow the researcher to detect the presence of error in recording and the establishment of inter-rater reliability. In addition, for the findings of observers to be credible Wragg (1994) recommends that the observers must receive training, or at least have the opportunity to discuss their purposes, procedures and intentions to the point where there is general agreement on what they will be doing. Thus, the researcher followed this recommendation.

Ten people (five men and five women) were recruited for training as observer using a snowball sampling methodology. These trainees were in general trainee teachers. They were paid for their services. The training involved the viewing of video recorded lessons that the researcher had used in designing the observation schedule. The trainees received 12 hours of training as a group over the afternoons during one week. This large group was usually split into smaller groups of two or three.

Initially the researcher explained the purpose of the classroom observation and the various categories of the grid. Videotaped lessons of mathematics lessons were then selected and the researcher led the trainees through the tape, stopping frequently to discuss the various classroom events that had been recorded and observed. These events were categorised after considerable discussion. The remainder of the training using videotapes was in the smaller groups, which strived for a consistent recording of the events observed. The same videotape was used so that the observers could compare their first coding of the events with their second coding the same videotaped events. They compared their first recordings of what had occurred in the two separate viewings using the same, videotaped lesson. The percentage of agreement of these two observation schedules was calculated. A similar process was followed with two different observers.

The second phase of training involved the observation of pupils in a natural classroom environment. The same secondary school that was used in piloting the Attitude Scale was also used in the training of observers. This aspect of training involved fifteen formal lessons with three teachers being observed in five lessons each. As passive observers, and in groups of two or three, the observers sat at the back of the selected classrooms with the observation instrument. In all cases the observers completed the grid and after each session they discussed what they had observed. Finally, agreement was accrued at on the way in which each event could be classified, and the form in which records could be assembled was completed.

The trainees were now evaluated by using inter-rater agreement. According to Wragg (1994), to ensure the level of agreement between observers when more than one person is involved, there are two formal measures that might be applied: the "inter-observer agreement" and the "intra-observer agreement". The first refers to the amount of agreement between two or more observers, while the second relates to the extent to which observers agree with themselves on another occasion, (Wragg, 1994). So, in this study, the level of agreement was established and the evaluations was done using the formula proposed in Good and Brophy, (1991):

$$Agreement = 1 - \frac{A - B}{A + B}.$$

Where, A indicates the number of observed events recorded by the first observer and B the number of observed events recorded by the second observer. The term

A must always designate the observer with the larger number of events (Good and Brophy, 1991).

Only those trainees with the best inter-rater agreement (at least 90%) were used in the main study. Four trainees met this requirement (two men and two women). This training phase also enhanced the observation schedule with suggestions from the trainees that clarified various observable events. The improvements in the schedule were:

a) The distinction between teacher-individual pupil interaction only and teacher- individual pupil with class as passive participants;

b) The modes of the question which were addressed to the class and whether the responses were given by all pupils at the same time or not;

c) The nature and the quality of the answer given by one specific pupil or by the class.

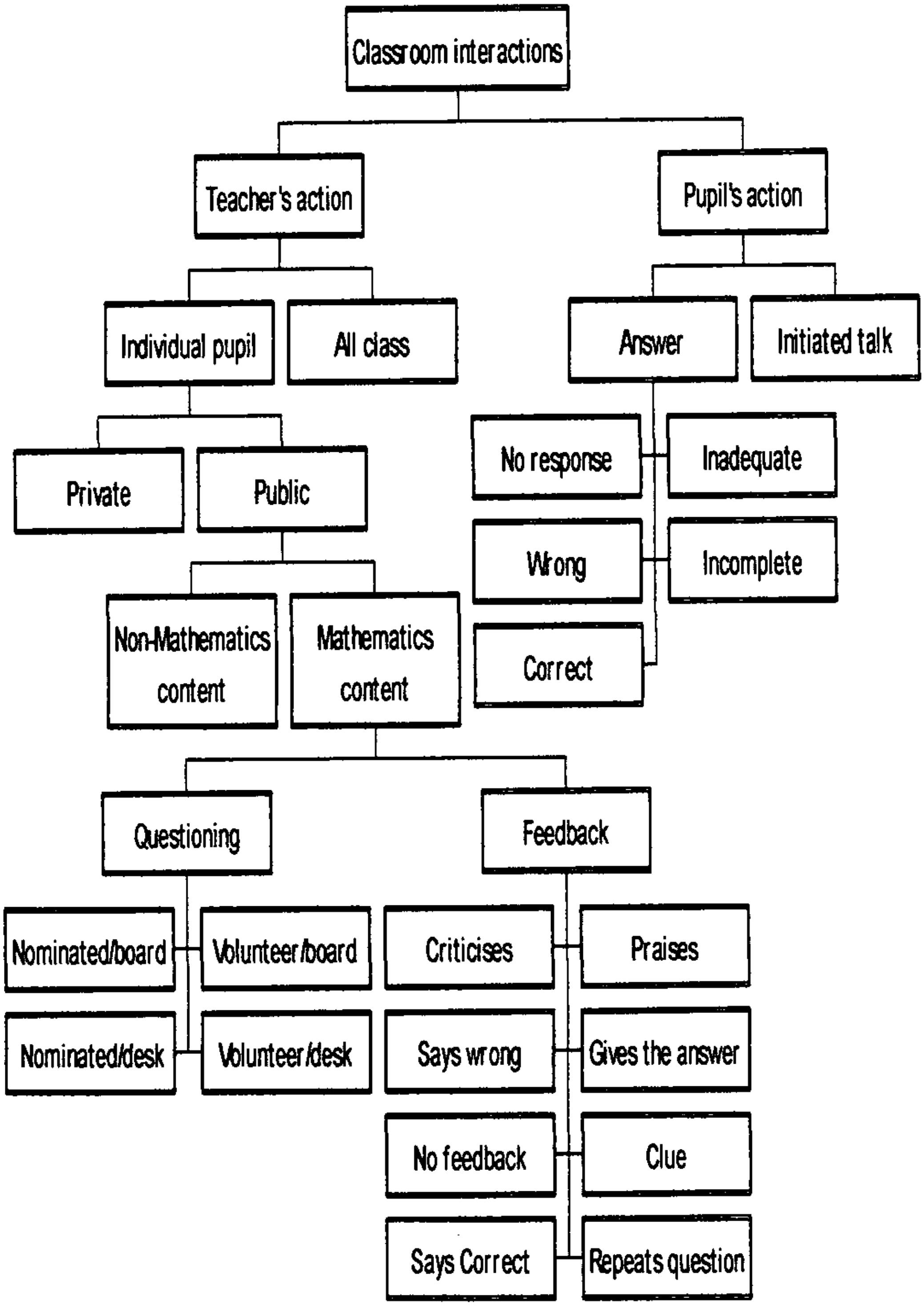
In Figure 3.3.1, the categories included are summarised in the final grid of classroom observation, (see Appendix A-2). The categories of the grid include all the kinds of interchanges involving the teacher and the class or the teacher and an individual pupil. In the latter, two types of interactions existed: **Public** and **Private** interactions. From Figure 3.3.1 it is evident that the **Public** interactions were coded according to the content of interaction and the way the interaction was initiated (**teacher**-initiated or **pupil**-initiated). Usually, during mathematics lessons most of the **teacher**-pupil interactions involved subject content. However, there were considerable interactions that were not directly related to the subject content. Thus, a category for summarising the non-mathematics content interactions, such as disciplinary or administrative interactions, was introduced in the schedule and, it was labelled as "**non-mathematics content** interactions".

Public interactions, with a specific pupil, refer to the interactions taking place when the teacher was working with an individual but with the rest of the class as the audience or passive participants. While **Private** interactions, with a specific pupil, refer to the interactions that occur when the teacher moved among the class working with an individual pupil as the class worked independently on some activity. In the case of **Private** interactions, only the gender of the pupil was recorded, as it was impossible and not ethical to overhear what the interchange between pupil and teacher was.

Five of the nine categories of teacher's feedback to the pupils' answers could be judged by the observer even by seeing the gestures, hearing the voice tone or the type of words addressed to a pupil after she or he had answered the question.

The **pupils'** action included also pupil-initiated verbal interaction, which was in most cases for clarifying their misunderstandings.

Figure 3.3.1: Diagram of the recorded events in the classroom interactions



Thus, the observational schedule comprised a grid of 14 categories, (see Appendix A-2), of possible teacher and pupils' action during question and answer classroom interchange in mathematics lessons. This was drawn up in such a way that it could be used by a single observer with pencil and paper, marking the appropriate space provided for each situation occurring during mathematics lessons, without the need for a tape or video recording. Since an event sampling record system was considered as being each of the teacher-pupil interchanges whenever the teacher asked a question and called on a pupil to respond, the observers code information about whether the pupil was male or female, about the quality of teacher's question and pupil's response and about the nature and quality of the teacher's feedback.

3.3.3 The Achievement Tests

This study also aimed to explore possible gender differences in pupil's mathematics performance in the lower secondary school and their possible relationships with the pupils' attitude and the patterns of classroom interactions.

As defined by some authors (e.g., Ebel and Frisbie, 1991; Grounlund, 1993), an achievement test is a systematic procedure for measuring the proficiency level of individuals in given areas of knowledge and it can be defined simply as a measure of one's performance at a given task. Although Frankel and Wallen (1993) stated that the achievement tests are mostly used in schools to measure learning or the effectiveness of instruction authors such as Ebel and Frisbie (1991) and Grounlund (1993) argued that, in most educational research involving pupils' performance the indices are in most cases the achievement tests administered.

Formally the teaching and learning of mathematics in secondary schools in Mozambique involves an assessment system (see Section1.1.3, page 12) where the pupils performance is measured through a continuous testing process conducted firstly by the mathematics teacher, secondly, by a panel of the school's mathematics teachers and at the end of a specific school cycle, it includes the National Examination, which is set externally.

The measurement of pupils' performance was therefore an evaluation of the three types of testing:

a) Three classroom tests (that is, ACS-1; ACS-2; ACS-3).

b) Three standardised tests (ACP-1; ACP-2; ACP-3).

c) The National Examination (for the tenth grade pupils only).

3.4 PROCEDURES

3.4.1 Mathematics Attitude Scale's Administration

The pupils of the chosen classes completed the Mathematics Aattitude scale in the second term (May 1999) of the school year. First, before the scale was administered to the pupils, the mathematics teachers explained its purpose following the instructions attached to the scale (see Appendix A-1) and then asked the pupils for completion on a voluntary basis. Thus, those pupils who agreed to participate in the study returned the scale. It should be noted that all pupils present in class returned the scale. Incomplete and thus, unusable scales were less than three percent.

When the pupils completed the mathematics attitude scale they were asked to disclose their personal details (name, age, gender, class, school) and confidentiality was assured. This procedure is supported by, amongst others, Cohen and Manion (1985), who argue that, if it is anonymous the motivation of the respondents cannot be checked, and it becomes difficult to judge the validity of their responses. On the other hand, as this research attempted to relate pupil-teacher interaction to both attainment and attitude, the individual pupil had to be identified.

3.4.2 Classroom Observations Recording

The observational programme was carried out in a period of twelve weeks distributed in two different periods, each of six weeks, during the second half of the first school semester (May-June) and the beginning of the second semester (August-September), usually with daily observation (excluding the testing days). As the teachers taught various numbers of classes, from only 2 classes of a grade in non-state schools, to one teacher who taught five classes of a grade in state schools; two classes per teachers were selected for observing. Thus, from the 33 classes involved in this study, only 18 (two classes per each teacher) were observed based on timetable constraints.

The data were gathered by direct observations carried out by the four trained observers, using the research grid. In the classes, the observers worked in pairs. This was necessary for the establishment of an accurate recording of what took place, hence the evaluation of inter-rater reliability. They employed the passive observer method being seated at the back of the classroom with the observational grid (see Appendices A-2) during the 45 minutes of each lesson.

At the end of each day's observation the researcher used to meet with the observers to collect and discuss their recorded data. During these meetings the inter-rater agreement was calculated following the index recommended by Good and Brophy (1991) (see Section 3.3.2.1, page 77). This index was always above 0.9.

In the first 6 weeks, all that was noted, were the responses according to researcher's observation schedule. Since it was deemed as necessary to relate teacher-pupil interaction to both attitude and performance, it was essential to identify every pupil accordingly. Thus, after further negotiation with the four head teachers, teachers and governing bodies, the pupils were requested to stay in the same places for each mathematics lesson.

The observers carried out the observations using a class map (see Appendices A-3) so that the identification of the pupils according to their seating place was possible and they were able to relate teacher-pupil patterns of interaction to individual pupil, and hence the researcher was able to identify responses of a particular pupil. Thus for the period August-September 1999 only, was it possible to relate classroom participation to both attitude and performance.

During the period of observation, the researcher participated in the subject meetings held every fortnight in all schools and several contributions were given to them in order to discuss their teaching styles, marking, evaluation and assessment procedures. After the completion of the observational period, and the completion of an initial analysis, the research and the teachers met and discussed the results informally.

Further feedback and discussion was held with teachers using the output of SPSS on the statistical analysis of pupils' performance and the question analysis procedure for assessment of the tests. These discussions were held during the meetings in all four schools. These activities were not part of the format research plan, but the teachers were interested in receiving feedback of the results achieved by this study that involved them and their pupils. It was also decided to discuss with (or to present to) them some of the findings during the meetings.

3.4.3 Achievement Testing

As already stated, this research tried to minimise the creation of artificial situations (see Section 3.1, page 63). Therefore, the achievement tests were designed according to the existing mathematics curriculum at secondary schools and were administrated to the pupils by their own teachers within the official assessment system.

The ACS (that is, the short classroom achievement tests assessing less than one unit's contents that had been covered during the previous period, with duration of about 45 minutes per test) in general, took place in the class before the introduction of a new topic. The individual teachers usually set these tests with questions selected from a "question bank". Meanwhile, the school committees of mathematics teachers set up the ACPs written during the semester.

With regard to the National Examination, its construction is under the responsibility of a Department in the Ministry of Education, (Comissão Nacional de Avaliação e Certificação). This Department was contacted by the researcher to discuss the content that is usually included in the Mathematics Examination and to request the inclusion of the three topics (Algebra, Geometry and Trigonometry) relevant to the study in the examination of 1999. The Department allowed the researcher to make suggestions about the construction of certain questions, both in content and the type of questions for the National Examination.

The researcher was also involved in all these achievement tests, including the National Examination, and particularly in the case of the continuous assessment ensured that the standard was equivalent across the schools.

The content and the time allocated for testing were not determined by the researcher but depended on the formal school regulations for the secondary level. The number of questions included in each test, (including the National Examination), was determined largely by the amount of time spent on the teaching of each topic.

The National Examination was marked, first, by the school's mathematics teachers and then remarked by the researcher. The aim of the second marking (by the researcher) was to reward correct correct mathematical reasoning and pupils were given partial credit. The results obtained from those tests were used to investigate the pupils' performance in mathematics tasks and its relationship with the attitude scores and patterns of classroom interactions.

3.5 DATA ANALYSIS

A statistical data analysis was performed using the "SPSS" - Statistical Package for the Social Sciences, version 7.5 for Windows. In general the analyses considered gender, age group, grade level and school type as the independent variables. The results are presented in tables and graphs.

3.5.1 Pupils' Attitude Towards Mathematics

The pupils' attitude towards mathematics was analysed using:

a) Factor analysis: which was conducted for determining the characteristics of the five option Likert-type scale;
b) Coefficient Alpha: for assessing the consistency of the scales;
c) Pearson's product-moment correlation coefficients: which were determined for the scores on all variables for all pupils, boys, and girls;
d) ANOVA: which explained the effect of the independent variables on the pupils' attitude;
e) Means scores and standard deviations of pupils' responses related to the items on the attitude scale. However, since the sub-scales have differing numbers of items, in order to do a comparison, it was decided to use the standardised mean of each of the sub-scales and the mean of the **MAS**;
f) Independent samples t-test: for testing the gender comparison;

g) Cross-tabulation: between the categories of pupil' attitudes toward mathematics, performance criteria and the patterns of classroom interactions. Thus, the attitude was grouped in 3 categories, (positive; neutral and negative), considering that means between 1 and 2 were classified as negative, between 4 and 5 as positive attitude and the rest are defined as neutral.

3.5.2 Patterns of Classroom Interactions

Categories used to analyze the data were derived from the knowledge obtained from the literature on gender and classroom environments in mathematics lessons, and the researcher's perspective of the teaching of mathematics in the education system of Mozambique. In the analysis, the following were taken into account: pupil action according to gender; way of questioning (selected or volunteer); quality of answer; pupils who initiate talk, etc.; teacher's action according to distribution of the questions among boys and girls in class; quality of the teacher's feedback to the pupil's answer; the mean number of interactions per pupil by gender. Then, it was necessary to compute:

a) Frequency distributions, which were used for all the categories identified in the grid.

b) The Chi-squared test was done to analyse the significance of the differences in the frequency distribution of each type of interaction between boys and girls and between the different categories defined in the grid.

c) The mean number of interactions per pupil of each gender group, which was determined by dividing the total number of interactions that involved all pupils of the group, by the number of pupils in that group.

d) A cross-tabulation, which was done involving the quality of the pupil's answers and the teacher's modes of questioning and feedback and also involving the performance criteria groups and attitude categories.

3.5.3 Pupils' Mathematics Performance

The analysis with regard to pupil performance was carried out considering the school's continuous assessment and the National Examination (for grade 10 pupils). As argued by some authors (e.g., Guilbert, 1981 and Smith et al., 1996), the majority of the classroom interchanges and consequently assessment level, occur at the **Knowledge** and **Understanding** levels, and seldom at the level of **Application** or problem solving.

Effectively, the questions of the National Examination could be grouped in these three cognitive levels using the "MATH" classification developed by Smith et al., (1996), as follow:

a) Cognitive level of Knowledge:

- The assumption in the questions of this level was that pupils have met the exercises before in the form required for the answer.
- Pupils would have been expected to work on problems using the required procedures in drill exercises.
- Pupils were required to bring to mind previously learned information in the form that it was given.

b) Cognitive level of Understanding:

- For the questions on this cognitive level it was assumed that various routine skills needed to do the exercises were familiar to the pupils and that they have done drill work in similar but not identical exercises.
- Pupils should be able to use a previously acquired knowledge or skills.
- Required the ability to use material in a way that goes beyond the recall of simple rules.
- Pupils might recognise the applicability of a formula or method in different or unusual context.

c) ***Cognitive level of Application or Problem Solving:***

- Here it was hoped that pupils had the ability to choose and apply appropriate methods or information in new situations.
- The assumption was that the pupils have not met any of the results they were asked to prove.
- Pupils should have the ability to do a transformation of information from one form to another - verbal to numerical or vice-versa.
- Pupils should have the ability to do the extrapolation of known procedures to new situations.

For the achievement tests in general, in addition to the cognitive levels and the above response categories, the researcher also followed a system of cumulative criteria performance (Mozambique's mark system), that allowed grouping the pupils according to their final level of performance (semester mark), as follow:

a) ***Lower performance criterion:*** - scores under 50% in achievement, (representing those pupils who fail the subject or who are not permitted to write the examination);

b) ***Middle performance criterion*** - scores from 50% and under 70%, (refers to those pupils achieving the adequate marks in the subject and should beallowed to write the examination if performance was adequate in the other subjects), and;

c) ***Upper performance criterion*** - scores of 70% and over, (corresponds to the group of pupils performing at higher level of achievement and who should gain credit without writing the examination in the case of a good performance in all the other subjects).

Therefore the mathematics pupils' performance was explored by:

a) Pearson's product-moment correlation coefficients that were calculated to determine any association between the scores of the cognitive and affective variables.
b) Analysis of variance (ANOVA) that was used to establish whether there is any statistically significant effect of the independent variables on the achievement measures.
c) Means, standard deviations and the t-test values of the **ACSs**, **ACPs**, semester, lower secondary cycle marks and National Examination were computed.
d) Discrimination and Difficulty indices for boys and girls were also computed for all the questions of the National Examination.

The Discrimination index was defined as a correlation coefficient between the total score of the pupil in the test and the respective score in a defined question. A high index for a particular question implies that the better pupils tended to answer the question correctly and the weaker pupils tended to answer incorrectly or not answer the question at all. This means that the question discriminates good pupils from the weak.

If the Discrimination index is low, for example 0.1 it could imply two different outcomes: all the pupils (good and weak) answered the question correctly or nobody answered correctly. The question did not discriminate the good from the weak pupils. Thus, using this index, the questions could be judged as poor (did not work) for index values under 0.24 or good (functioned as a discriminator) if the index values are equal to or above 0.25.

A Difficulty Index is the percentage of pupils who correctly answered the question, taking into account that it was considered correct if the mark of the question was at least 80% of the question's possible mark. This implies that, for the questions of the National Examination, four categories were defined to correspond to each response for crediting of partial marks and in each question, the mark achieved by the pupils was converted to a percentage. The categories included:

- ***No answer*** - leaving a blank space or a zero mark, for working that had no value.
- ***Wrong answer*** - achieving the mark between 0% and 50% of the mark allocated to the question/task.
- ***Partially correct answer*** - achieving between 50% and 80% of the allocated mark
- ***Correct answer*** - achieving at least 80% of the allocated mark. If the mark is between 80% and 100% the error made it usually one of carelessness not concept.

e) Cross-tabulation was done between the semester achievement and MAS categories and also with the patterns of classroom interactions. The results were illustrated using graphs.

f) Further analyses in the study, used the analysis of covariance (ANCOVA). In the set of analyses, the covariate was the lower secondary mark with national examination performance and each of the cognitive levels as the dependent variable.

3.6 VALIDITY AND RELIABILITY

The present scale was derived from the "Modified Fennema-Sherman Mathematics Attitude Scale" (Doepken, Lawsky and Padwa, 1996) and the work of Forgasz, (Forgasz, 1995), which has been applied in several other studies. To check its reliability, a Cronbach's Coefficient Alpha and Factor Analysis were carried out, for the MAS and also for the related sub-scales for the total sample and for boys and girls separately. This was done in both the pilot phase and in the main study.

To increase the validity of the Mathematics Attitude Scale (MAS), pupils were requested to disclose their names. According to Cohen and Manion (1985) this procedure can contribute to higher validity of an instrument since, if the response is anonymous, the motivation of the respondents cannot be checked and it becomes very difficulty to judge the validity of the responses.

According to Schumacher and McMillan (1993) to ensure the validity and reliability of the observational schedule, it is recommendable to locate existing observational schedules that have been standardised to some degree. Many schedules have been developed, and because they have been piloted and used in previous studies, they are more likely than new schedules to demonstrate good validity and reliability. Thus, in this study a grid based on the combination of the **FIAC** System (Flanders, 1970) and the Brophy and Good Dyadic Interaction Observation System (Brophy and Good, 1991) was used.

For the reliability of the adapted observational schedule a triangulation was used involving the checking of the observations of events of one observer with the observations of these same events with that of other observers. The inter- and intra-observers agreement can also contribute to the reliability of this type of instrument. In this context, the observers were trained until they reached a high level of agreement in the interpretation of the events occurring during a mathematics class, at least of 90 percent. These levels of agreement were calculated using the formula presented in Section 3.3.2.1 (page 77). That formula gives us the level of reliability of the observational grid used.

The content validity of the achievement tests used in this research, (including the National Examination), is supported by the fact that the study makes use of the formal assessment procedures defined by the Ministry of Education.

CHAPTER IV

RESULTS

"Tell me, and ...I will listen.
Show me, and ...I will understand.
Involve me, and... I will learn"
(Lakota Indian Saying)

4.1 INTRODUCTION

This popular saying stressed an interesting aspect of teaching-learning environment, which sometimes is relegated to a secondary plan. However, it is necessary for both boys and girls that the learning process in any subject requires the involvement of the pupil.

In this Chapter, the main results of the study regarding the school factors influencing gender disparities in the learning of mathematics are presented as means, standard deviations, frequency distributions, and percentages in the form of tables and/or graphs. The results on gender-related differences are presented and described in the following sequence:

a) the pupils' attitudes toward mathematics
b) the patterns of teacher-pupils classroom interactions
c) the pupils' mathematics performance
d) the relationships between the pupils' attitude towards mathematics, teacher-pupils patterns of classroom interactions and pupils' mathematics performance.

The other variables considered for the analyses were the grade level, school type, and the age group (see Section 3.5, page 88).

4.2 SAMPLE

The first result that is presented in this Section relates to the characteristics of the sample used for the three components of the study, "Attitude", "Interaction", and "Performance". The general sample consisted of 1221 pupils of whom 531 (43.5%) were boys and 690 (56.5%) were girls and their nine mathematics teachers (2 women and 7 men). These subjects were from four different co-educational schools (2 state and 2 non-state) and they were distributed in 33 classes of grades 9 and 10. The class sizes varied from 45 to 55 in the state schools and from 23 to 25 in the non-state schools. The pupils' age varied from 13 to 23 years of age in both types of schools. In state schools, the mean age was 17 years old for both girls and boys, while in non-state schools it was 15 and 16 years old for girls and boys, respectively. Overall, only 28% of the participating pupils were in the appropriate age group (i.e. under 16 years of age) for schooling at their expected educational level. Table 4.2.1 displays the frequency distribution of the pupils by gender, school type, grade, and age group.

Table 4.2.1: Total number of pupils by school type, grade and gender

School/Grade		Younger			Older			All		
		Boy	**Girl**	**Total**	**Boy**	**Girl**	**Total**	**Boy**	**Girl**	**Total**
State	Grade 9	63	83	146	162	206	368	225	289	514
	Grade 10	25	36	71	176	236	412	201	272	473
	Total	**88**	**119**	**217**	**338**	**442**	**780**	**426**	**561**	**987**
Non-State	Grade 9	46	45	101	18	14	32	64	59	123
	Grade 10	11	35	46	30	35	65	41	70	111
	Total	**57**	**80**	**137**	**48**	**49**	**97**	**105**	**129**	**234**
All	Grade 9	109	128	237	180	220	400	289	348	637
	Grade 10	36	71	107	206	271	477	242	342	584
	Total	**145**	**199**	**344**	**386**	**491**	**877**	**531**	**690**	**1221**

When aggregating the subjects by gender and age group (see Section 1.1.2, page 7), it was found that only 27% of boys and 29% of girls were theoretically considered as within the appropriate age for schooling at that level. Taking into account the school type a different picture was found in the two types of schools. In the state schools, 21% of both boys and girls were under 16 years old, while in the non-state schools this proportion (pupils aged under 16) was 54% for boys and 62% for girls.

The proportion between girls and boys in general varied slightly being 13:10 for the total sample, 12:10 and 14:10, in grades 9 and 10, respectively. Considering the school type the girls/boys proportion of the state schools was 13:10 pertaining to grade 9, while the highest ratio was 14:10 in grade 10. In non-state schools, a different picture was found. In grade 9 boys outnumbered girls (9:10) although in grade 10 this proportion was 17:10 in favour of the girls.

4.3 PUPILS' ATTITUDE TOWARDS MATHEMATICS

4.3.1 Introduction to Pupil's Attitude Towards Mathematics

With modifications based on the results of the pilot study (see Section 3.3.1, pages 67-69), 47 items of the MAS were taken from the "Modified Fennema-Sherman Attitude Scales" for Mathematics and Science (Doepken, Lawsky and Padwa, 1998). A further five items were based on a scale developed by Forgasz (1995). The pupils were asked to express their perceptions toward 52 items, which tapped into the attitude towards mathematics using a five point Likert-type rating scale.

The Mathematics Attitude Scale, (MAS), was completed by the 1221 lower secondary pupils who were in class on that day and was not taken home by any pupils. The pupils returned the completed scales with their demographic details, so that the researcher was able to identify each individual pupil. The ratio between the sample size and the number of items of the MAS was 24:1 exceeding the ratio of 20:1 which is advocated by some researchers for a sample of several hundred (e.g., Glencross and Cherian, 1992). The data was then entered into a spreadsheet and elementary descriptive statistics were then computed on the 52 item scale.

4.3.2 Validity and Reliability of the MAS

4.3.2.1 The Factor Analysis

An initial factor analysis was run on the 52 items. Principal Component Analysis (PCA) was preferred to Common Factor Analysis (CFA) as the researcher wished to find the percentage variance explained by each factor (Hair et al., 1998). The factor analysis was carried out on the correlation matrix. All the items were on the same scale. The matrix had a measure of sampling adequacy of 0.863, which is excellent (Hair et al., 1998 and Kaiser, 1970; 1974).

The initial Principal Component Analysis (PCA) was run yielding, according to Kaiser's criterion (1970; 1974), 14 possible factors. A scree-plot yielded the possibility of between 4 and 7 factors. Upon further examination, it was decided to keep only 4 factors, which explained 36% of variance. Only 43 of the 52 items loaded significantly on these 4 factors.

The factor analysis was then re-run on these 43 items. All the items loaded on the primary four factors, and now explained 40% of variance. These 4 factors yielded 4 sub-scales that were named as per Fennema-Sherman **MAS** (1977): "pupils' perceived **Confidence** in learning mathematics" (11 items: 8, 12, 23, 29, 35, 36, 38, 39, 43, 45, 52), "Pupils Perception of mathematics as a **Male Domain**" (11 items: 2, 5, 7, 15, 19, 20, 22, 33, 34, 41, 44), "Pupils' Perception about their mathematics **Teacher Attitude**" (9 items: 3, 9, 10, 11, 14, 30, 37, 47, 49) and "Pupils' Perception about the **Usefulness** of mathematics" (12 items: 1, 6, 16, 17, 21, 24, 27, 28, 31, 32, 50, 51), (see Appendix A-1).

The discarded items included 3 from the **Teacher Attitude** sub-scale (items: 4, 18, 26), 1 from **Confidence sub-scale** (item 40) and all the items adapted from Forgasz (1995), which were grouped as the "pupils' feelings of **Anxiety** when doing mathematics" and these items did not load on any of the 4 extracted factors.

In an attempt to explore possible gender differences in pupils' attitude towards mathematics the **MAS** as a whole and each of the defined sub-scales were analysed taking into account the school type, grade level, and age group.

4.3.2.2 The Cronbach's Coefficient Alpha

Coefficient Alpha was run on all 43 items yielding $\alpha = 0.84$ which is acceptable (Anastasi and Urbina, 1998). The results, by the primary demographic groups are displayed in Table 4.3.1 for the general sample.

Table 4.3.1: Cronbach's Coefficient Alpha by school type, grade and gender

Sub-Scale		State schools			Non-State schools			Total		
		Grade			Grade			Grade		
		9	*10*	*All*	*9*	*10*	*All*	*9*	*10*	*All*
	Boy	0.86	0.78	0.83	0.95	0.81	0.90	0.89	0.78	0.85
Usefulness	**Girl**	0.83	0.87	0.85	0.87	0.78	0.83	0.84	0.86	0.85
(12 items)	**Total**	0.84	0.84	0.84	0.92	0.80	0.88	0.86	0.83	0.84
	Boy	0.83	0.77	0.80	0.72	0.78	0.74	0.82	0.77	0.80
Teacher	**Girl**	0.80	0.81	0.80	0.76	0.70	0.72	0.79	0.79	0.79
attitude (9 items)	**Total**	0.81	0.79	0.80	0.74	0.73	0.73	0.80	0.78	0.85
Male	**Boy**	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Domain	**Girl**	0.90	0.92	0.91	0.86	0.90	0.89	0.90	0.92	0.90
(11 items)	**Total**	0.92	0.93	0.93	0.93	0.92	0.92	0.92	0.93	0.93
	Boy	0.86	0.63	0.79	0.54	0.23	0.46	0.83	0.61	0.77
Confidence	**Girl**	0.59	0.58	0.59	0.55	0.57	0.56	0.59	0.58	0.60
(11 items)	**Total**	0.77	0.63	0.71	0.54	0.48	0.52	0.75	0.61	0.69
	Boy	0.88	0.85	0.86	0.88	0.84	0.87	0.88	0.84	0.86
MAS	**Girl**	0.83	0.84	0.84	0.69	0.80	0.76	0.82	0.83	0.83
(43 items)	**Total**	0.86	0.84	0.84	0.84	0.81	0.83	0.85	0.83	0.84

When the items were analysed in their relevant sub-scales (as per the factor analysis and the intended design), all four sub-scales had Coefficient Alpha values within the acceptable bounds for the general sample. Examining Coefficient Alpha by gender yielded very acceptable values for all but the **Confidence** sub-scale for girls. A similar examination adding the school type and grade also yielded similar low values for Coefficient Alpha for the **Confidence** sub-scale.

4.3.2.3 Attitude Correlations

Another way to look at the relationship between the MAS and the different sub-scales (**Confidence**, **Male Domain**, **Teacher Attitude** and **usefulness**) was to perform Pearson's Product-Moment correlations. Table 4.3.2 gives the correlation coefficients between the scores of the four sub-scales and the **MAS**. It is of interest to note that when interpreting the scores of the **Male Domain** a high score must be interpreted as negative attitude towards mathematics (Sherman, 1980; Tartre and Fennema, 1995; Forgasz and Leder, 1996 and Norton and Rennie, 1998). Thus, in order to make the expected positive contribution to the **MAS** it was necessary to reverse the **Male Domain** sub-scale scores.

In general, the correlations between the sub-scales were small but most of them reached statistical significance at $p<0.01$. The exceptions were found in the correlations involving **Male Domain** and **Usefulness** sub-scales and, **Male Domain** and **Confidence**. These results were consistent by gender.

Table 4.3.2: Correlation coefficients between the Mathematics Attitude Scale (MAS) and Sub-scales for ***boys*** *(below diagonal)* and ***girls*** *(above the diagonal)*

	Confidence	Usefulness	Teacher Att	M.Domain	MAS
Confidence		0.235[a]	0.219[a]	- 0.086	0.551[a]
Usefulness	0.195[a]		0.203[a]	- 0.066	0.611[a]
Teacher Att	0.251[a]	0.273[a]		- 0.117[a]	0.620[a]
M.Domain	- 0.098	- 0.025	- 0.157[a]		0.392[a]
MAS	0.560[a]	0.602[a]	0.572[a]	0.453[a]	

a) $p < 0.01$

The relatively low correlation between the sub-scales is reflective of the Factor Analysis results. The relatively high correlation between the MAS and each of the sub-scale exists because the **MAS** is a linear combination of the sub-scales. Here, the highest correlation in absolute size was 0.620 for girls and 0.602 for boys, both between the **Usefulness** sub-scale and the **MAS**.

The largest correlation found between the sub-scales was 0.273 involving the **Teacher Attitude** and the **Usefulness** sub-scales for boys and 0.235 between **Confidence** and **Usefulness** for girls. The correlation coefficients were similar for both boys and girls. The **Male Domain** sub-scale correlated negatively with the remaining sub-scales indicating that a high score on this sub-scale implied a low score on the others.

4.3.3 Gender Differences in Attitude Towards Mathematics

In establishing whether statistically significant effects existed on pupils' attitude towards mathematics a four-way ANOVA was performed with gender, age group, grade and school type as the independent variables. In Table 4.3.3 a summary of the Four- way ANOVA's is provided.

Table 4.3.3: Four-way ANOVA: Mathematics Attitude Scale and Sub-scales scores by gender, age group, grade and school type

	df	MAS	Confid	MDom	Teacher Att	Usef
		F	F	F	F	F
Gender	1:1205	12.637[b]	6.685	14.160[b]	2.554	0.377
Age	1:1205	0.284	0.967	0.112	1.211	1.680
Grade	1:1205	1.347	0.926	0.144	0.043	1.203
School	1:1205	1.473	22.792[b]	3.216	6.411	1.027
Gender x Age	1:1205	1.844	0.289	6.290	1.174	0.478
Gender x Grade	1:1205	0.191	0.097	0.219	0.243	0.846
Gender x School	1:1205	2.420	7.268[a]	0.041	0.142	1.668
Age x Grade	1:1205	0.264	2.116	0.065	1.830	1.053
Age x School	1:1205	1.861	5.374	0.019	0.243	0.103
Grade x School	1:1205	1.445	0.118	0.221	0.003	3.268
Gender x Age x Grade	1:1205	0.339	5.801	1.244	0.535	0.067
Gender x Age x School	1:1205	1.613	1.206	1.145	0.001	0.383
Gender x Grade x School	1:1205	0.784	0.239	2.166	0.071	0.876
Age x Grade x School	1:1205	1.339	0.160	1.387	0.009	0.529
Gender x Age x Grade x School	1:1205	0.181	1.587	0.273	0.031	1.642

a) $p<0.01$; b) $p<0.001$

As can be seen, a significant main effect of gender was found for the MAS ($F_{1:1205}$=12.637; $p<0.001$) and the **Male Domain** sub-scale ($F_{1:1205}$=14.160; $p<0.001$). The others significant results noted were the main effect of school type ($F_{1:1205}$=22.792; $p<0.001$) and the interaction between gender and school type ($F_{1:1205}$=7.286; $p<0.01$), on **Confidence**. There were no significant main effects or interactions of the independent variables on the ratings of the **Teacher Attitude** and **Usefulness** sub-scales.

4.3.3.1 General Pupils' Attitude

In an attempt to identify possible gender differences in attitudes toward mathematics, means, standard deviations and the t-student values of the 43 items which remained, as constituting the MAS, after the factor analysis by gender, grade, school type and age group are presented in Table 4.3.4. Because of the different number of items in each sub-scale, standardised mean item scores are reported. Each mean therefore, has a range of 1 through 5.

In general, the analysis revealed that there were statistically significant differences between the patterns of attitudes toward mathematics expressed by boy and girl pupils in which boys were found to be rating their attitude more positively than girls ($t_{1:1220}$=6.889; $p<0.001$). It was also found that in both grades (9 and 10), boys rated their attitude towards mathematics significantly higher than did girls (grade 9: t_{636} = 4.608; $p<0.001$; grade 10: t_{583} = 5.273; $p<0.001$).

Table 4.3.4: Means, standard deviations and the t-values of MAS rating' scores by gender, school type, grade and age group

			Boys		Girls		
			Mean	SD	Mean	SD	*t*
State	Grade 9	Younger	3.49	0.43	3.30	0.37	2.945[a]
		Older	3.41	0.43	3.29	0.36	2.934[a]
		Total	3.43	0.43	3.29	0.36	4.045[b]
	Grade 10	Younger	3.45	0.41	3.30	0.32	1.682
		Older	3.48	0.41	3.26	0.43	5.206[b]
		Total	3.48	0.41	3.27	0.41	5.477[b]
	All	Younger	3.48	0.42	3.30	0.35	3.413[a]
		Older	3.44	0.42	3.27	0.40	5.835[b]
		Total	3.45	0.42	3.28	0.39	6.735[b]
Non-State	Grade 9	Younger	3.41	0.45	3.21	0.29	2.591
		Older	3.44	0.46	3.42	0.44	0.114
		Total	3.42	0.45	3.26	0.34	2.252
	Grade 10	Younger	3.34	0.38	3.23	0.29	0.987
		Older	3.27	0.27	3.33	0.29	-0.861
		Total	3.29	0.30	3.28	0.29	0.094
	All	Younger	3.40	0.43	3.22	0.29	2.920[a]
		Older	3.33	0.36	3.35	0.34	-0.314
		Total	3.37	0.40	3.27	0.31	2.098
Total	Grade 9	Younger	3.46	0.44	3.27	0.34	3.798[b]
		Older	3.41	0.43	3.30	0.36	2.897[a]
		Total	3.43	0.43	3.28	0.36	4.608[b]
	Grade 10	Younger	3.42	0.40	3.27	0.30	2.214
		Older	3.45	0.40	3.27	0.41	4.744[b]
		Total	3.44	0.40	3.27	0.39	5.273[b]
	All	Younger	3.45	0.43	3.27	0.33	4.489[b]
		Older	3.43	0.42	3.28	0.39	5.471[b]
		Total	3.44	0.42	3.28	0.37	6.889[b]

a) $p<0.01$; b) $p<0.001$

A similar result was found in the state schools ($t_{986} = 6.735$; $p<0.001$) and it was also consistent when the comparison was done within grade level (grade 9: $t_{513}=4.045$; $p<0.001$; grade 10: $t_{472}=5.477$; $p<0.001$). However in the non-state schools, the MAS did not disclose any statistically significant gender difference.

Analysing the sample by age group, it was found that boys rated their attitude significantly higher than did girls in both age groups (younger: $t_{343}=4.489$; $p<0.001$; older: $t_{876}=5.471$; $p<0.001$). Within grade 9, these gender differences were more evident in the younger age group ($t_{236}=3.798$; $p<0.001$) although a statistically significant gender difference favouring boys was also noted in the older age group ($t_{399}=2.897$; $p<0.01$). In grade 10, the differences were statistically significant only for the older pupils ($t_{476}=4.744$; $p<0.01$).

The picture in the state schools indicated that only the younger pupils of the tenth grade did not show a statistically significant difference between the boys' and the girls' groups while in the non-state schools the opposite was seen. Here, the only statistically significant gender-related differences favouring boys, was found within the younger pupils ($t_{136}=2.920$; $p<0.01$).

Previous research using the **MAS** suggested further analyses to investigate the magnitude of possible gender differences among the sub-scales. These analyses are then presented in Sections 4.3.3.2 to 4.3.3.5.

4.3.3.2 Perceived Confidence in Learning Mathematics

A total of 11 items constituted the **Confidence** sub-scale which purported to measure pupils' confidence in their ability to learn and to perform well on mathematics tasks. The pupils mean ratings scores are displayed in Table 4.3.5 with respect to gender, grade, school and age groups. The pair-wise differences on gender indicated that in general boys (3.49) were shown to be more confident in working in mathematics than girls (3.22). This difference was found to be statistically significant ($t_{1220} = 7.185$; $p<0.001$).

In both grades, 9 and 10, boys were shown to have higher **Confidence** scores than did the girls ($t_{636} = 4.207$; $p<0.001$ in grade 9 and $t_{583} = 6.113$; $p<0.001$ in grade 10). A similar result was found for pupils in the state schools where girls (3.25) expressed a significantly lower level of **Confidence** than boys (3.56) in their mathematical abilities, and this difference was statistically significant ($t_{986}=7.408$; $p<0.001$). In both grades of the state schools boys rated their **Confidence** significantly higher than did girls ($t_{513}=4.505$; $p<0.001$ in grade 9 and $t_{472}=6.169$ in grade 10). On the other hand, in the non-state schools boys and girls rated their **Confidence** in learning mathematics similarly.

When the data were analysed for gender-age differences, in general there were significant differences between the scores of boys and girls of both age groups (Younger: $t_{343}=3.120$; $p<0.01$ and Older: $t_{876}=6.523$; $p<0.001$).

Table 4.3.5: Means, standard deviations and the t-values of the Confidence sub-scale by gender, school type, grade and age group

			Boys		Girls		
			Mean	*SD*	*Mean*	*SD*	*t*
State	**Grade 9**	**Younger**	3.61	0.91	3.29	0.66	2.481
		Older	3.57	0.81	3.31	0.50	3.760[b]
		Total	3.58	0.84	3.30	0.55	4.505[b]
	Grade 10	**Younger**	3.57	0.56	3.39	0.57	1.223
		Older	3.53	0.60	3.17	0.58	6.161[b]
		Total	3.54	0.60	3.20	0.58	6.169[b]
	All	**Younger**	3.60	0.82	3.32	0.63	2.769[a]
		Older	3.55	0.71	3.23	0.55	6.981[b]
		Total	3.56	0.74	3.25	0.57	7.408[b]
Non-State	**Grade 9**	**Younger**	3.19	0.54	2.96	0.49	2.169
		Older	3.18	0.56	3.51	0.53	-1.704
		Total	3.19	0.54	3.09	0.55	1.015
	Grade 10	**Younger**	3.07	0.32	3.14	0.41	-0.525
		Older	3.25	0.46	3.11	0.64	1.037
		Total	3.20	0.43	3.12	0.53	0.814
	All	**Younger**	3.17	0.51	3.04	0.46	1.567
		Older	3.23	0.49	3.22	0.63	0.024
		Total	3.19	0.50	3.11	0.54	1.266
Total	**Grade 9**	**Younger**	3.44	0.80	3.17	0.62	2.821[a]
		Older	3.53	0.80	3.32	0.50	3.165[a]
		Total	3.49	0.80	3.27	0.55	4.207[b]
	Grade 10	**Younger**	3.41	0.55	3.26	0.51	1.401
		Older	3.49	0.59	3.16	0.59	6.052[b]
		Total	3.48	0.59	3.18	0.57	6.113[b]
	All	**Younger**	3.43	0.74	3.21	0.59	3.120[a]
		Older	3.51	0.70	3.23	0.56	6.523[b]
		Total	3.49	0.71	3.22	0.57	7.185[b]

a) $p<0.01$; b) $p<0.001$

Even when the sample was compared within grade level, the gender differences still favoured the boys in both the younger and older age groups in grade 9 significantly (younger age group: t_{236} = 2.821; $p<0.01$ and older age group (t_{399}=3.165; $p<0.01$). While in grade 10 only the gender differences favouring boys in the older age group, were found to be statistically significant (t_{476}=6.052; $p<0.001$). The state school pupils showed a significant gender difference in mathematics **Confidence** within the age group. Here, this difference was in favour of boys in both the younger pupils (t_{216}=2.769; $p<0.01$), and the older pupils (t_{779}=6.981; $p<0.001$). In both grades significant gender differences were also found between the means of the older pupils (grade 9: t_{367}=3.760; $p<0.001$ and grade 10: t_{411}=6.161; $p<0.001$). None of the mean differences in the non-state school pupils displayed statistically significant differences based on gender.

4.3.3.3 Perceptions of Mathematics as a Male Domain

In an attempt to measure the degree to which pupils see mathematics as a **Male Domain** or gender neutral, a sub-scale comprising 11 items' of the Fennema-Sherman **Male Domain** sub-scale was used. As mentioned (Section 4.3.2.3 page 104) the **Male Domain** sub-scale scores have been reversed so that a low score implies that mathematics was more stereotyped as a **Male Domain** and thus, a high score indicates less stereotyping or gender neutral. Thus, Table 4.3.6 presents the means and standard deviations of the pupils' scores by gender, school type, grade and age group.

Table 4.3.6: Means, standard deviations and the t-values of the Male Domain Sub-scale by gender, school type, grade and age group

			Boys		Girls		
			Mean	*SD*	*Mean*	*SD*	*t*
State	Grade 9	Younger	2.08	0.98	1.84	0.75	1.638
		Older	1.96	0.91	1.85	0.79	1.249
		Total	2.00	0.93	1.85	0.78	1.932
	Grade 10	Younger	2.18	0.97	1.62	0.45	3.006[a]
		Older	2.11	0.98	1.85	0.83	2.891[a]
		Total	2.12	0.98	1.82	0.80	3.645[b]
	All	Younger	2.11	0.97	1.78	0.68	2.872[a]
		Older	2.04	0.95	1.85	0.81	2.976[a]
		Total	2.05	0.95	1.84	0.79	3.929[b]
Non-State	Grade 9	Younger	2.02	1.06	1.52	0.43	2.950[a]
		Older	2.02	1.05	1.80	0.90	0.616
		Total	2.02	1.05	1.58	0.58	2.808[a]
	Grade 10	Younger	2.08	1.13	1.54	0.65	1.998
		Older	1.63	0.75	1.85	0.79	-1.144
		Total	1.75	0.87	1.69	0.74	0.374
	All	Younger	2.03	1.06	1.53	0.54	3.649[b]
		Older	1.77	0.88	1.83	0.81	-0.350
		Total	1.91	0.99	1.64	0.67	2.485
Total	Grade 9	Younger	2.05	1.01	1.73	0.67	2.945[a]
		Older	1.97	0.92	1.85	0.80	1.391
		Total	2.00	0.95	1.80	0.75	2.887[a]
	Grade 10	Younger	2.15	1.01	1.58	0.56	3.758[b]
		Older	2.04	0.97	1.85	0.83	2.452
		Total	2.06	0.97	1.80	0.79	3.596[b]
	All	Younger	2.08	1.01	1.68	0.64	4.515[b]
		Older	2.01	0.94	1.85	0.81	2.641[a]
		Total	2.03	0.96	1.80	0.77	4.567[b]

a) $p<0.01$; b) $p<0.001$

The pair-wise differences on gender yielded that overall boys scored higher than did girls and this difference between boys and girls was statistically significant (t_{1220}=4.567; $p<0.001$). It was also consistent in both grades (9 and 10) where boys also scored significantly higher than did girls (grade 9: t_{636}=2.887; $p<0.01$ and grade 10: t_{583}=3.596; $p<0.001$).

Further pair-wise differences on gender yielded that in general, when considering the school type the boys were still found to have higher scores than the girls, particularly in the state schools (t_{986}=3.929; $p<0.001$). However, when grade levels were taken into account within each school type, the differences favouring boys were found to be statistically significant only in grade 10 of the state schools (t_{472}=3.645; $p<0.001$) and in grade 9 of the non-state schools (t_{122}=2.808; $p<0.01$).

In addition, when the age group was accounted for in the gender comparison, it was found that overall, in both age groups, boys also scored significantly higher than did the girls (t_{343}=4.515; $p<0.001$ for the younger group and t_{876}=2.641; $p<0.01$ for the older group), confirming that girls more than boys stereotyped mathematics as a **Male Domain**. However, only within the younger age groups of the two grades were the gender-based differences statistically significant (t_{236}=2.945; $p<0.01$ in grade 9 and t_{106}=3.758; $p<0.001$ in grade 10). This situation was also evident when the comparison was done by school type, with statistical significance particularly in the state schools for both age groups (younger age group: t_{216}=2.872; $p<0.01$; older age group: t_{779}=2.976; $p<0.01$).

Similar results were found in grade 10 where boys also rated their perceptions of mathematics as a **Male Domain** significantly higher than did girls in both age groups, (Younger: t_{70}=3.006; $p<0.01$ and Older: t_{411}=2.891; $p<0.01$). In non-state schools, only within the younger age group was a statistically significant difference found in favour of boys (t_{136}=3.649; $p<0.001$) and it was consistent across the two grades. Only the younger pupils of grade 9 showed statistical significance in the difference between boys and girls, (t_{100}=2.950; $p<0.01$). It means that, in this sub-scale, the girls' group, had low scores compared with their counterpart boys meaning that girls were more convinced that mathematics is a **Male Domain** than were boys.

4.3.3.4 Perceived Mathematics Teacher Attitude

Table 4.3.7 gives the mean and standard deviation of the data obtained by using the scores of the 9 items which comprised the **Teacher Attitude** sub-scale that measures the pupils' perception of how their teachers feel about them as learners of mathematics. The analysis of the results of the mean scores comparison on the **Teacher Attitude** sub-scale showed in general, gender related differences. Indeed, boys more than girls rated their perception, on how their mathematics teachers feel about them as learners of mathematics, significantly more positively than girls (t_{1220}=3.063; $p<0.01$).

Table 4.3.7: Means, standard deviations and the t-values of the Teacher Attitude Sub-scale by gender, school type, grade and age group

			Boys		Girls		
			Mean	*SD*	*Mean*	*SD*	*t*
State	**Grade 9**	**Younger**	4.01	0.78	3.89	0.81	0.887
		Older	3.96	0.81	3.82	0.76	1.666
		Total	3.97	0.80	3.84	0.77	1.878
	Grade 10	**Younger**	3.80	0.72	3.89	0.73	-0.512
		Older	4.05	0.72	3.90	0.80	2.031
		Total	4.02	0.73	3.90	0.79	1.750
	All	**Younger**	3.95	0.76	3.89	0.78	0.523
		Older	4.01	0.77	3.86	0.78	2.599
		Total	4.00	0.77	3.87	0.78	2.555
Non-State	**Grade 9**	**Younger**	4.13	0.68	4.02	0.66	0.750
		Older	4.19	0.56	4.01	0.72	0.783
		Total	4.14	0.65	4.02	0.67	1.055
	Grade 10	**Younger**	3.98	0.74	3.97	0.73	0.020
		Older	4.27	0.55	4.05	0.42	1.834
		Total	4.19	0.61	4.01	0.59	1.527
	All	**Younger**	4.10	0.69	4.00	0.69	0.820
		Older	4.24	0.55	4.04	0.51	1.853
		Total	4.16	0.63	4.02	0.63	1.786
Total	**Grade 9**	**Younger**	4.06	0.74	3.93	0.76	1.251
		Older	3.98	0.79	3.84	0.76	1.901
		Total	4.01	0.77	3.87	0.76	2.285
	Grade 10	**Younger**	3.85	0.72	3.93	0.73	-0.546
		Older	4.09	0.70	3.92	0.77	2.452
		Total	4.05	0.71	3.92	0.76	2.095
	All	**Younger**	4.01	0.74	3.93	0.75	0.889
		Older	4.04	0.75	3.88	0.76	3.052[a]
		Total	4.03	0.74	3.90	0.76	3.063[a]

a) $p<0.01$; b) $p<0.001$

This was also evident when this comparison was done within the older group pupils, where boys were also found to exceed the girls on the perception of the **Teacher Attitude** sub-scale with the difference being statistically significant at $p<0.01$, ($t_{876}=3.052$). However, when the sample was aggregated by school type, an interesting result was found. No statistically significant difference was yielded by any of these gender pair-wise comparisons in both types of schools.

4.3.3.5 Perceived Mathematics' Usefulness

The measure of the degree of the **Usefulness** of mathematics considering its application in daily life was done using a sub-scale comprising 12 items out of the 43 items of the **MAS** (see Section 4.3.2.1, page 102). The means and standard deviation for the **Usefulness** sub-scale is given in Table 4.3.8.

In general, the Mozambican lower secondary school pupils, to a great extent, rated the **Usefulness** of mathematics, as being important, as the average rating values were more than 4 on the 5-point-rating-scale for boys as well as for girls.

A further examination of the gender pair-wise differences showed that boys and girls rated mathematics **Usefulness** equally across the different school types, grade levels and age groups. Though, it was in this sub-scale that girls' ratings surpassed in various cases the scores of boys but this was not significant. This was particularly evident in the non-state schools, yet none of these differences were statistically significant.

Table 4.3.8: Means, standard deviations and the t-values of the **Usefulness** Sub-scale by gender, school type, grade and age group

			Boys		Girls		
			Mean	*SD*	*Mean*	*SD*	*t*
State	**Grade 9**	**Younger**	4.28	0.63	4.17	0.59	1.016
		Older	4.14	0.74	4.16	0.68	-0.341
		Total	4.17	0.71	4.16	0.66	0.173
	Grade 10	**Younger**	4.28	0.52	4.29	0.45	-0.121
		Older	4.22	0.61	4.12	0.78	1.358
		Total	4.23	0.60	4.15	0.75	1.270
	All	**Younger**	4.28	0.60	4.21	0.55	0.839
		Older	4.18	0.67	4.14	0.74	0.751
		Total	4.20	0.66	4.16	0.70	1.004
Non-State	**Grade 9**	**Younger**	4.32	0.85	4.34	0.66	-0.102
		Older	4.38	0.88	4.37	0.53	0.040
		Total	4.34	0.85	4.34	0.63	-0.054
	Grade 10	**Younger**	4.23	0.46	4.29	0.42	-0.356
		Older	3.91	0.78	4.30	0.61	-2.410
		Total	4.00	0.72	4.29	0.52	-2.501
	All	**Younger**	4.30	0.78	4.32	0.57	-0.100
		Older	4.09	0.84	4.32	0.58	-1.576
		Total	4.20	0.81	4.32	0.57	-1.231
Total	**Grade 9**	**Younger**	4.30	0.73	4.23	0.62	0.733
		Older	4.16	0.75	4.17	0.67	-0.198
		Total	4.21	0.74	4.19	0.65	0.286
	Grade 10	**Younger**	4.26	0.49	4.29	0.43	-0.280
		Older	4.17	0.64	4.15	0.76	0.436
		Total	4.19	0.62	4.18	0.71	0.214
	All	**Younger**	4.29	0.67	4.25	0.56	0.530
		Older	4.17	0.70	4.16	0.72	0.191
		Total	4.20	0.69	4.19	0.68	0.377

a) $p<0.01$; b) $p<0.001$

4.4 PATTERNS OF CLASSROOM INTERACTIONS

4.4.1 Introduction to Classroom Interactions

In this part of the study, it was intended to find out the possible gender patterns in the classroom interactions between the pupils and their mathematics teacher. Thus, as referred to in Section 3.3.2, (pages 78-79), a grid was developed by the researcher covering the most usual interactions that occur during a mathematics lesson in Mozambique which would be judged to involve individual pupil or the whole class.

A total of 344 lessons each of about 45 minutes were observed in May-June and August-September 1999, during the school year. The classroom interactions made distinction between **Public** and **Private** interactions, **Modes of Initiation** of the interactions (teacher-initiated or pupil-initiated), **Modes of Teacher-Questioning** (nomination or selecting a volunteer), **Quality of Pupil Answers** and **Quality of the Teacher Feedback**.

As described in Section 3.3.2 (page 79), the **Public** interactions are those with the mathematics teacher working with individual pupils during lessons, with the rest of the class as spectators, while the **Private** interactions included the types of interactions involving the mathematics teacher and a specific pupil with no involvement of any other pupil.

4.4.2 Sample for Classroom Observations

The observational study involved 672 lower secondary pupils distributed in 18 different classes of grades 9 and 10 of the two state and two non-state schools in Maputo City, and their mathematics teachers. In Table 4.4.1 the distribution of pupils that were involved in the classroom observation by gender, grade and school type is displayed. FromTable 4.4.1, it can be seen that among the number of pupils involved, 287 (42.7%) were boys while 385 (57.3%) were girls.

Table 4.4.1: Number of pupils in the observed mathematics classes by school type, grade and gender

Schools	**State**		**Non-State**		**Total**		
Grade	**Boy**	**Girl**	**Boy**	**Girl**	**Boy**	**Girl**	**Total**
9	118	**149**	40	**41**	158	**190**	348
10	101	**152**	28	**43**	129	**195**	324
Total	219	**301**	68	**84**	287	**385**	672

As mentioned in Section 3.4.2 (page 84), in order to evaluate the possible relationship between pupils' mathematics performance, pupils' attitudes toward mathematics and the patterns of classroom interactions, the pupils interacting individually with their teacher had their identification recorded in the second period of the observational schedule (August-September 1999).

4.4.3 Patterns of Classroom Interactions based on Gender

In the four schools (2 state and 2 non-state) a total of 3864 interactions were recorded in the 344 observed lessons. However, within the total number of interactions recorded, 17.8% (687) involved the mathematics teacher interacting with the class as a whole and thus, only the remaining 3177 interactions were analysed for possible gender differences in the classroom interactions.

4.4.3.1 Types of Interactions

Frequencies and mean number of teacher-individual pupil interactions are summarised in Table 4.4.2 by the gender of the pupils, the grade level and the school type. First of all, these interactions could be categorised as **Public** or **Private** interactions (see Section 3.3.2.1, pages 78-79). The **Public** interactions were then split by the content involved in the interaction, (mathematics content or non-mathematics content), while in the case of **Private** interactions it was impossible and not ethical to ascertain whether they involved mathematics content or not.

Here and more generally, the mean number of interactions was obtained by dividing the total number of teacher-pupil interactions in each gender-group by the total number of pupils of each group (boys or girls).

Table **4.4.2**: Frequencies and mean number of interactions by type, gender, school type and grade

	Grade 9					Grade 10				
	Boy (118)		Girl (149)		X_1^2	Boy (101)		Girl (152)		X_1^2
State School	b_i	b_i/b	g_i	g_i/g		b_i	b_i/b	g_i	g_i/g	
Public	336	2.85	279	1.87	*27.176*[b]	407	4.03	444	2.92	*22.173*[b]
Math Cont	281	2.38	220	1.48	*28.733*[b]	385	3.81	424	2.79	*19.836*[b]
Non Math Cont	55	0.47	59	0.40	*0.758*	22	0.22	20	0.13	*2.719*
Private	5	0.04	8	0.05	*0.173*	55	0.55	115	2.21	*4.060*
TOTAL	341	2.89	287	1.92	-	462	4.57	559	3.68	-
Non-State School	Boy (40)		Girl (41)		X_1^2	Boy (28)		Girl (43)		X_1^2
	b_i	b_i/b	g_i	g_i/g		b_i	b_i/b	g_i	g_i/g	
Public	211	5.28	194	4.73	*1.195*	168	6.00	253	5.88	*0.039*
Math Cont	194	4.85	185	4.51	*0.494*	146	5.21	220	5.12	*0.032*
Non Math Cont	17	0.43	9	0.22	*2.663*	22	0.79	33	0.77	*0.007*
Private	68	1.70	82	2.00	*0.984*	151	5.39	401	9.33	*33.735*[b]
TOTAL	279	6.97	276	6.73	-	319	11.39	654	15.21	-
ALL	Boy (158)		Girl (190)		X_1^2	Boy (129)		Girl (195)		X_1^2
	b_i	b_i/b	g_i	g_i/g		b_i	b_i/b	g_i	g_i/g	
Public	547	3.46	473	2.49	*27.838*[b]	575	4.46	697	3.57	*15.419*[b]
Math Cont	475	3.01	405	2.13	*26.103*[b]	531	4.12	644	3.30	*14.175*[b]
Non Math Cont	72	0.46	68	0.38	*2.051*	44	0.34	53	0.27	*1.245*
Private	73	0.46	90	0.47	*0.025*	206	1.60	516	2.65	*38.357*[b]
TOTAL	620	3.92	563	2.96	-	781	6.05	1213	6.22	-

Math Cont=Mathematics Content's Interaction; ***Non Math Cont***=Non-mathematics content's interaction; b_i=Number of boys' interactions; g_i = Number of girls' interactions; b=Number of boys; g=Number of girls.
a) $p<0.01$; b) $p<0.001$

In general, in grade 9, boys could expect to interact more frequently with their mathematics teacher ($b_i/b=3.5$), in **Public**, than girls ($g_i/g=2.5$) and the differences were found to be statistically significant ($X_1^2=27.838$; $p<0.001$). Similarly in grade 10, boys reached a higher frequency of interactions of $b_i/b=4.5$ than girls who had on average $g_i/g=3.6$ and the chi-square value yielded a statistical significance at $p<0.001$ ($X_1^2= 15.419$).

In comparing the classroom interactions involving teacher and pupils in each school type it was found that frequencies of gender interactions with the teacher were different in the two school types. These differences in frequencies were larger in state schools than the non-state schools. Within the state schools, pupils' group, in grade 9, boys on average ($b_i/b=2.9$) had significantly more **Public** interactions with the mathematics teacher than had girls $g_i/g=1.9$). In grade 10 the results were consistent with the boys having a greater average frequency ($b_i/b=4.0$), whereas the girls average frequency was lower ($g_i/g=2.9$). All these differences were found to be highly significant (grade 9: $X_1^2=27.176$; $p<0.001$ and grade 10: $X_1^2=22.173$; $p<0.001$). However, in non-state schools, boys and girls had similar frequencies of the **Public** interactions.

In the expectation of interacting with their mathematics teacher on mathematics content in grade 9, it was also seen to the boys' advantage ($b_i/b=3.0$) compared to the girls ($g_i/g=2.1$), and this difference in frequency was statistically significant ($X_1^2=$ 26.103; $p< 0.001$). In grade 10, the mathematics content interactions could be expected to occur involving mostly the mathematics teacher and the boy pupils

(b_i/b=4.1) when compared with the mathematics teacher and the girl pupils (g_i/g=3.3). This difference was also found to be statistically significant (X_1^2= 14.175; p< 0.001).

In grade 9 of the state schools there was a significant gender difference in favour of boys (b_i/b=2.4) compared to the girls (g_i/g=1.5) in **Public** interactions covering mathematics content (X_1^2=28.733; p<0.001). Meanwhile, in non-state schools boys and girls were found to interact similarly with their mathematics teachers in all the considered types of interactions.

Gender-based difference in interacting with the mathematics teacher was also seen in grade 10. In state schools boys (b_i/b=3.8) had significantly more chance to have mathematics content interactions (X_1^2=19.836; p<0.001) than had girls (g_i/g=2.8). While in non-state schools the girls' advantage (g_i/g=9.3) was seen in receiving significantly more of the **Private** interactions (X_1^2=33.735; p<0.001) than boys (b_i/b=5.4).

On the other hand, in grade 10 the **Private** interactions differentiate between teacher-boy and teacher-girl interactions. Within this type of interaction it was found that girls (g_i/g=2.6) could be expected to interact much more with their mathematics teacher than boys (b_i/b=1.6), yielding a X_1^2= 38.357, with a statistical significance of p< 0.001.

4.4.3.2 Modes of Initiation of the Mathematics-Content Interactions

The mathematics content interactions were further subdivided in 2 categories according to the modes of initiation, whether the interchange was **teacher**-initiated or **pupil**-initiated. In Table 4.4.3 the frequencies and the mean numbers of these interactions considering pupils' gender, grade and school type is displayed.

Table 4.4.3: Frequencies and mean number of the mathematics content interactions by Modes of Initiation, gender, school type and grade

		Grade 9					Grade 10				
State Schools		Boy(118)		Girl(149)		X_1^2	Boy(101)		Girl(152)		X_1^2
		b_i	b_i/b	g_i	g_i/g		b_i	b_i/b	g_i	g_i/g	
	T-I	264	2.2	203	1.4	*28.816*[b]	359	3.6	404	2.6	*16.173*[b]
	P-I	17	0.1	17	0.1	*0.465*	26	0.3	20	0.1	*5.286*
	Total	281	2.4	220	1.5	-	385	3.8	424	2.8	-
Non-State Schools		Boy(40)		Girl(41)		X_1^2	Boy(28)		Girl(43)		X_1^2
		b_i	b_i/b	g_i	g_i/g		b_i	b_i/b	g_i	g_i/g	
	T-I	168	4.2	143	3.5	*2.675*	134	4.8	168	3.9	*3.078*
	P-I	26	0.7	42	1.0	*3.381*	12	0.4	52	1.2	*11.467*[a]
	Total	194	4.9	185	4.5	-	146	5.2	220	5.1	-
All		Boy(158)		Girl(190)		X_1^2	Boy(129)		Girl(195)		X_1^2
		b_i	b_i/b	g_i	g_i/g		b_i	b_i/b	g_i	g_i/g	
	T-I	432	2.7	346	1.8	*32.173*[b]	493	3.8	572	2.9	*18.641*[b]
	P-I	43	0.3	59	0.3	*0.433*	38	0.3	72	0.4	*1.275*
	Total	475	3.0	405	2.1	-	531	4.1	644	3.3	-

T-I= Teacher Initiated; **P-I**=Pupil Initiated; $\mathbf{b_i}$ =Number of boys' interactions; $\mathbf{g_i}$ = Number of girls' interactions; **b**=Number of boys; **g**=Number of girls.

a) $p<0.01$; b) $p<0.001$

As can be seen, from the total number of these types of interactions 90% (1843) were initiated by the mathematics teacher and only 10% (212) were initiated by the pupils.

Indeed, taking into account the grade level, the teacher-initiated interactions were consistent over the grades, being more often addressed to the boys than to the girls. In grade 9, of the 778 teacher-initiated interactions 55% (432) involved boys against the other 45% (346) that involved girls. In this regard boys ($b_i/b=2.7$) were expected to have more of the teacher-initiated interactions than girls were ($g_i/g=1.8$). The Chi-squared test showed that the proportions between boys and girls in the teacher initiating the interaction with their pupils were significantly different ($X_1^2 = 32.173$; $p<0.001$).

In grade 10, on average, boys ($b_i/b=3.8$) could also expected to be involved in teacher-initiated interactions much more than girls ($g_i/g=2.9$). This picture is similar to that found in state schools. Teachers initiated a greater proportion of interactions in their mathematics lessons with boy pupils than with girl pupils, and it was also consistent when considering both grades (grade 9: $X_1^2=28.816$; $p<0.001$ and grade 10: $X_1^2=16.173$; $p<0.001$).

However, in non-state schools gender differences displayed in the frequencies and mean numbers of the teacher-initiated interactions did not disclose statistical significance in either grade. Meanwhile, in most cases the interactions initiated by the pupils consisted by means of questions and the observational data show that in general girls and boys had similar frequencies of teacher interactions. In both grades, (9 and 10) boys and girls were found to have similar proportion in initiating interactions with their mathematics teacher.

Even when considering the school type, boys and girls were still showing similar frequencies in initiating this type of classroom interactions in the state schools. In non-state schools, a significant difference was found in grade 10, where there were more interactions initiated by girls ($g_i/g=1.2$) than boys ($b_i/b=0.4$), showing that the girls were dominant in this domain ($X_1^2=11.467$; $p<0.01$).

4.4.3.3 Modes of Teacher Questioning

During mathematics lessons, teacher-questioning modes could be classified into four categories covering different ways of initiating the interactions: by nominating a specific pupil or selecting a volunteer. The pupil involved in the interaction could answer verbally from the desk or could solve a problem on the board in writing and verbally (see Figure 3.3.1, page 80). The results of these teacher-questioning procedures are shown in Table 4.4.4.

From Table 4.4.4, it is evident that in general, boys received more pupils-addressed questions than did girls regardless of the mode of questioning. In grade 9, mathematics teachers have shown greater preference in nominating boys ($b_i/b=1.1$) than girls ($g_i/g=0.7$) to solve problems on the board ($X_1^2=14.403$; $p<0.001$).

Table 4.4.4: Frequencies and mean number of Interactions by Modes of Teacher's Questioning, gender, school type and grade

		Grade 9					Grade 10				
State Schools		Boy (118)		Girl (149)		X_1^2	Boy (101)		Girl (152)		X_1^2
		b_i	b_i/b	g_i	g_i/g		b_i	b_i/b	g_i	g_i/g	
	TNB	54	0.5	34	0.2	*10.578*[a]	80	0.8	86	0.6	*4.736*
	TND	29	0.3	45	0.3	*0.752*	88	0.9	105	0.7	*2.591*
	PVB	134	1.1	96	0.6	*18.451*[b]	124	1.2	148	1.0	*3.642*
	PVD	47	0.4	28	0.2	*10.376*[a]	67	0.7	65	0.4	*6.463*
Non-State Schools		Boy (40)		Girl (41)		X_1^2	Boy (28)		Girl (43)		X_1^2
		b_i	b_i/b	g_i	g_i/g		b_i	b_i/b	g_i	g_i/g	
	TNB	119	3.0	101	2.5	*1.951*	79	2.8	87	2.0	*4.621*
	TND	27	0.7	29	0.7	*0.031*	31	1.1	53	1.2	*0.225*
	PVB	14	0.4	11	0.3	*0.438*	9	0.3	13	0.3	*0.020*
	PVD	8	0.2	2	0.1	*3.750*	15	0.5	15	0.4	*1.402*
All		Boy (158)		Girl (190)		X_1^2	Boy (129)		Girl (195)		X_1^2
		b_i	b_i/b	g_i	g_i/g		b_i	b_i/b	g_i	g_i/g	
	TNB	173	1.1	135	0.7	*14.403*[b]	159	1.2	173	0.9	*9.038*[a]
	TND	56	0.4	74	0.4	*0.284*	119	0.9	158	0.8	*1.144*
	PVB	148	0.9	107	0.6	*16.427*[b]	133	1.0	161	0.8	*3.609*
	PVD	55	0.4	30	0.2	*12.777*[a]	82	0.6	80	0.4	*7.889*[a]

TNB= Teacher Nominated pupil to the **Board**; **TND**=Teacher Nominated pupil from the **Desk**; **PVB**=Pupil Volunteered to the **Board**; **PVD**=Pupil Volunteered from the Desk b_i =Number of boys' interactions; g_i=Number of girls' interactions; b=Number of boys; g=Number of girls.

a) $p<0.01$; b) $p<0.001$

Other statistically significant differences favouring boys were found in teacher selecting a pupil from those who volunteered to solve a problem on the board (X_1^2=16.427; p<0.001) or to answer from the desk (X_1^2=16.777; p<0.001). The only exception was the category of teacher nominating a specific pupil to answer at the desk, where boys and girls had similar proportions.

In grade 10, the difference in proportion in giving the answer from the desk by nomination or to solve a problem on the board by being selected from those who put up their hands was not statistically significant when comparing boys and girls. Though, in this grade, mathematics teachers on average nominated significantly more boys than girls to answer or to solve a mathematics problem on the board, (X_1^2=9.038; p<0.01), and also selected more volunteering boys to answer from the desk than girls (X_1^2=7.889; p<0.01).

When the comparisons were done within the grade level and school type a similar picture was seen with boys getting more attention only in grade 9 of the state schools. Here, in general, boys were found to be called-upon by their teachers to solve problems on the board, nearly two times more frequently than were the girls ($X_1^2 = 10.578$; p<0.01) and boys also volunteered answer to their teacher more than did girls on the board ($X_1^2 = 18.451$; p<0.001); and at their desks, ($X_1^2 = 10.376$; p<0.01). In grade 10 of both types of schools, there were no statistically significant gender-differences.

4.4.3.4 Patterns of Pupils Responses to Teacher's Questioning

The description of the Patterns of Pupil Answers (see Section 3.3.2, page 74) comprised 5 categories: (a) - no response, (b) - an inadequate answer (c) - the wrong answer, (d) – incomplete/partially correct answer, (e) – the correct answer. The frequencies and Chi-square values related to each category of pupils answer by gender, grade and school type are presented in Table 4.4.5.

Table 4.4.5: Frequencies and mean number of the Quality of Pupil Answer by gender, school type and grade

		Grade 9					Grade 10				
State Schools		Boy (118)		Girl (149)		X_1^2	Boy (101)		Girl (152)		X_1^2
		b_i	b_i/b	g_i	g_i/g		b_i	b_i/b	g_i	g_i/g	
	NA	2	0.02	7	0.1	*	7	0.1	8	0.1	*0.285*
	IA	10	0.1	6	0.04	*2.174*	17	0.2	15	0.1	*2.326*
	WA	77	0.7	36	0.24	*26.274*[b]	113	1.1	97	0.6	*16.889*[b]
	PCA	36	0.3	33	0.28	*1.781*	44	0.4	64	0.4	*0.030*
	CA	139	1.2	121	0.81	*9.052*[a]	178	1.8	220	1.5	*3.828*
Non-State Schools		Boy (40)		Girl (41)		X_1^2	Boy (28)		Girl (43)		X_1^2
		b_i	b_i/b	g_i	g_i/g		b_i	b_i/b	g_i	g_i/g	
	NA	1	0.03	2	0.1	*	1	0.04	3	0.1	*
	IA	3	0.1	0	0.0	*	6	0.2	3	0.1	*
	WA	25	0.6	19	0.5	*0.973*	25	0.9	32	0.7	*0.467*
	PCA	17	0.4	6	0.2	*5.537*	3	0.1	7	0.8	*
	CA	122	3.1	116	2.8	*0.336*	99	3.5	123	2.9	*2.473*
All		Boy (158)		Girl (190)		X_1^2	Boy (129)		Girl (195)		X_1^2
		b_i	b_i/b	g_i	g_i/g		b_i	b_i/b	g_i	g_i/g	
	NA	3	0.5	9	0.1	*2.015*	8	0.1	11	0.1	*0.042*
	IA	13	0.1	6	0.03	*4.061*	23	0.2	18	0.1	*4.061*
	WA	102	0.7	55	0.3	*24.246*[b]	138	1.1	129	0.7	*15.701*[b]
	PCA	53	0.3	39	0.2	*5.530*	47	0.4	71	0.4	*0.000*
	CA	261	1.7	237	1.3	*9.865*[a]	277	2.2	343	1.8	*6.118*

NA=No Answer; IA=Inadequate Answer; WA=Wrong Answer; PCA=Partially Correct Answer; CA=Correct Answer. a) $p < 0.01$; b) $p < 0.001$; *- Chi-squared is inappropriate.

A gender comparison of the frequency distribution of the quality of the pupils' answer taking into account the grade level, showed that in grade 9 boys proportionally gave more correct answers (X_1^2=9.865; $p<0.01$) as well as more wrong answers (X_1^2=24.246; $p<0.001$) than did girls, and they were asked proportionately more questions.

However, the gender difference found in grade 10 was only significant for the wrong answers given (X_1^2=15.701; p<0.001), where boys (b_i/b=1.1) reached a significantly higher proportion than did the girls (g_i/g=0.7).

Comparing within school type and grade level (see Table 4.4.5), boys consistently gave a higher proportion of wrong answers than did girls in both grades (9 and 10) of state-schools, and the Chi-square test showed that these differences were statistically significant at p<0.001 (grade 9: X_1^2 = 26.274 and grade 10: X_1^2 = 16.889).

However in the non-state schools there were no statistically significant gender differences in the frequencies of the patterns of pupils' answers to the teacher's questions. Although there was not an evident gender pattern of pupils' answers to the teacher's questions, it was found that girls proportionally more frequently did not give any answer (no response) than did boys in both grades, while boys tended to give proportionally more inadequate answers than occurred with girls.

4.4.3.5 Quality of Teacher's Feedback to Pupils' Answers

In Table 4.4.6 the summary of the frequencies and mean number of interactions considering the categories provided in the Observation schedule (see Figure 3.3.1, page 80), with reference to the teachers' feedback by gender, grade level and school type is presented. Thus, the following eight categories were then distinguished:

a) Teacher gave no reaction (NoR);

b) Teacher criticised the answer (TCri);

c) Teacher simply said wrong (SW);

d) Teacher simply said correct (SCor);

e) Teacher praised the answer (TPri);

f) Teacher gave the answer (TGA);

g) Teacher gave a clue (TGC); and,

h) Teacher repeated the question (TRQ).

The result of the quality of the teacher feedback to pupils' answers is presented in Table 4.4.6. In grade 9 the teacher was indifferent to the pupils' answer (did not give any feedback) more frequently to the boys (b_i/b=0.5) than it was to the girls (g_i/g=0.3). Similarly the teacher finished the interchange by giving the answer, proportionally more times to the boys (b_i/b=1.0) than to the girls (g_i/g=0.6). Both of these differences were statistically significant at $p<0.01$. The other statistically significant gender difference in this grade, and also favouring boys, was found when comparing the teachers' feedback in simply saying "correct", ($X_1^2 = 6.252; p<0.01$). Thus, from these results the teachers' reactions were in certain categories gender-related.

In grade 10, the simplest reaction of the mathematics teacher confirming the answer by saying "**Correct**" was found proportionally more frequently for boys who reached the higher proportion (b_i/b=1.7) compared to the girls (g_i/g=1.2). The Chi-square statistic indicated statistical significance (X_1^2=13.647; $p<0.001$).

Table 4.4.6: Frequencies and mean number of the Quality of Teacher Feedback by gender, school type and grade

		Grade 9					Grade 10				
State Schools		Boy (118)		Girl (149)		X_1^2	Boy (101)		Girl (152)		X_1^2
		b_i	bi/b	g_i	gi/g		b_i	bi/b	g_i	gi/g	
	TCri	17	0.14	13	0.09	*1.892*	18	0.18	23	0.15	*0.271*
	SW	4	0.03	4	0.03	*	22	0.22	14	0.09	*6.740*[a]
	NoR	65	0.55	45	0.30	*9.897*[a]	26	0.26	48	0.32	*0.707*
	SCor	78	0.66	72	0.48	*3.705*	142	1.41	145	0.95	*10.928*[a]
	TPr	9	0.08	9	0.06	*0.246*	18	0.18	33	0.22	*0.455*
	TGA	87	0.74	62	0.42	*12.173*[b]	127	1.26	120	0.79	*13.610*[b]
	TGC	8	0.07	6	0.04	*0.952*	6	0.06	7	0.05	*0.211*
	TRQ	13	0.11	9	0.06	*1.979*	26	0.25	34	0.22	*0.291*
Non-State Schools		Boy (40)		Girl (41)		X_1^2	Boy (28)		Girl (43)		X_1^2
		b_i	bi/b	g_i	gi/g		b_i	bi/b	g_i	gi/g	
	TCri	0	0.00	2	0.05	*	9	0.32	6	0.14	*2.656*
	SW	4	0.10	3	0.07	*	11	0.39	12	0.28	*0.678*
	NoR	19	0.48	19	0.46	*0.006*	20	0.71	38	0.88	*0.596*
	SCor	92	2.30	83	2.02	*0.712*	72	2.57	83	1.93	*3.194*
	TPr	11	0.28	14	0.35	*0.290*	7	0.25	6	0.14	*1.130*
	TGA	63	1.58	59	1.44	*0.249*	22	0.79	69	1.61	*8.873*[a]
	TGC	0	0.00	1	0.02	*	2	0.07	2	0.05	*
	TRQ	5	0.13	4	0.10	*0.137*	3	0.11	4	0.09	*
All		Boy (158)		Girl (190)		X_1^2	Boy (129)		Girl (195)		X_1^2
		b_i	bi/b	g_i	gi/g		b_i	bi/b	g_i	gi/g	
	TCri	17	0.11	15	0.08	*0.770*	27	0.21	29	0.14	*1.649*
	SW	8	0.05	7	0.04	*0.381*	33	0.26	26	0.13	*6.396*
	NoR	84	0.53	64	0.34	*7.697*[a]	46	0.36	86	0.44	*1.359*
	SCor	170	1.08	155	0.82	*6.252*[a]	214	1.66	228	1.17	*13.647*[b]
	TPr	20	0.13	23	0.12	*0.021*	25	0.19	39	0.20	*0.015*
	TGA	150	0.95	121	0.64	*10.820*[a]	149	1.16	189	0.97	*2.569*
	TGC	8	0.05	7	0.04	*0.381*	8	0.06	9	0.05	*0.372*
	TRQ	18	0.11	13	0.07	*2.005*	29	0.22	38	0.20	*0.336*

NoR= Teacher did not have reaction; **TCri**= Teacher criticised the answer; **SW**= Teacher simply said wrong; **SCor**= Teacher simply said correct; **TPr**= Teacher praised the answer; **TGA**= Teacher gave the answer; **TGC**= Teacher gave a clue; and, **TRQ**= Teacher repeated the question.

a) $p<0.01$; b) $p<0.001$; *- Chi-squared is inappropriate

In the state schools the gender-pattern was continued. In grade 9 the absence of teacher reaction as well as the teacher reaction of giving the answer, were gender-biased and reached statistical significance ("**No reaction**": X_1^2=9.897; p<0.01 and "**Gave** the answer": X_1^2=12.173; p<0.001). Gender differences in grade 10 were found in the teacher's reaction when saying "**Wrong** answer", (b_i/b=0.2 and g_i/g=0.1) and "**Correct** answer", (b_i/b=1.4 and g_i/g=1.0) and also when the teacher "**Gave** the answer", (b_i/b=1.3 and g_i/g=0.8).

In the non-state schools, the only significant gender pattern found was the teacher's feedback in giving the answer (X_1^2=8.873; p<0.01), where girls (g_i/g=1.6) received this type of feedback proportionally about two times more frequently than boys (b_i/b=0.8).

4.4.6 Quality of Pupils' Answers and the Teacher's Modes of Questioning

In an attempt to explore the possible pattern of the classroom interactions, a cross-tabulation between the quality of pupil answers and the teacher modes of questioning was performed and the results are displayed in Table 4.4.7. As it is shown in this table, most of the questions asked by the teacher received a correct answer from boys as well as from girls although in almost of all modes of teacher asking a question, either by nomination or by selecting a volunteer, girls proportionally answered more questions correctly than did boys.

Table 4.4.7: Percentage distribution of the Quality of Pupil Answer and TeacherModes of Questioning by gender, and grade

		No Answer (%)		Inadequate (%)		Wrong (%)		Incomplete (%)		Correct (%)	
		Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
Grade 9	TNB	1	3	1	1	19	14	12	4	67	79
	TND	2	7	11	5	23	15	7	8	57	65
	PVB	0	0	3	1	24	19	16	23	57	57
	PVD	0	0	2	0	38	17	7	10	53	73
		Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
Grade 10	TNB	1	0	6	2	22	13	8	13	63	72
	TND	5	7	8	7	29	30	7	10	51	46
	PVB	0	0	2	1	25	22	13	15	60	62
	PVD	0	0	2	1	43	30	11	13	44	56

TNB= Teacher Nominated pupil to the **Board**; **TND**=Teacher Nominated pupil from the **Desk**; **PVB**=Pupil Volunteered to the **Board**; **PVD**=Pupil Volunteered from the **Desk**

Meanwhile, the opposite can be seen in the case of wrong answers. Boys answered incorrectly in all the different questioning modes, more often than did girls. It implies that in questions answered on the board boys answered 19% and 22% of their answers incorrectly in grades 9 and 10 respectively, while girls gave wrong answers only 14% and 13% in these grades respectively.

Contrasting the answers given by nominated pupils from their desk the gender difference was evident in grade 9 where boys got 23% of their answers wrong against 15% of the girls' answers. However, in grade 10 there was a similarity between the two genders with 29% of the boys' answers and 30% of the girls' answers being wrong. A similar picture was also seen within the volunteers. Boys were still found to answer more questions wrongly than did girls in grades, 9 and 10, either on the board or from the desk. However, the differences were more evident when the answer was given from the desk with the boys of grades 9 and 10, having respectively 38% and 43% of their answers wrong against the 17% and 30% of the wrong answers given by the girls of the two grades respectively. Similarly, boys tended to give more inadequate answers than occurred with girls. However, very few boys or girls were called upon to give an answer on the board or at the desk and then gave an inadequate answer or kept silent. It is of importance to note that within the pupils who gave an incomplete answer, only the girls nominated by the teacher to solve a problem on the board had lower percentage compared to the boys.

4.4.7 Quality of Pupils' Answers and Teacher's Feedback

Another way to look for the possible gender differences was to do a cross-tabulation between the quality of pupil answer and the related teacher feedback. These results are presented in Table 4.4.8. From that table, it is evident that when the pupils have answered correctly, the teachers followed three general behaviours: No reaction, confirmation of the answer or confirmation with praise. Gender and grade had no effect on teacher reaction to the correct answers.

However, when a partially correct answer or incomplete solution was presented, in grade 9, the boys were given the correct answer more frequently than were the girls. Meanwhile, the girls were more likely to have the question repeated. In grade 10, boys were helped more frequently by their mathematics teacher by being given a clue than were girls, but no differences were seen when comparing the teacher's feedback related to the possibility of receiving the answer or having the question repeated.

Another gender-based difference was found within the teacher's feedback. In the few occasions when an inadequate answer was set up in grade 9, the boys were given the solution or a clue, while the girls had the question more frequently repeated. In grade 10, girls received more help by being given clues than boys.

Examining the wrong answers given by the pupils, in grade 9 as well as in grade 10 the teacher's feedback was based on several different types of reactions: criticised the answer, simply said wrong, did not react, gave the answer, gave a clue or repeated the question. Only in grade 9 did boys have the question repeated more often than did girls. All the other teacher's reactions have a similar distribution within boys and girls.

When the pupils gave no answer, in general, the teacher for both genders gave the answer. It is also important to note that in grade 9 only girls had the question repeated, while in grade 10 there was not an evident difference between boys and girls. In a few cases, the teacher tried to help the girls by giving a clue in grade 10.

Table 4.4.8: Percentage distribution of the Quality of Pupil Answer by gender, and Teacher Feedback

	No Answer (%)		**Inadequate (%)**		**Wrong (%)**		**Incomplete (%)**		**Correct (%)**	
Grade 9	**Boys**	**Girls**	**Boys**	**Girls**	**Boys**	**Girls**	**Boys**	**Girls**	**Boys**	**Girls**
TCri	0	**0**	15	**33**	6	**9**	17	**20**	0	**0**
SW	0	**0**	0	**0**	8	**13**	0	**0**	0	**0**
NoR	0	**0**	0	**0**	8	**4**	9	**8**	27	**25**
SCor	0	**0**	0	**0**	0	**0**	0	**0**	65	**65**
TPr	0	**0**	0	**0**	0	**0**	0	**0**	8	**10**
TGA	100	**89**	55	**33**	63	**60**	63	**49**	0	**0**
TGC	0	**0**	15	**0**	1	**7**	9	**8**	0	**0**
TRQ	0	**11**	15	**33**	14	**7**	2	**15**	0	**0**
Grade 10	**Boys**	**Girls**	**Boys**	**Girls**	**Boys**	**Girls**	**Boys**	**Girls**	**Boys**	**Girls**
TCri	0	**0**	31	**17**	9	**12**	15	**16**	0	**0**
SW	0	**0**	0	**0**	24	**20**	0	**0**	0	**0**
NoR	0	**0**	4	**0**	3	**4**	6	**7**	14	**22**
SCor	0	**0**	0	**0**	0	**0**	0	**0**	77	**67**
TPr	0	**0**	0	**0**	0	**0**	0	**0**	9	**11**
TGA	75	**73**	35	**22**	52	**50**	55	**56**	0	**0**
TGC	0	**9**	4	**11**	2	**2**	9	**4**	0	**0**
TRQ	25	**18**	26	**50**	10	**12**	15	**17**	0	**0**

NoR= Teacher did not have reaction; **TCri**= Teacher criticised the answer; **SW**= Teacher simply said wrong; **SCor**= Teacher simply said correct; **TPr**= Teacher praised the answer; **TGA**= Teacher gave the answer; **TGC**= Teacher gave a clue; and, **TRQ**= Teacher repeated the question.

4.5 PUPIL'S MATHEMATICS PERFORMANCE

4.5.1 Introduction to Pupil's Mathematics Performance

The first step in the analysis of the mathematics pupils' performance was to determine any gender based pattern in the pupils performance in the ACSs (mean of classroom tests); ACPs (mean of standardised tests); Semester (Combination of ACSs and ACPs) and in the National Examination (for grade 10 only). Apart from the pupils' gender, other independent variables (school type; grade level and age group) were taken into account.

4.5.2 Sample for the Mathematics Performance

In this part of the study a sample of 1221 pupils corresponding to those who had completed the MAS was used. This means that, the sample was in general the same as was used in the study of the pupils' Attitudes Toward Mathematics (see Section 4.2, page 98). However, only the grade 10 pupils of the state schools who achieved the cycle mark between 10 and 13and the grade 10 pupils of the non state schools achieving 10 or above (see Section 1.1.3, page 14) wrote the National Examination. Thus, for the analysis of the Mathematics National Examination results only this portion of the sample (n=233 pupils) was considered.

4.5.3 Validity and Reliability of the Achievement Tests

To determine if there is any inter-relationship between the different achievement measures, used in assessing the pupils' mathematics performance, a Person's product-moment correlation was performed between the pupils' marks obtained in the three continuous assessment measures (semester, ACSs and ACPs). The results are presented in Table 4.5.1 considering also the pupils' gender as an independent variable.

Table 4.5.1: Correlation coefficients between semester, ACSs and ACPs pupils' marks by gender

	Semester	**ACSs**	**ACPs**
Semester		0.741[b]	0.894[b]
ACSs	0.756[b]		0.595[b]
ACPs	0.931[b]	0.613[b]	

Note: The correlation values for girls are presented above the diagonal and for boys below it; a) $p<0.01$; b) $p<0.001$.

As can be seen, all the variables correlated positively and all of them with high significance ($p<0.001$). However, it is of importance to note that the high values found between semester and ACSs as well as between semester and ACPs may be derived from the fact that semester is a weighted combination of the other measures, (see Section 1.1.3, page 13).

4.5.4 Gender-related Differences in the Continuous Assessment

In establishing whether there is any statistical significant effect of the independent variables of gender, age and school type in the Semester, ACSs and ACPs, a three-way ANOVA was carried out.

Table 4.5.2 displays these results by grade levels since mathematics attainment testing, for grades 9 and 10, in Mozambican lower secondary level differs at the end of the year. At grade 10 there is a possible component of external assessment, whilst in grade 9 the assessment is all internal. In addition to that is the fact that grade 9 mathematics content also differs from the grade 10 mathematics content.

From Table 4.5.2 it was evident that in both grades (9 and 10), no significant main effects were found on the ACSs results. However, on the ACPs in grade 9, only the main effect of school type was found to be significant ($F_{1:629}=10.770$; $p<0.01$).

In grade 10, only the main effect of age group was found to be statistically significant ($F_{1:576}=22.349$; $p<0.001$).The semester results, which were a weighted combination of ACSs and ACPs, at grade 9 showed only two significant main effects. These were age group, ($F_{1:629}=7.040$; $p<0.01$), and school type, ($F_{1:629}=17.301$; $p<0.001$). There were however, no significant interactions.

Table 4.5.2: Three-way ANOVA of the pupils' performance with gender, age group and school type

		ACSs	ACPs	Semester
GRADE 9	**df**	**F**	**F**	**F**
Gender	1; 629	0.000	0.078	0.045
Age group	1; 629	0.923	5.486	7.040[a]
School type	1; 629	1.142	10.700[a]	17.301[b]
Gender x Age group	1; 629	0.340	0.202	0.002
Gender x School type	1; 629	0.215	0.057	0.226
Age group x School type	1; 629	2.141	0.098	0.009
Gender x Age group x School type	1; 629	0.003	0.838	0.342
GRADE 10				
Gender	1; 576	0.221	0.157	0.128
Age group	1; 576	4.872	22.349[b]	19.898[b]
School type	1; 576	1.648	0.004	3.213
Gender x Age group	1; 576	2.677	1.821	0.608
Gender x School type	1; 576	2.935	4.201	7.799[a]
Age group x School type	1; 576	0.155	0.042	0.196
Gender x Age group x School type	1; 576	0.275	0.979	0.248

a) p<0.01; b) p<0.001

In grade 10 the semester mark is also a part of the continuous assessment system, as it is for grade 9. Here, the ANOVA that was performed yielded a significant interaction between gender and school type, ($F_{1:576}$=7.799, p<0.01), as well as a significant main effect of age group ($F_{1:576}$=19.898; p<0.001).

4.5.4.1 Pupils' Mathematics Performance

As there was no gender effect on any performance measure no gender comparison is necessary. However the other significant results are evaluated. In Table 4.5.3 mean scores and standard deviations of pupils' performance in the Semester tests are presented taking into account the independent variables analysed.

Table 4.5.3: Means and standard deviations of the semester mathematics performance by gender, age group, grade and school type

			Boys		Girls	
			Mean	*SD*	*Mean*	*SD*
State	**Grade 9**	**Younger**	10.00	2.51	9.98	2.72
		Older	9.49	2.25	9.13	1.95
		Total	9.63	2.33	9.37	2.23
	Grade 10	**Younger**	11.60	2.65	10.83	2.79
		Older	9.95	3.04	8.99	2.67
		Total	10.16	3.03	9.23	2.76
Non-State	**Grade 9**	**Younger**	11.15	2.53	11.09	3.00
		Older	10.28	2.30	10.50	1.56
		Total	10.91	2.48	10.95	2.73
	Grade 10	**Younger**	10.91	2.98	12.49	2.91
		Older	9.93	1.91	10.60	2.92
		Total	10.20	2.25	11.54	3.05
Total	**Grade 9**	**Younger**	10.49	2.57	10.37	2.86
		Older	9.57	2.26	9.21	1.95
		Total	9.91	2.42	9.64	2.39
	Grade 10	**Younger**	11.39	2.73	11.65	2.95
		Older	9.95	2.90	9.20	2.76
		Total	10.17	2.91	9.70	2.97

In grade 9 the only significant differences were for the main effects of school type on both ACPs and semester and age group on semester. In the two measures on school type differences in both cases were when the non-state pupils performed better than their colleagues in the state schools. In evaluating the significant difference in age group the younger pupils did better that the older pupils.

In grade 10 the differences were on semester scores for the interaction of gender and school type and the main effect of age group on ACPs and semester. The interaction yielded the following order: the non-state schools girls statistically outperformed the boys in both type of schools who in turn performed statistically better than the girls in state schools. Again in grade 10 the younger pupils performed better than the older pupils in both ACPs and semester.

4.5.4.2 Pupils' Performance in the ACSs

Examining further pair-wise differences on gender, the results of the comparison of boys and girls scores obtained in the classroom tests (ACSs), at grades 9 and 10 of the state and non-state schools are presented in table 4.5.4 as means and standard deviations.

In Table 4.5.4, a similar performance for both boys and girls in the ACSs at grade 9 was found. When taking into account the school type, it was found that within each type of school, boys and girls performed similarly with the only exception in grade 10 of the state schools where boys outperformed the girls, but not significantly, and this difference was more evident among the older pupil.

Table 4.5.4: Means and standard deviation of the ACSs by gender, age group, grade and school type

			Boys		Girls	
			Mean	*SD*	*Mean*	*SD*
State	**Grade 9**	**Younger**	10.13	2.48	10.16	3.46
		Older	10.14	2.78	9.82	2.67
		Total	10.14	2.69	9.92	2.92
	Grade 10	**Younger**	10.42	2.80	10.37	2.89
		Older	9.82	3.50	8.87	3.22
		Total	9.90	3.42	9.07	3.21
Non-State	**Grade 9**	**Younger**	9.84	2.72	10.20	3.07
		Older	10.84	3.60	10.79	2.83
		Total	10.12	3.00	10.34	3.00
	Grade 10	**Younger**	9.88	2.40	11.63	3.00
		Older	10.02	2.37	10.03	2.51
		Total	9.98	2.35	10.83	2.86
Total	**Grade 9**	**Younger**	10.01	2.58	10.17	3.32
		Older	10.21	2.86	9.88	2.68
		Total	10.14	2.76	9.99	2.93
	Grade 10	**Younger**	10.26	2.66	10.99	2.99
		Older	9.85	3.36	9.02	3.16
		Total	9.91	3.26	9.43	3.22

4.5.4.3 Pupils' Performance in the ACPs

In a similar way to the ACSs, a comparison of the standardised tests scores (ACPs) was also done considering the variables gender, school type, grade and age group. The results are shown in Table 4.5.5 as means and standard deviations.

Table 4.5.5: Means and standard deviation of the ACPs by gender, age group, grade and school type

			Boys		Girls	
			Mean	*SD*	*Mean*	*SD*
State	**Grade 9**	**Younger**	9.75	2.88	9.74	3.17
		Older	9.11	2.55	8.82	2.15
		Total	9.29	2.66	9.08	2.51
	Grade 10	**Younger**	11.63	3.13	10.81	3.73
		Older	9.98	3.22	8.87	3.13
		Total	10.19	3.25	9.12	3.27
Non-State	**Grade 9**	**Younger**	10.83	2.80	10.42	2.94
		Older	9.83	2.32	10.22	1.42
		Total	10.55	2.70	10.37	2.65
	Grade 10	**Younger**	10.48	2.46	12.07	2.74
		Older	9.46	1.98	9.18	3.13
		Total	9.73	2.14	10.63	3.26
Total	**Grade 9**	**Younger**	10.21	2.88	9.98	3.09
		Older	9.18	2.53	8.91	2.14
		Total	9.57	2.71	9.30	2.58
	Grade 10	**Younger**	11.28	2.95	11.43	3.31
		Older	9.91	3.07	8.91	3.13
		Total	10.11	3.09	9.43	3.32

The ANOVA showed that there were no significant differences on any of the interactions or main effects. Thus, boys and girls of grade 9 and 10 performed similarly. This was consistent when the age groups were considered.

4.5.5 Gender Differences in the Mathematics National Examination

The results of the previous sections refer to all pupils. However, as mentioned (see Section 4.5.2, page 139) only a small proportion of these pupils sit for the National Examination. The pupils in state schools who achieved a mathematics performance between 10 and 13 marks (out of 20) and all pupils in the tenth grade in the non-state schools who had achieved at least 10 (out of 20), as well as other external candidates, wrote the National Examination.

Although the two school systems have different entry criteria to the National Examination, it is usual for the non-state schools to be selective as to who is permitted to write the National Examination using the same lower entry criteria. Thus, the performance of the pupils of the two types of schools can be compared.

Therefore, a sub-sample comprising 233 pupils (102 boys and 131 girls) was used to explore possible gender differences in the Mathematics National Examination. From this sub-sample, 118 subjects (52 boys and 66 girls) were state school pupils while the remaining group of 115 subjects were non-state school pupils (50 boys and 65 girls).

As a whole, the Mathematics National Examination included a total of 19 questions, which varied from questions that could be answered by applying simple rules to more complex problems and were designed to be interpreted on a question-by-question basis. The scores in the questions, which covered the relevant mathematical topics, taught in the grades 8, 9 and 10 (Algebra, Euclidean Geometry, Trigonometry and Statistics) were compared taking the pupils' gender into account. An aggregation was necessary in order to draw any conclusions about how mathematics performance differed between the two genders.

The content of the Mathematics National Examination questions was assessed at the different cognitive levels of **Knowledge**, **Understanding** and **Application**. As described in Section 3.5.3 (pages 91-92), these cognitive levels were composed as follow:

a) **Knowledge** questions involved recall of simple rules with the assumption that pupils have met the exercises before in the form required for the answer. This included such tasks as manipulating algebraic expressions, (Smith et al., 1996).

b) **Understanding** questions tested pupils' ability in using a previously acquired knowledge or skills in a way which goes beyond the recall of simple rules or routine algorithms. Pupils might recognise the applicability of a formula or method in different or unusual context, (Smith et al., 1996).

c) **Application** exercises required the pupils' ability to choose and apply appropriate methods or information in a new situation. In this case it tested particularly the pupils' ability to do a transformation of information from one form to another (e.g., verbal to numerical or vice-versa). Both routine textbook problems and non-routine problems were included in this cognitive level, (Smith et al., 1996).

Thus, for the purpose of this research the mathematical content covered by the National Examination were also broken down into the cognitive levels of Knowledge, Understanding and Application, and a three-way ANOVA was performed with gender, age group and school type as the independent variables. In Table 4.5.6 a summary of these three-way ANOVAs is provided with the total scores in the Mathematics National examination and each of the cognitive levels **(Knowledge, Understanding** and **Application)** as the dependent variable.

In Table 4.5.6, it was evident that, significant main effect of age groups was found in each of the dependent variables, (Knowledge: $F_{1;224}=12.879$; $p<0.001$, Understanding: $F_{1;224}=8.978$; $p<0.01$ and Application: $F_{1;224}=18.777$; $p<0.001$, Mathematics National Examination: $F_{1;224}=22.160$; $p<0.001$).

Table 4.5.6: ANOVA for the Mathematics National Examination variables

Cognitive Levels	df	Knowledge	Understanding	Application	Maths Exam
		F	*F*	*F*	*F*
Gender	1;224	0.715	0.002	4.437	1.468
Age	1;224	12.879[b]	8.978[a]	18.777[b]	22.160[b]
School	1;224	0.225	3.219	0.738	0.754
Gender x Age	1;224	0.943	1.604	0.446	1.604
Gender x School	1;224	3.168	4.927	0.573	4.465
Age x School	1;224	0.313	0.008	0.954	0.382
Gender x Age x School	1;224	0.127	0.025	0.015	0.003

a) $p<0.01$; b) $p<0.001$

4.5.5.1 Gender Differences at Mean Level

A gender comparison of the pupil mean scores in the Mathematics National Examination was done considering each of the three cognitive levels and the two age groups that are being considered in this study. The results of this comparison are displayed in Table 4.5.7.

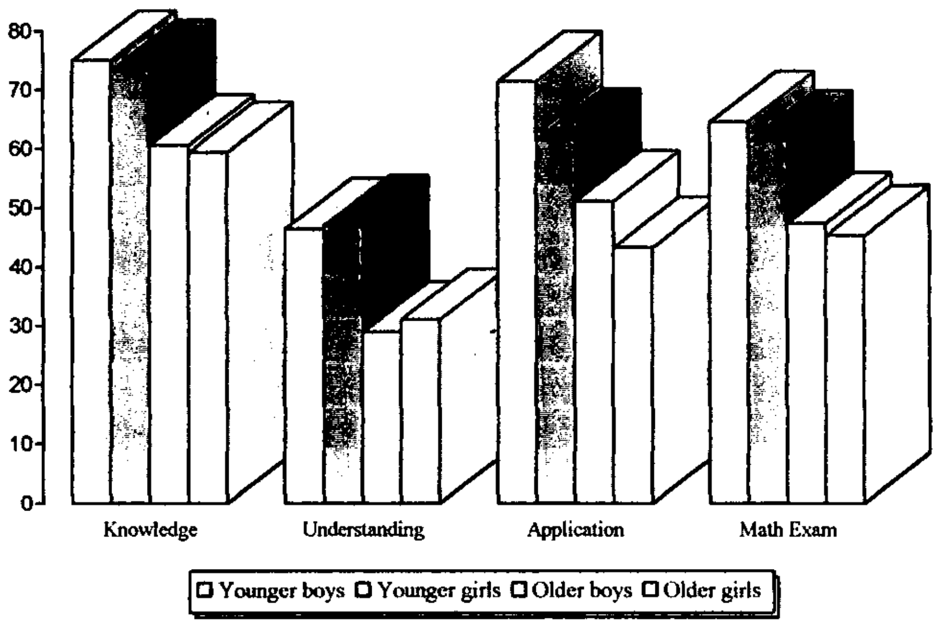
Table 4.5.7: Means and standard deviations of the National Examination and cognitive levels by gender and age group

		Boys		Girls	
		Mean	*SD*	*Mean*	*SD*
Math National Examination	**Younger**	64.40	14.35	61.02	18.02
	Older	47.20	16.64	45.10	15.78
	Total	50.40	17.50	50.70	18.20
Knowledge	**Younger**	74.96	18.55	73.35	16.44
	Older	60.49	22.77	59.32	22.94
	Total	63.18	22.68	64.25	21.88
Understanding	**Younger**	46.33	20.93	46.87	26.58
	Older	28.90	17.80	31.03	21.77
	Total	32.14	19.54	36.59	24.66
Application	**Younger**	71.23	14.13	61.38	21.57
	Older	50.96	23.21	43.22	19.32
	Total	54.74	23.15	49.59	21.86

The summary in Table 4.5.7 shows that in general no statistically significant gender differences were found, indicating that girls and boys performed similarly in the National Examination. However, in all aspects of the National Examination, the younger pupils significantly outperformed the older pupils. Not surprisingly the mean performance decreased as the level of the question increased that is the simple type of questions (knowledge) had a higher mean than the more difficult type of questions.

An illustration of these results of the Mathematics National Examination on age groups is given by the Figure 4.5.1. When a Bonferroni multiple "t" comparisons were performed, it yielded that younger girls significantly outperformed ($p<0.01$) the older boys at the cognitive level of knowledge. A similar result was also found at the cognitive level of understanding where the younger girls were still found to outperform the older boys as well as the older girls, with statistical significance ($p<0.001$). While on the other hand, at the cognitive level of application the younger boys significantly surpassed ($p<0.001$) the two older-gender groups (older boys and older girls).

Figure 4.5.1: Means of the Mathematics National Examination and cognitive levels by gender and age groups



However, taking the Mathematics National Examination as a whole the, the younger gender groups (younger boys and younger girls) consistently outperformed the older ones ($p<0.001$).

For the total scores achieved by boys and girls in the Mathematics National Examination, the apparent differences favouring boys were also non significant in both age groups.

4.5.5.2 Gender Differences by Question

To complement the analysis of the differences between boys and girls achievement in the Mathematics National Examination, it was also necessary to do a comparison by individual question. Thus, apart from the scores on each question, the Discrimination and Difficulty Indices for boys and girls were computed for each of the questions of the National Examination.

As defined in Section 3.5.3 (page 93) the Discrimination Index is the correlation coefficient between the pupils' total score in the test and the respective score in a defined question. The higher the index implies that the better pupils tended to answer the question correctly and the weaker pupils tended to leave it without answering or answering incorrectly, meaning that the question discriminates the good pupils from the weak.

Table 4.5.8: Discrimination and Difficulty Indices of the questions of the Mathematics National Examination by gender

	State School				Non-State School				All			
	Disc(*r*)		Diff. (%)		Disc (*r*)		Diff. (%)		Disc (*r*)		Diff.(%)	
	Boy	*Girl*	Boy	*Girl*	Boy	*Girl*	Boy	*Girl*	Boy	*Girl*	Boy	*Girl*
1	.352	*.255*	60	*61*	.399	*.431*	72	*65*	.374	*.327*	66	*63*
2a	.503	*.335*	52	*39*	.340	*.267*	48	*65*	.417	*.367*	50	*52*
2b	.369	*.440*	75	*58*	.379	*.197*	56	*72*	.349	*.350*	66	*65*
2c	.555	*.516*	27	*17*	.475	*.374*	26	*43*	.507	*.453*	27	*30*
3a	.548	*.409*	73	*59*	.666	*.500*	74	*75*	.604	*.467*	74	*67*
3b	.508	*.428*	58	*49*	.317	*.433*	60	*65*	.406	*.437*	59	*57*
4a	.468	*.435*	40	*36*	.254	*.323*	18	*35*	.314	*.312*	29	*36*
4b	.498	*.381*	35	*27*	.355	*.411*	33	*46*	.417	*.436*	34	*36*
4c	.428	*.489*	67	*50*	.262	*.515*	52	*60*	.319	*.490*	60	*55*
5	.137	*.115*	4	*6*	.122	*.277*	18	*35*	.125	*.352*	11	*21*
6a	.319	*.127*	0	*5*	.377	*.522*	30	*37*	.340	*.485*	15	*21*
6b	.201	*.022*	6	*6*	.378	*.539*	12	*29*	.301	*.469*	9	*18*
7a	.439	*.270*	54	*35*	.185	*.529*	50	*54*	.308	*.462*	52	*44*
7b	.493	*.454*	65	*67*	.474	*.301*	82	*86*	.485	*.423*	74	*76*
7c	.331	*.152*	17	*24*	.203	*.331*	42	*51*	.265	*.304*	29	*37*
7d	.128	*.243*	23	*14*	.479	*.025*	38	*23*	.300	*.167*	30	*18*
8a	.326	*.184*	52	*41*	.402	*.249*	58	*59*	.365	*.235*	55	*50*
8b	.324	*.120*	48	*33*	.370	*.232*	58	*52*	.350	*.211*	53	*43*
8c	.185	*.062*	15	*5*	.288	*.284*	26	*26*	.244	*.305*	21	*15*

If the Discrimination Index is low, for example 0.1 two cases arise: all the pupils (good and weak) answered the question correctly or very few got the correct answer. Thus, such a question did not discriminate between the two types of pupils.

On the other hand, the Difficulty Index was defined as the percentage of pupils who correctly answered the item taking into account that it was considered correct if the answer scored at least 80% of the maximum score (see Section 3.5.3, page 94). In other words, the higher the index, the less difficult the question is. The results of these indices are presented in Table 4.5.8.

The restricted range of both the Discrimination and Difficulty indices is due to the attenuated sample that wrote the National Examination. Most of the top pupils, from the state schools, and all the weakest pupils did not write the examination. This will materially affect the range of these two indices.

Firstly the values of the Discrimination Indices show that 3 out of 19 questions (questions 5, 6b and 8c) for the state schools' pupils did not discriminate within boys' group as well as within the girls' group, while 5 questions (6a, 7c, 7d, 8a, 8c) discriminate differently for boys and for girls.

Questions 6a, 7c, 8a and 8b did not discriminate the high and low achievers in the girls group, which also had the Difficulty Indices of these questions below 41%.

Question 7d did not discriminate adequately for the boys although it discriminated adequately for the girls.

Within the non-state schools' pupils, the questions 2b, 4a, 4c, 5, 7a, 7c, 8b discriminate differently for boys and girls. In other words, questions 5, 7c and 8b discriminated better for girls than boys. For question 5 the assumption was that pupils have met the type of this exercise before, in the form required for the answer, while for question 7c and 8b the assumption was that the pupils have not met the type of examples in the form given in the Mathematics Examination . Pupils were required to extrapolate a known procedure to a new situation.

The values of the Difficulty Indices show that in general pupils experienced the same difficulty in the National Examination. Boys and girls found the question 7b the easiest with the Difficulty Indices of 74% and 76% respectively while the most difficult questions were questions 5, 6a, 6b and 8c.

However, in question 7d girls experienced more difficulty than did boys. It is interesting to note that there are 5 questions where the girls surpassed the boys on the cognitive level of Understanding (questions 4a, 5, 6a and 6b) and Application (question 7c). These questions will then be discussed in more detail.

In question 4 a quadratic equation in the context of the study of Algebra was presented. It was expected that pupils should be able to recognise the application of a formula.

4. Given the equation $x^2 + 2x + m = 4$,

a) Determine the value of ***m*** *if the product of the roots is –4.*

Solution:

$$x^2 + 2x + m - 4 = 0$$

$$p = \frac{c}{a} = -4$$

$$\frac{m-4}{1} = -4$$

$$m = 0$$

b) Determine the value of ***m*** *for which the equation has a repeated root.*

Solution:

$$\Delta = 0$$
$$4 - 4(m-4) = 0$$
$$4 - 4m + 16 = 0$$
$$-4m = -20$$
$$m = 5$$

In other words, in question 4a it was necessary to know (memorise) a formula (the product of the roots is equal to the ratio of the ***c***-value to the ***a***-value). Only a small percentage of boys (29%) answered this question correctly compared to the 36 % of girls. But as a discriminator it functioned significantly well for both gender groups.

Meanwhile, in question 4b it was also necessary to know the formula for equal roots $\Delta=0$, and the percentage of girls who correctly answered reached the same value (36%) as in the previous question while boys increased the percentage to 34%.

However most of the pupils who answered the question were the good ones since the Discrimination Indices were higher than for the previous question, for boys as well as for girls.

5. In triangle ABC, $\angle A = 90^o$, $\sin B = \frac{2m+1}{5}$ *and* $\cos C = \frac{-m+3}{2}$.

- *Determine the value of* ***m***.

Solution:

$$\sin B = \frac{AC}{BC} \; ; \; \cos C = \frac{AC}{BC}$$

Thus, as $\angle C = 90^0 - \angle B$, $\sin B = \cos C$

$$\frac{2m+1}{5} = \frac{-m+3}{2}$$

$$4m + 2 = -5m + 15$$

$$9m = 15 - 2$$

$$m = \frac{13}{9}$$

The results show that a large proportion of the sample did not answer this question correctly. Here it was assumed that pupils would have the technical knowledge and skills needed to solve the problem, but in fact the majority of boys (Diff.=11%) as well as girls (Diff.=21%) had a great degree of difficulty in this question. On the other hand, this question discriminates within the girls group (Disc. = 0.352), but it did not do so in the same way within the boys' group where the Discrimination Index was low (Disc. = 0.125). This implies that this question discriminates differently in the girls' group, to that of the boys' group. A further implication is that in the boys' group answering the question correctly was not necessarily related to the boys' ability.

6. In a square prism the area of the base is 64cm^2 and its height is 12cm.

Insides the prism there is a pyramid with the same base and height:

a) Determine the volume of the pyramid.

Solution:

$$v_{pyramid} = \frac{64x12}{3} = 256cm^3$$

b) Determine the length of the diagonal of the prism

Solution:

$$A = l^2 = 64$$
$$\therefore\ l = 8$$

$$d^2 = a^2 + b^2 + c^2$$
$$\therefore d^2 = 12^2 + 8^2 + 8^2$$
$$\therefore d = \sqrt{272}cm$$

The pupils were required to recognise the application of a geometrical formula in a different context. Here, it was assumed that various routine geometrical skills needed to do the exercises are familiar to the pupils and they have done drill work in similar but not identical exercises. Although more girls, (21% in this question 6a and 18% in question 6b than boys, 15% in question 6a and 9% in question 6b), have attained the correct answer, these questions discriminate significantly within both gender groups. As this question is related to geometry/spatial ability this is an unusual result (e.g., Leder, 1990b; Cronjé, 1995).

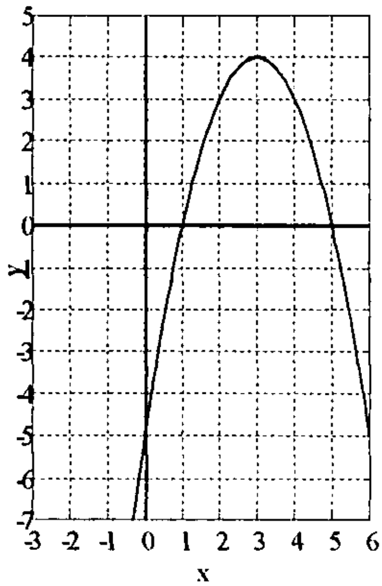
7. Given the graph of
$f(x) = -(x-k)^2 + m$,

c) Find the range of the function.

Solution:
range of $f = (-\infty;4]$

d) Fill the spaces with the correct sign (>, < or =)

Solution:
$f(3) = 4$
$f(0) < f(1)$
$f(2) > f(-1/2)$
$f(6) < f(4)$



Question 7c whose Difficulty Indices reveal that it was a relatively harder question for boys (29%) than for girls (37%) showed the reverse of the question 7d where the percentage of boys (30%) achieving the correct answer surpassed that of the girls (18%). In these questions the assumption was that the pupils have not met any of the results they are asked to prove and they have the ability to do a transformation of information from one form to another. Both questions (7c and 7d) discriminate between good and weak boys but for girls, only question 7c did do so.

4.5.6 Pupils' Mathematics Performance Across the Lower Secondary Cycle

In addition to the analysis of the National Examination the mathematics attainment of the pupils involved, were also compared for possible gender differences in their performance across the lower secondary school cycle, that is the mathematics performance at grade 8 in 1997, grade 9 in 1998 and grade 10 in 1999.

A three-way ANOVA was performed with gender, age group and school type as independent variables on pupils' performance in mathematics across the lower secondary cycle (grades 8, 9 and 10). This analysis was only possible for the grade 10 pupils who wrote the National Examination. The results of this analysis are presented in Table 4.5.9.

Table 4.5.9: ANOVA for the pupils' lower secondary cycle mathematics achievement by gender, age group and school type

		Grade 8	**Grade 9**	**Grade 10**	**Cycle**
	df	***F***	***F***	***F***	***F***
Gender	1;225	4.388	4.376	0.002	3.667
Age	1;225	1.127	0.007	8.596[b]	4.392
School	1;225	8.865[a]	19.418[b]	0.681	4.251
Gender x Age	1;225	1.538	0.116	0.939	0.908
Gender x School	1;225	3.784	3.738	0.170	4.578
Age x School	1;225	0.082	0.002	0.538	0.616
Gender x Age x School	1;225	0.011	0.050	0.001	0.046

a): $p<0.01$; b): $p<0.001$

There, in Table 4.5.9, significant main effects were found for age group ($F_{1:225}$ = 8.596; p<0.01) in grade 10 and school type in grade 8 ($F_{1:225}$ = 8.865; p<0.01) and in grade 9 ($F_{1:225}$ = 19.418; p<0.001). None of the interactions were statistically significant.

Further gender pair-wise analysis was performed considering the lower secondary cycle marks. Table 4.5.9 presents the means and standard deviations for grades 8, 9 and 10 as well as for the cycle for the end of first secondary schooling cycle for boys and girls, who sat for the National Examination.

As stated in Section 1.1.3 (pages 12-13), the components of the year mark are made up of the various classroom tests (**ACSs**) and standardised tests (**ACPs**). This mark is then combined with the National Examination for a final mark. Although the material examined in the National Examination is based on the material taught during those three years and, the National Examination mark is independent of the school cycle mark. Thus, cycle is defined as the weighted average of the 3 years performance of the lower secondary school.

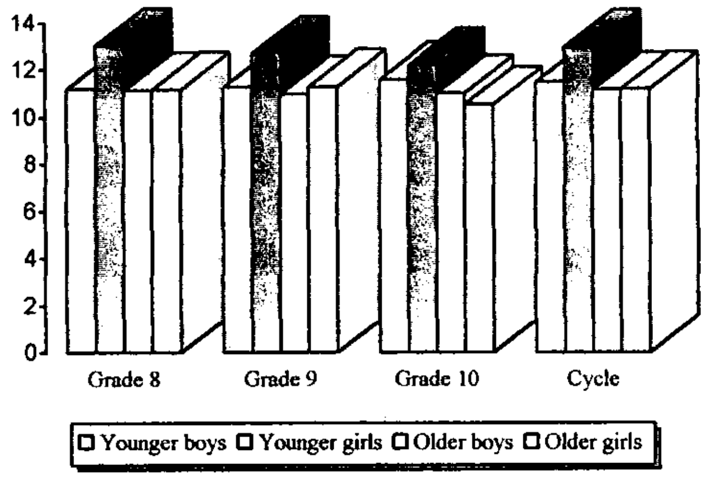
An inspection of the Table 4.5.10 shows that boys and girls performed similarly in state schools, while in non-state schools girls in general outperformed boys at all but grade 10 albeit non-significantly. When this selected sample was taken as a whole, the gender differences in grades 8, 9 and 10 and the cycle mean scores, showed no statistically significant results.

Table 4.5.10: Means and standard deviations of the pupils' mathematics performance across the lower secondary cycle by gender and school type

			Boys		Girls	
			Mean	SD	Mean	SD
State	*Boys=52* *Girls=66*	Grade 8	10.92	1.53	10.65	1.44
		Grade 9	10.60	1.42	10.47	1.47
		Grade 10	11.17	2.75	10.73	2.13
		Cycle	11.10	1.67	10.74	1.18
Non-State	*Boys=50* *Girls=65*	Grade 8	11.40	2.18	13.00	2.40
		Grade 9	11.48	1.96	13.09	2.70
		Grade 10	11.04	1.97	11.48	2.45
		Cycle	11.30	1.68	12.83	2.32
All	*Boys=102* *Girls=131*	Grade 8	11.16	1.88	11.82	2.89
		Grade 9	11.03	1.75	11.77	2.53
		Grade 10	11.11	2.39	11.10	2.32
		Cycle	11.20	1.67	11.78	2.11

Another way to look for possible differences in pupils' performance across the lower secondary cycle was to compare the achievement of the pupils involved in the study within and between gender groups with respect to their age group. Thus, boys and girls were then compared to determine whether there were any significant differences between and within the gender groups on the mean performance of each grade of the lower secondary cycle (grades 8, 9 and 10). The results are illustrated in the Figure 4.5.2, and showed that there were no significant differences within these groups.

Figure 4.5.2: Means of the pupils'mathematics performance across the lower secondary cycle by gender and age groups



From the ANOVA, post-hoc analyses were carried out on these scores yielding that at grades 8 and 9 the non state schools pupils significantly outperformed the state schools pupils ($p<0.001$). In grade 10 the younger pupils outperformed the older pupils significantly.

The results presented previously lead to an Analysis of Covariance (ANCOVA) of the pupils' performance in the Mathematics National Examination and each of the cognitive levels of knowledge, understanding and application, considering as independent variables gender, age group distribution and the school type. The scores of the lower secondary cycle schooling were taken as the covariate and the results are displayed in Table 4.5.11.

Table 4.5.11: ANCOVA of the pupils' performance in the Math National Examination by gender, age and school type, with lower secondary cycle marks as covariate

Cognitive Levels		**Knowledge**	**Understanding**	**Application**	**Math Exam**
	df	*F*	*F*	*F*	*F*
Covariate		52.811[b]	53.573[b]	12.430[a]	70.345[b]
Gender	1;224	3.425	0.768	6.699	5.937
Age	1;224	8.624[a]	5.213	15.300[b]	17.405[b]
School	1;224	2.282	0.955	0.154	0.025
Gender x Age	1;224	2.359	3.489	0.823	3.911
Gender x School	1;224	0.862	1.980	0.073	1.460
Age x School	1;224	0.058	0.232	0.665	0.071
Gender x Age x School	1;224	0.249	0.005	0.006	0.034

a) $p<0.01$; b) $p<0.001$

The ANCOVA on **Knowledge** yielded the school cycle mark as significant ($F_{1:224}=52.811$; $p<0.001$), as well as the main effect of age group ($F_{1;224}=8.624$; $p<0.01$). On the **Understanding** level only the cycle mark as a covariate was statistical significance found ($F_{1;224}=53.573$; $p<0.001$). On the **Application** level, statistically significant results were found for the covariate cycle mark, ($F_{1;224}=12.430$; $p<0.01$) and the main effect of the age group variable ($F_{1;224}=15.300$; $p<0.001$). On the National Examination as a whole, that is, since it is a linear combination of the various cognitive levels **(Knowledge, Understanding** and **Application)**, only the covariate cycle mark ($F_{1;224}=70.345$; $p<0.001$), and the main effect of age group ($F_{1:224}=17.405$; $p<0.001$), were statistically significant.

4.6. MATHEMATICS CLASSROOM INTERACTIONS, PUPILS' ATTITUDES AND PERFORMANCE

Pearson's product-moment correlations between affective and cognitive variables by gender were calculated and are reported in Table 4.6.1. Correlations were pooled over school type, as there were few differences between correlations at both types of schools and no meaningful pattern could be discerned from the separate analysis.

In general, little variation was seen when considering the different grades. In grade 9, the largest value of correlation, in absolute size was 0.216 for girls, between **Confidence** and the ACPs, and 0.153 for boys, between **Teacher Attitude** and the semester scores. In grade 10, the values of the correlation were still found to have little variation and both gender groups produced the highest correlation values between **Usefulness** and ACPs (Girls: r=0.162; p<0.01; boys: r=0.185; p<0.01).

Significant, but very small relationship between mathematics achievement and attitude was found when considering the MAS and different sub-scales, and the mathematics performance in the classroom tests (ACSs), standardised tests (ACPs) and semester marks.

In grade 9 the relationship between the MAS and its sub-scales, and the performance measures were in general small and occasionally significant. In general the relationships were stronger for girls than boys. In grade 10, there was less significance and no pattern.

Table 4.6.1: Pearson's product-moment correlation coefficients (*r*) between the affective and cognitive measures by gender and grade

		Semester		ACSs		ACPs	
		Boys	Girls	Boys	Girls	Boys	Girls
Grade 9	**MAS**	0.130	**0.145[a]**	0.030	**0.134**	0.144	**0.165[a]**
	Confidence	0.104	**0.190[a]**	0.071	**0.203[a]**	0.118	**0.216[a]**
	MDomain	0.060	**0.153[a]**	0.147	**0.104**	0.048	**0.149[a]**
	Teacher Att.	0.153[a]	**0.188[a]**	0.098	**0.157[a]**	0.142	**0.193[a]**
	Usefulness	0.109	**0.115**	0.079	**0.059**	0.122	**0.125**
Grade 10	**MAS**	0.085	**0.134**	0.045	**0.074**	0.100	**0.145[a]**
	Confidence	0.073	**0.069**	0.106	**0.089**	0.071	**0.116**
	MDomain	0.063	**0.002**	0.118	**0.007**	0.036	**0.060**
	Teacher Att	0.074	**0.082**	0.089	**0.058**	0.054	**0.123**
	Usefulness	0.166[a]	**0.155[a]**	0.100	**0.038**	0.185[a]	**0.162[a]**

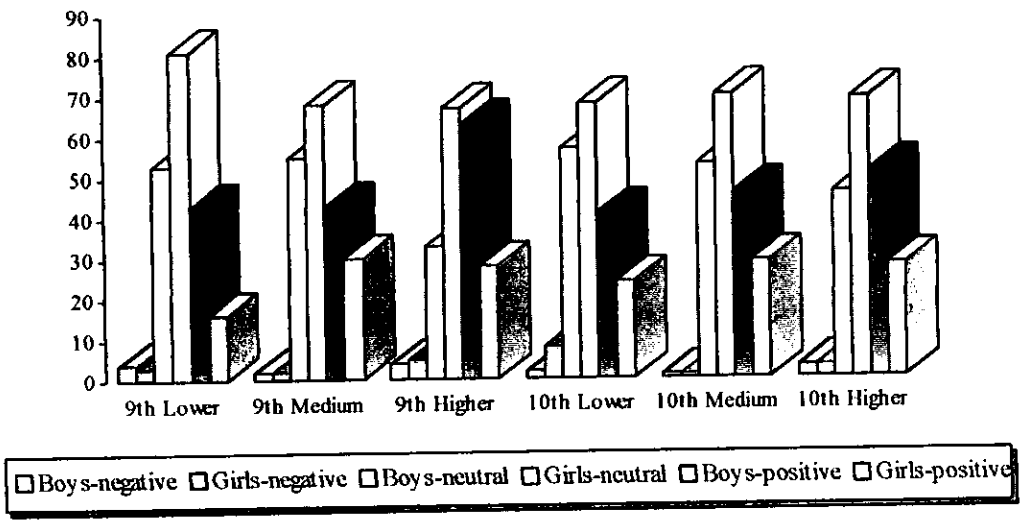
a)p<0.01; b) p<0.001

In the attempt to evaluate the possible relationship between the level of achievement of the pupils and the patterns of mathematics classroom interactions based on gender, it was agreed, (by the researcher and the mathematics teachers participating in the study), that the pupils would sit consistently in the same seat during the second period of the classroom observation, so that they could be identified by the seating arrangement. Therefore, in about one third of the total number of the interactions recorded it was possible to identify the pupils involved in each type of interaction.

4.6.1 Pupils' Mathematics Performance and Attitude Towards Mathematics

A cross-tabulation between the categories of the pupils' attitude (positive, neutral and negative attitudes) as defined in Section 3.5.1 (page 88) and the three performance criteria groups (see Section 3.5.3, pages 91-92) was done. An illustration using these results is given in Figure 4.6.1.

Figure 4.6.1: Frequency distribution of pupils by performance criteria and attitude categories per gender and grade



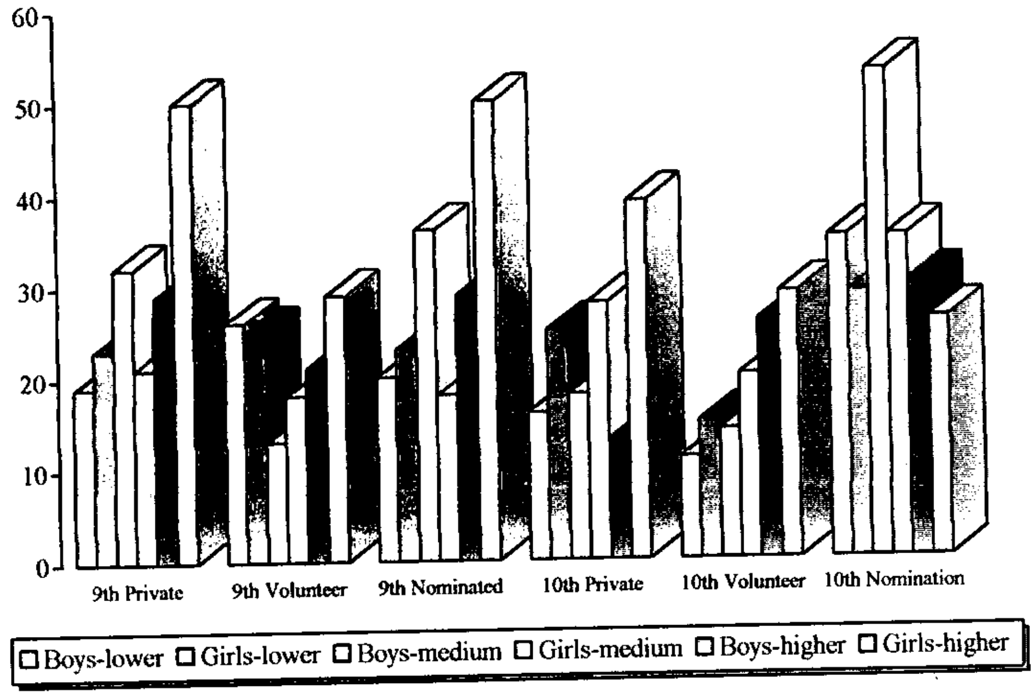
As can be seen, within each of the performance criteria groups most of pupils showed to have a neutral attitude towards mathematics regardless of the gender. An exception was the higher achieving group as in grade 9 as well as in grade 10, where boys with positive attitude towards mathematics reached higher percentage than boys with neutral attitude.

In general there was a very low percentage of pupils with negative attitude towards mathematics, regardless of gender, in all the performance criteria groups. Though, of importance, it must be noted that in grade 10, the girls with negative attitude towards mathematics in the lower achievers group showed a higher percentage compared to the boys with the same characteristics. On the other hand, girls with positive attitude towards mathematics were present in a similar percentage in all the performance criteria groups. In the lower achievers group of grade 9, this presence was less evident.

4.6.2 Mathematics Classroom Interaction and Pupils' Performance

The patterns of the classroom interactions were related to the pupils' mathematics performance. Figure 4.6.2 illustrates the results. From the figure it is evident that in grade 9, the higher achiever girls had the highest percentage of interactions when considering the categories of: i) private interactions, ii) selection within the volunteers, and iii) nomination by the mathematics teachers. A slightly different picture emerges in grade 10. Here, the medium achiever boys were proportionally more nominated by the mathematics teacher than the other gender-performance criteria groups, while taking into account the private interactions and the selection of the volunteers to answer/solve the mathematics teacher question/problem, the medium achievers girls had more interactions.

Figure 4.6.2: Frequency distribution of pupils by performance criteria and types of classroom interactions per gender and grade

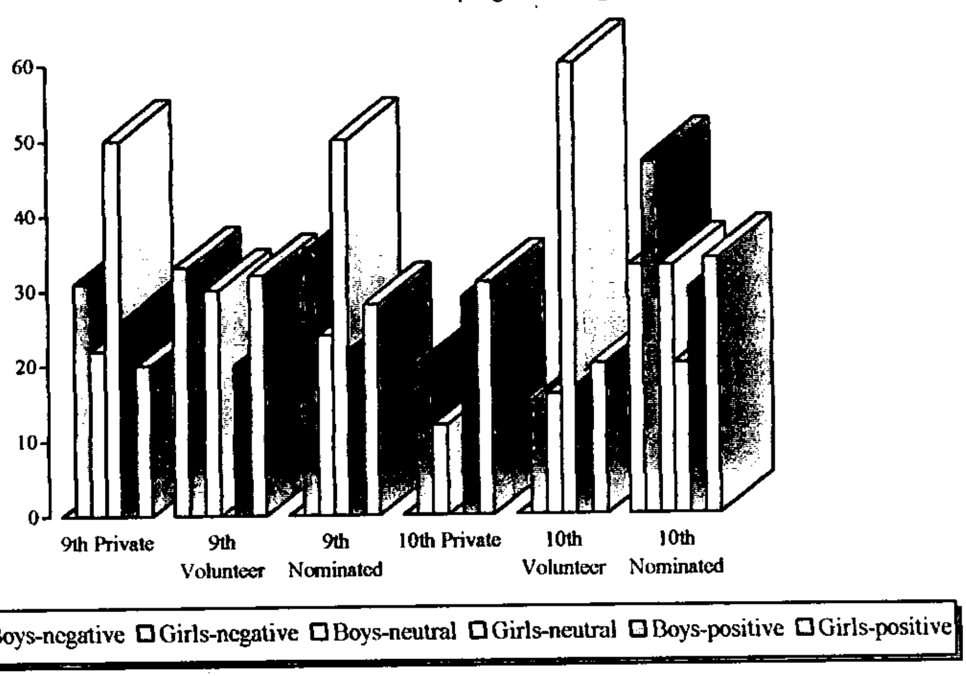


A particular aspect was evident in grade 10 within the classroom interactions. A higher percentage of higher-achievers girls had private interactions with the mathematics teacher. Although relatively more higher-achieving girls were selected within the volunteers, the mathematics teachers nominated more higher achieving boys than girls at the same performance level.

4.6.3 Mathematics Classroom Interactions and Pupils' Attitude

The patterns of the mathematics teacher-individual pupil interactions were related with the three categories of the pupils' attitude. The girls with neutral attitude towards mathematics, in grade 9, were found to have proportionally more Private interactions than all the other groups. This group was not represented within the volunteers selected in grade 9 and, within the pupils with Private interactions in grade 10.

Figure 4.6.3: Frequency distribution of pupils by attitude categories and types of classroom interactions per gender and grade



Boys who had negative attitudes toward mathematics did not have Private interactions with the mathematics teachers in both grades 9 and 10 and they were only nominated in grade 10 and selected within the volunteers in grade 9.

Comparing boys and girls with positive attitudes toward mathematics it was found that the Private interaction percentage in grade 9 differed from the others hence only here, boys reached higher percentage than girls. Even the nomination by the mathematics teacher presented higher percentage of girls witha positive attitude than boys.

CHAPTER V

DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

"... I wonder you let Mary waste her time in reading; she never sews more than if she was a man ..."

(Tabor, 1933 in Osen, 1974:98)

5.1 INTRODUCTION

The females under-representation in formal education can be seen as an ancient problem which was born with the common belief that females are not considered as equally talented as males for working in mathematics as this is reflected in the above quotation.

In Mozambique, an undeveloped country with a ratio of illiteracy of 72% and masculinity index of 0.92, although the main aim of the National Education policy is to promote, among others, gender equity in the access to all levels of Education, there are more females than males, who do not benefit from this. This gender discrepancy increases over the education levels, being more evident at the tertiary level and particularly in mathematics and its related fields. This aspect is of extreme importance since it is recognised worldwide that a strong mathematical background is a pre-requisite to many career and job opportunities in this technological world of today and it is not possible to think of the development of the country without female contribution where they are in the majority.

During the preceding 25 to 30 years much has been written about this low participation of females in advanced mathematics courses and careers that involve mathematics. In fact, many authors, (e.g., Fennema and Sherman, 1977; Armstrong, 1985; Fennema, 1985; De Boer, 1986; Leder, 1990a; Dick and Rallis, 1991 and Maple and Stage, 1991), have argued that female under-representation is evident as soon as pupils have the opportunity to select their own courses, hence fewer females choose to continue studying mathematics and science subjects. On the other hand, this situation is viewed by authors such as Eccles (1986), Dick and Rallis (1991) and Forgasz (1995), as a consequence of gender differences in attitudes toward mathematics, mathematics performance and mathematics classroom interactions.

Taking into account that in Mozambique it is at the end of grade 10 (the last grade of the lower secondary school cycle), that pupils have to decide about their future courses/careers (i.e., to follow or not to follow mathematics based-courses), the present study involved 1221 secondary pupils (531 boys and 690 girls) of grades 9 and 10 aged from 14 to 23 and their mathematics teachers from 4 co-educational schools in Maputo City. In other studies at this level the age range has been substantially smaller, and the average age lower. Thus, applying both quantitative and qualitative approaches, possible gender differences in the patterns of mathematics classroom interactions, pupils' performance and attitudes toward mathematics were explored. As in other studies of this nature (Casserly, 1980; Armstrong, 1981; Fennema, 1985, Becker, 1990; Bohlin, 1994; Fennema and Hart, 1994 and Fennema, 1996), the interaction of these variables was examined to explore gender differences in mathematics performance and possibly explain the low participation of women in courses involving more advanced mathematics in Mozambique.

Overall only 28% (27% of boys and 29% of girls) of the participating pupils were in the appropriate age group (i.e. under 16 years old) for schooling in the 2 senior grades in lower secondary level. These details showed that the characteristics of the sample used are similar to those of general secondary school population. Thus, this could be interpreted as a representative sample in Mozambique. On the other hand, these characteristics show that although females are more represented at this level, in the schools participating in this study, most of them are as equally as boys, above the expected age.

In keeping with most existing research, mean differences in attitudes toward mathematics, classroom interactions and mathematics performance were compared with reference to pupils' gender, grade level and school type. The sample was not split taking into account the teachers' gender since only one female teacher remained in this part of the study. It must be noted that the majority of the mathematics teachers in the Mozambican secondary schools are males. Thus, in the context of this study, the gender of the teacher could not be investigated.

5.2 PUPILS' ATTITUDE TOWARDS MATHEMATICS

Pupils of grades 9 and 10 from the 4 secondary schools present in the mathematics classes on one day in May 1999 were asked by their mathematics teachers to participate in this study on a voluntary basis knowing that refusal in participating would not result in any penalty.

The decision to apply the MAS on only one day in each school is based on the premise that the pupils' answers should reflect their individual perception and not a shared opinion by discussing the MAS and then answering it. By getting the co-operation of the mathematics teachers, two particular aspects were protected. Firstly the return rate was excellent since all the pupils present in the classes' returned the MAS. Secondly, the pupils understood that the contents of the MAS were also of teachers' interest.

After the factor analysis 43 of the original 48 MAS items designed by Fennema and Sherman (1977) remained, these items loaded on 4 sub-scales similar to those in the original. These sub-scales covered the pupils **Confidence** in learning and perform well in mathematics, mathematics as a **Male Domain**, mathematics **Teacher Attitude** towards pupils and mathematics' **Usefulness**.

In general boys rated their attitude more positively than did girls. Even when the comparison was done within grade level, the gender difference favouring boys, in terms of demonstrating a more positive attitude than girls was still evident. The school type was also shown to be an influencing factor since in the state schools, girls were found rating their attitude towards mathematics less positively than did boys regardless the age group, while in non-state schools only the younger pupil group displayed a statistically significant gender difference in their attitude to mathematics.

These results are partially supportive of different studies (e.g. Fennema and Sherman, 1977; Leder, 1990a and Weinburgh, 1995), where females have been noted to have less positive attitudes toward mathematics and that these differences increase as pupils' progress in school. However, these results are different from the findings reported by Tressou-Milonas (1990), which stated that no serious differences were detected in the attitudes of boys and girls toward mathematics since both boys and girls exhibited the same enthusiasm or faced the same difficulties on different topics. Perhaps the apparent contradiction between these sets of findings and those from the present study could be clarified by the gender comparison in the different sub-scales hence the general attitude may be masked by the depth of the differences in each sub-scale.

It is evident that **Confidence** in learning mathematics has consistently emerged as an important component of gender-related differences (Fennema and Sherman, 1977, 1978; Armstrong, 1981; Shaughnessy, Haladyana, and Shaughnessy, 1983; Norton and Rennie, 1998). The results of this study are supportive in that boys were more confident in working in mathematics than girls. Although in both grades these gender differences were found, they were less evident within the younger group, which reached a similarity in grade 10. It should be noted that only 11 of the 12 items used on the Fennema-Sherman MAS were used in this study.

A particular finding was that in non-state schools there were no gender differences in the **Confidence** in working in mathematics. This could possibly infer that school factors may have had an influence on pupil **Confidence** in mathematics in this study.

The results of several studies (e.g. Sherman, 1980; Fennema and Carpenter, 1981; Joffe and Foxman, 1986; Kaiser-Messmer, 1993, Bohlin, 1994; Kaur, 1995; Solar, 1995; Seegers and Boekaerts, 1996 and Relich, 1996) have consistently found that, from the beginning of the secondary school stage, females perceive their mathematical ability to be lower than that of males and that males are significantly more confident of themselves as learners of mathematics and this pattern was supported by the findings of the present study.

These gender differences were similar to those found in the **Male Domain** sub-scale. Although girls did not strongly stereotype mathematics as a **Male Domain** they believe much more than boys that mathematics is more appropriate for males than for females and this was particularly evident in the younger pupils. Low scores indicate that mathematics is not a **Male Domain**. In this study, the results on this sub-scale are similar to other research in different countries and different educational levels (e.g. Forgasz, Leder and Gardner 1996, and Norton and Rennie, 1998). Although gender differences in perceptions of mathematics as a **Male Domain** may not be as significant as it may have been when the original scale was constructed, they are persistent and still evident in current work.

However there were studies where contradictory findings were reported. Further, Kaiser-Messmer (1993) noted that girls believed much more than boys that females are as equally talented in mathematics as males.

The mathematics teachers influences are frequently invoked to explain gender differences in pupil participation and performance in post-compulsory mathematics courses (Fennema and Sherman, 1978; Becker, 1981; Fennema and Peterson, 1985; Mallan, 1993; Jungwirth, 1991 and Fennema, 1996). In general, boys rated their perception more positively than girls on how their mathematics teachers feel about them as learners of mathematics. This was particularly evident within the older pupils.

However, if the sample was split by grade level, the gender comparison did not display any significant difference and this was consistent within the school type. The picture found here, was similar to that of Sherman and Fennema (1977) who reported little evidence that females more than males perceived their teachers as less positive toward them as learners of mathematics but contradicts that of Forgasz (1995) who stated that teacher variables were stronger indicators of mathematics attitude for males than for females.

In the study of Forgasz and Leder, (1996) the results of the large scale survey suggested that individual students who perceive their mathematics teachers to be interested in them as individuals, who feel classroom participation is promoted (pupil-centred) are also likely to have more functional beliefs about themselves as learners of mathematics. This suggests that in the case of the present study, it could be expected that boys and girls having a similar perception about the interest of their teacher of them as learners, would be similar in **Confidence** in working in mathematics. However this was not found in this study as mathematics teaching in Mozambique is basically teacher-centred.

The **Usefulness** sub-scale comprised 12 items and in general the Mozambican lower secondary pupils involved in this study to a great extent rated these items highly with means reaching above 4 on the 5 point rating scale. Toomey and O'Donovan (1997) stated that there is a conventional wisdom for most people about the importance of mathematics in western and other societies.. The grounds for its special importance include, amongst many other things, the role that it plays in developing logico-deductive thinking skills and its contribution to improving the nation's economic competitiveness. This underlined importance could be the same reason by which pupils of this study decided to rate the mathematics' **Usefulness** so highly.

Maccoby and Jacklin (1974); Fennema and Sherman (1977); Forgasz (1995) and Tartre and Fennema (1995) reported that pupil perceptions about the **Usefulness** of mathematics showed minimal if any differences between males and females, and showed to be independent of the other attitudinal variables. In this study, only in this sub-scale did girls' ratings slightly surpass some of the values of boys, apparently showing that girls agreed equally with boys that mathematics is useful.

This gives support to Kaur (1995) when reporting that regardless of gender, a majority of the students believed in the practical utility of mathematics, which is in opposition to Fennema (1985), Barnes and Coupland (1990), Leder (1993), Tartre and Fennema (1995) and Forgasz (1995). These authors have found that females do not perceive the **Usefulness** of mathematics, for their future, as clearly as males do, since many more females than males see mathematics as neither relevant to their interests and experiences, nor useful to them, in their future lives and careers.

5.3 PATTERNS OF CLASSROOM INTERACTIONS

This research explored the possible gender patterns in the mathematics classroom interactions between the pupils and their teacher. An observation scheduled was constructed and used. Within the total number of interactions recorded (3864), 18% involved the mathematics teacher interacting with the class as a whole. Therefore, only the teacher-individual pupil's interactions could be analysed for possible gender trends. The observed classes had more girls than boys.

Boys were found to interact in public much more with their mathematics teacher than girls and, this boy domination can be seen as a consequence of the higher proportion of teacher-boy interactions on mathematics content. It appears that, as Fennema (1996) argued, these mathematics classrooms were often more favourable to boys' learning than to girls' learning. In other studies, (Becker, 1981; Koehler, 1990; Leder, 1990b; Leder, 1993; Atweh and Cooper, 1995; Forgasz and Leder, 1996 and Reliech, 1996) it was also found that males and females are not treated equally in the mathematics classroom.

Females are interacted with less frequency. Similarly, Leder (1990a) and Taber (1992) reported that boys were involved in significantly more public interactions with their teachers than girls, and in particular, in more interactions related to the subject content. This male dominance in interactions with the teacher was in classrooms with more girls than boys. Gender related differences in pupils' attitudes toward mathematics as well as in their mathematics performance, are reported (e.g. Armstrong, 1985; Fennema and Sherman, 1977, 1978 and Joffe and Foxman, 1986) as being influenced by patterns of interaction in mathematics classrooms which, according to Kimball (1989), are particularly affected by the teacher's attitude and classroom climate.

In this study, within the private interaction and particularly in grade 10, it was found that girls could be expected to interact much more with their mathematics teacher than boys but as it was previously mentioned (see Section 3. 3.2.1, page 79) these type of interactions did not allow the observers to note the contents.

It is not possible to reject the possibility that teacher tried to encourage girls by working one-to-one (**Private** interaction) instead of stimulating a total competitive atmosphere. This argument is supportive of Peterson and Fennema, (1985), who concluded that girls' mathematics performance related negatively with a competitive environment and on the other hand, according to Fennema et al. (1990) boys were perceived to be more independent in mathematics than were girls.

Of the total classroom mathematics interactions 90% were initiated by the teacher and were more often addressed to the boys than to the girls. It shows that the Mozambican mathematics teaching is still following the traditional teacher-centred approach, which according to Isaacson (1990), favours only the confident pupils while the more reticent and of course, less confident are at a disadvantage. If the lower confidence expressed by girls in this study, is taken into account then girls should be seen as disadvantaged in these mathematics classrooms. Effectively, Gerdes, (1985) argues with the view that a competitive classroom is destructive for a lot of students who change their view of mathematics, and it is particularly important for Mozambican pupils who need to be encouraged to participate in mathematics and related fields.

During mathematics lessons, in both grades the mathematics teachers have shown greater preference in nominating boys than girls to solve problems on the board while in the category of teacher nominating a specific pupil to answer at the desk, boys and girls had similar proportions. The teacher reaction was gender-based, since the teacher was indifferent to the pupils' answer (did not give any feedback) more frequently to the boys than it was to the girls. Similarly the teacher finished the interchange by giving the answer, proportionally, more times to the boys than to the girls.

Most of the questions asked by the teacher received a correct answer from boys as well as from girls although in almost all of the modes of teacher asking a question, either by nomination or by selecting a volunteer, girls answered more correctly than did boys and, very few boys or girls were called upon to give an answer on the board or at the desk and then gave an inadequate answer or kept silent. These results could be interpreted as supportive of Wood's argument (1994) when saying that in traditional school mathematics classes, the patterns of classroom interactions that are constituted, are of such a kind that students do not need to be involved in any mathematical thinking to participate. Instead they need only to be able to carry out the appropriate behaviour in response to the teacher's actions.

A particular finding is related to the incorrect answer given by the pupils. Boys answered incorrectly in all the different questioning modes, more often than did girls and it can be justified by the argument of Solar (1995), who also noted that sexism in the classroom interaction is evident in gender differentiating feedback, differentiating when giving attention and the opportunity to speak in the classroom or by asking males the more complex and difficult questions.

Leder, (1990a) and Jungwirth (1991), have reported that boys were spoken too more often than girls, particularly where asking questions and giving spontaneous answers. In this study, the pupil-initiated interactions were dominated by means of questions, and the data shows that in general girls and boys had similar frequencies, regardless of the grade level.

However, as Fennema (1996), stated, the impact of this classroom differential treatment from the teacher to the boys and girls is still unclear and difficult to ascertain and it does not support the premise that differential teacher treatment of boys and girls causes gender differences in mathematics enrolment. Eccles and Blumenfeld, (1985); Koehler, (1990) and Leder (1982a), all arrived at a similar conclusion when they claimed that there still is not sufficient evidence to conclude that interacting more or differently with girls than boys is a major contributor to the development of gender differences in mathematics performance.

5.4 PUPILS' MATHEMATICS PERFORMANCE

There is substantial evidence in the literature, that males frequently perform better in mathematics but this difference is affected by many factors such as pupils' age and school level. It can be seen in the findings of authors such as Maccoby and Jacklin, (1974); Hilton and Berglund (1974); Hall and Hoff (1988); Kaelley (1988); Hyde et al. (1990); Levin, Sabar and Libman (1991) and Kaiser-Messmer (1993), when stating that there are no gender differences in elementary or middle schools, and only small differences in favour of the males in high schools and higher education meaning that gender differences in mathematics learning are not usually evident in elementary/primary grades school, but emerge during adolescence.

Particularly in this study, pupils' mathematics performance in general, did not display significant gender differences since only in grade 10 were the older state school pupils shown to be different, the boys being better than the girls. Though as Becker (1990a) argued the absence of mean differences in the performance of both gender groups is not sufficient evidence for a conclusion that such differences do not exist. On the other hand, some authors (e.g. Fox and Cohn, 1980; Fennema, 1985; Kaiser-Messmer, 1993; Bohlin, 1994 and Forgasz, 1995) argued that there were several factors that may influence the levels of performance of males and females. In this context, classroom and standardised tests were independently compared in an attempt to explore possible gender differences.

An interesting finding came from the comparison of means of the classroom tests (ACSs). Within the younger pupils of the non-state schools, in both grade levels, girls slightly surpassed boys, while in the state schools older boys of grade 10 performed significantly better than girls of the same age group and grade. This is consistent with the findings of various authors (e.g., Armstrong, 1981; Marshall, 1984; Hall and Hoff, 1988; Tartre, 1990; Battista, 1990; Mji and Glencross, 1996; Cronjé, 1995 and Barnard and Cronjé, 1996) who argued that male superiority in mathematics is found especially in performance on tasks of higher cognitive complexity that have not been explicitly taught such as true problem solving, and they were non-existent, or even to the advantage of girls, for algorithmic problems reflecting the classroom contents.

When considering the standardised tests (ACPs), it was evident that tenth grade pupils' differed within the older group with boys significantly outperforming the girls. Boys and girls of grade 9 performed similarly and this was also the case when the age group was considered. Different findings reported by Friedman, (1989) and Hyde, Fennema and Lamon, (1990) said that differences in performance favouring males, are decreasing as a function of the grade level. The increasing gender difference in the present study could be interpreted as influenced by factors such as anxiety and a competitive learning environment affecting grade 10 pupils, who have to write an external assessment (the National Examination), more than pupils of grade 9.

As a whole, the mathematics National Examination included a total of 19 questions, which varied from questions that could be answered by applying simple rules to more complex problems comprising 3 cognitive levels (**Knowledge**, **Understanding** and **Application**). The scores in the questions, which covered the relevant mathematical topics, taught in the grades 8, 9 and 10 (Algebra, Euclidean Geometry, Trigonometry and Statistics) were compared taking note of the pupils' gender.

In general there were no apparent gender differences in the performance on the Mathematics National Examination. However, there was a significant age group effect with the younger pupils performing better than the older pupils. This indicates that boys and girls belonging to the same age group were more similar than different. This contradicts the findings of Linn and Hyde (1989) who have found that, although gender related differences in mathematics achievement are visible as early as late childhood, they are clearer in old students.

However, if this comparison is done between the gender and age groups, a different picture is seen. The main effect of age group on the Mathematics National Examination was found to be statistically significant with the younger pupils outperforming the older ones, regardless of the gender. This could be interpreted in accordance with the Leder's (1992) point of view: the extent and direction of the gender differences might depend on the age of students, and on the type, the format, and the content of the measures administered. It means that the issue of gender and mathematics is extremely complex and must be concerned with an issue much broader than the domain of the scholarship (Fennema and Hart, 1994; Fennema, 1996).

On the other hand, the displayed gender similarities might reflect particularly the present educational goals and teaching approaches in use. This could include the content and formats of the assessment measures (including the National Examination), which are biased and oriented to the lower cognitive levels reflecting mostly the classroom content, with little or no examining at the **Application** level as this is not a requirement.

These characteristics are reinforced by the way in which the instructional instruments were developed. Hence for instance, problem solving and topics like spatial geometry, which are reported to produce gender differences favouring boys (Leder, 1990b; Bohlin, 1994; Fennema and Peterson, 1985 and Cronjé, 1996), are covered minimally and relegated to a small space in the curriculum and also in the manuals used as textbooks. Thus, the results here described are necessarily expected.

The pupils involved in this study have been educated in the Mozambican Education System, which is centrally controlled. Thus, they have received the same general education, as well as the equivalent mathematics education; which is compulsory to grade 10. The system is supposed to be gender fair, yet small differences in attitude to mathematics have developed in general favouring the boys. Nonetheless both boys and girls have the perception that both genders are equally talented mathematically.

An in depth analysis of the pupils' performance in the National Examination at question level showed that in 3 questions (4c, 5, 6b) out of 6 of the understanding level and a further 5 (7a, 7c, 8a, 8b, 8c) of 7 questions at the Application level discriminated differently for boys and for girls. Questions 4c, 5, 6b, 7a, 7c and 8c discriminate badly in the boys' group while questions 8a and 8b did not discriminate adequately for the girls although they did discriminate adequately for the boys.

In question 7d, the assumption was that the pupils have not met this type of example in the form given in the mathematics examination, it was required to extrapolate a known procedure to a new situation, girls more than boys found it difficult. The reverse was seen in question 6b, where it was expected that pupils should be able to recognise the applicability of a formula or method in different or unusual context. This question was found easy mostly for girls than for boys.

Once again it was evident that what is reported in the literature is applicable here. At the lower levels, girls' advantage is seen while having to solve what was not explicitly taught shows boys' superiority. Similar findings were reported by Kaur, (1990) who found that the few questions in which girls surpassed boys were generally of the type that call for recognition or classification, application of techniques or substitution of numbers into an algebraic expression.

The reported values of the difficulty indices showed that in general pupils experienced the same difficulty in the National Examination, however comparing the mathematics performance of the same pupils at grades 8 and 9 it was found that the younger girls statistically significantly outperformed the other three age-gender groups. This result is still partially consistent in grade 10, only within the girls' group, since the other comparisons did not display statistically significant differences. Here, it was noted that the lower secondary cycle performance as a whole, showed younger girls consistently outperforming the other three gender-age groups with statistical significance. These results stressed the perception that the mathematics lessons and assessments concentrated on the lower cognitive levels and, younger pupils may benefit from the teaching approaches and assessment measures.

On the other hand, the results of previous studies in Mozambique (e.g. Cassy, 1997, Cassy and Fridjhon, 1999, Cassy and Fridjhon, 2001) related to the pupils' performance are supported here. Hence, the negligible gender differences in performance reported here, cannot justify the stronger gender differences in participation in mathematics and related fields.

A similar point of view held by authors (e.g., Hanna 1989 and Solar 1995) who argued that females are succeeding just as well as males in mathematics, yet they participate much less in mathematics related careers. For them, just because females can succeed in mathematics does not ensure that females will choose to pursue careers in this field. Meanwhile, Linn and Hyde, (1989) underlined that the development of gender differences in career choices occurs independently of girls' achievement levels. Their findings showed that as girls grow older they begin to lose their interest in science even when they perform as well, or even better, in the subject as their classmate boys.

5.5 CLASSROOM INTERACTIONS, PUPILS'ATTITUDES AND PERFORMANCE IN MATHEMATICS

In examining the correlations between the attitudinal variables and performance measures it was found that significant, but not meaningful relationship between mathematics achievement and attitude were found when considering the MAS and the different sub-scales, and the mathematics performance in the Classroom tests (ACSs) and Standardised tests (ACPs) for boys as well as for girls. An interesting pattern appeared, **Male Domain**, **Confidence** and **Teacher attitude** sub-scales correlated significantly higher with the ACPs for girls than for boys. Marsh, Smith and Barnes (1985), have found that although the girls outperformed boys on a standardised mathematics test, they nevertheless had lower mathematics **Confidence** than the boys. This was contradicted in this study. Girls not only performed significantly worse in the standardised tests but also showed that they were less confident than boys, supporting Fennema and Sherman (1977) who have noted that **Confidence** in one's ability to learn mathematics is strongly correlated with mathematics achievement. Another point of view claimed by Seegers and Boekaerts (1996) when arguing that the greatest differences between males and females could be found in their attitudes to mathematics and confidence rather than in their mathematical achievement.

In grade 9, the largest correlation, was between **Confidence** and the ACPs, for girls, and between **Teacher Attitude** and the semester scores for boys. In grade 10, both gender groups reached the highest correlation values between **Usefulness** and ACPs. This is partially supportive of Reliech (1996) who found that, although boys and girls have a similar performance, there is considerable evidence that males are more positive about personal abilities in mathematics when compared to females.

Most of the pupils were found to have a neutral attitude towards mathematics regardless of the gender. The exceptions were the higher achievers group in grade 9 as well as in grade 10, where boys with positive attitude towards mathematics attained higher percentage than boys with neutral attitude. It shows that boys' positive attitude could be a consequence of their positive achievement. This particular finding contradicts Weinburgh, (1995) who found that, in general, the correlation between attitude towards science and achievement in science was somewhat stronger for girls than for boys, indicating that a positive attitude is more necessary for girls in achieving high scores. Tartre and Fennema (1995) reported identical patterns showing strong positive correlations between mathematics achievement and **Confidence**, for males and females. Neither gender showed consistent patterns of correlations between mathematics achievement and the effect of the **Teacher Attitude** or the perceived **Usefulness** of mathematics.

However, there appeared to be differences between genders in the pattern of the correlations between mathematics achievement and the stereotyping of mathematics as a **Male Domain**. The **Male Domain** sub-scale was not related to mathematics achievement for males. Though, for females less stereotyping was positively correlated to mathematics achievement. This supports the findings of Forgasz, Leder and Garner (1996), confirming that although the gender differences in the perceptions of mathematics as a **Male Domain** had declined over the years, they are still persistent and evident currently . Similarly, Kaur (1995) has found that only higher achievers males believed in the common stereotype of mathematics being a **Male Domain**.

When considering the correlations between the patterns of classroom interactions and pupils' mathematics performance it was found that in grade 9, the higher achievers girls had the highest percentage of interactions in the categories of Private interactions, selection within the volunteers, and nomination by the mathematics teachers. In grade 10, medium-achievers boys were proportionally nominated more by the mathematics teacher than the other gender-performance criteria groups, while in Private interactions and selection of the volunteers to answer/solve the mathematics teacher question/problem, the medium achieving girls had more interactions.

Higher achievers girls had more Private interactions with the mathematics teacher than did the boys of the same achievement level. Although relatively more higherachievers girls were selected within the volunteers, the mathematics teachers nominated more higherachievers boys than girls. It is reflective of the common belief that mathematics is more appropriate for boys than for girls and thus only after girls have shown an interest in participating that mathematics teacher tried to involve them. These results allow one to make the inference that traditional classrooms may also be implicated and differentially influence the affective beliefs of male and female pupils as found by Forgasz and Leder (1996).

Girls with neutral attitude towards mathematics, in grade 9, were found to have proportionally more Private interactions than all the other groups. This group was not represented within the volunteers selected in grade 9 and, within the pupils with Private interactions in grade 10. Perhaps the proportionate difference in Private interactions could infer that these pupils are more unsure about their mathematical abilities, and that the teacher then approaches them in a more co-operative way by means of Private interactions.

The mathematics teacher nominated and selected within the volunteers more girls than boys, regardless of the pupils' attitude towards mathematics in grade 10. However, in grade 9, the teacher selected more volunteer boys with a negative or neutral attitude than girls with similar attitudes, while within the pupils' group of positive attitude more girls than boys were selected. The teachers' nomination also differentiated boys and girls in grade 9 since girls more than boys, within all the attitude groups were nominated. This shows that the patterns of classroom interactions are a direct consequence of teacher's attitude and influenced by the pupils' attitude towards mathematics. Clearly the attitude of teachers was of great importance and these results give support to the findings of Barnes and Coupland (1990) who stated the teaching methods used in mathematics contribute to create barriers to female participation. On the other hand, the same results confirmed the argument that teachers have interacted more frequently with pupils for whom they held positive expectations. This conclusion was also found by Koehler (1990) and Forgasz and Leder (1996) amongst others.

5.6 CONCLUSIONS

This study aimed to find out the influence of certain school-based factors on gender differences in participation in mathematics by means of an attitude scale, achievement tests and an observational schedule. To this end two research questions were addressed:

Research Question 1:

> ***Do teacher-pupil and pupil-teacher interactions in the mathematics lessons show a typical pattern based on gender?***

The observed classroom interactions showed the existence of patterns based on gender with boys having more interactions, particularly those involving mathematics content, with the mathematics teacher, and being selected more frequently within the volunteers than were girls. However, the girls more frequently answered the questions correctly when they were asked directly by the teacher or when volunteers were called for, and also interacted one-on-one with the teachers more frequently than did the boys.

The teacher's feedback also presented a gender-related difference since when a partially correct answer or incomplete solution was presented, the boys were given the correct answer or helped more than the girls. The girls were more likely to have the question repeated. An inadequate response yielded the boys being given the solution, and the girls having the question repeated more frequently.

Thus, it is possible to conclude that the mathematics classroom interactions are influenced by the teacher's behaviour and, the way in which the interactions occur are likely to promote more active participation from boys than from girls.

Research Question 2:

Does a relationship exist between classroom interactions, pupils' attitudes toward mathematics and pupils' mathematics performance? If so, how is it affected by gender?

In this study it was evident that there are gender differences in pupils' attitudes toward mathematics and boys were found to rate themselves with a more positive attitude than girls. Important components of these differences were the pupils' **Confidence** in working in mathematics and the perception of mathematics as a **Male Domain** since it was in these attitude sub-scales that the pupils significantly differed by gender.. Although both boys and girls rated as positive, but not to a great extent, boys showed to be more confident than girls. Similarly, boys admitted less than girls, that mathematics is a **Male Domain**.

Teacher Attitude and **Usefulness** sub-scales did not show gender differences in pupils' attitudes, boys and girls rated them similarly. The stronger positive correlation between **Male Domain**, **Confidence**, **Teacher Attitude** and the standardised tests (ACPs), that was evident for girls was not so for boys. This allows one to infer that pupil attitude is a stronger predictor of girl achievement in this type of tests.

Positive attitude was more related to positive achievement for girls than it was for boys. However, the small differences in performance between boys and girls did not mask the gender differences in **Confidence** where girls where shown to be more unsure of their mathematical abilities than boys.

On the other hand, patterns in classroom interactions were clearly affected by the gender differences in **Confidence** in working in mathematics. This conclusion emerged particularly from the differences observed in being selected from within the volunteers. More than for girls, boys were selected by their mathematics teacher to answer at the desk as well as on the board. This is of interest since, if no girls were volunteers, the mathematics teachers did not select girls in an attempt to mantain a gender equity. Therefore, the pupils' confidence in performing well in mathematics contributed to the existence of patterns of interactions favouring boys.

Thus, it was concluded that:

a) Albeit gender differences are small, they exist in the patterns of mathematics classroom interactions, attitude towards mathematics and mathematics performance.

b) The gender differences in mathematics performance, attitudes toward mathematics and classroom interactions by themselves are not large enough to justify the gender disparities that exist in the pupil's participation and career choice involving mathematics.

c) Teacher attitude may have contributed to the gender differences observed.

d) Other school and socio-cultural factors might play a role in creating or reducing gender differences.

5.7 RECOMMENDATIONS

The study was limited to relationship between pupils' mathematics performance, attitudes toward mathematics and classroom interactions. It would be beneficial in the future to extend the data to include a self-reported attitude measure on pupils' mathematical performance and attitudes toward mathematics of these pupils for parents and school staff.

The current study also did not investigate the out of school factors that may have exerted an influence on pupils' mathematics performance and attitudes toward mathematics. It must be examined how these socio-cultural conditions affect the educational environment of the pupil as well as affect the personal belief system of each learner taking into account the differences based on gender. Efforts to improve students' mathematics performance and attitudes toward mathematics should be made at both primary and secondary schools and may need tailoring to gender.

Thus, if girls will not spend time in making an effort in studying mathematics, and if they do not have sufficient time to do tasks which they regard as essential for females, if the society regards the promotion of a greater participation of women in the professions that require a strong background in mathematics then, the mathematics' teachers must be aware of gender issues, particularly:

a) That mathematics is useful in the real world.

b) That a gender neutral domain is required for successful teaching of mathematics to both genders.

c) That the girls are equally talented as boys with a similar potential for learning mathematics.

Naturally females faced several obstacles, among them the fact that the teaching approaches are teacher-centred promoting a competitive climate, which is not conducive to female higher performance and they have few female role models since even their teachers are predominantly male.

It is imperative therefore that any strategy designed to produce gender equity in mathematics and related fields should focus not only on encouraging more females pupils to take mathematics, but also to promote classroom active learning (student-centred approaches) and by recruiting training and retraining more female educators.

The following strategies should serve as recommendations from this study to contribute to the reduction of the gender bias observed, through the improvement of the teaching/learning approaches and for guiding further research:

a) Promote short in-service teacher training courses to modernise teaching approaches, (active learning approaches/co-operative climate).

b) Create female role models in the education system by attracting more females to activities mostly for science subjects since in Mozambique there are a small number of women mathematics and science teachers who can serve as these role models.

c) Involve society in the attempts to find the solutions for the low participation of girls especially in the mathematics field.

d) Promote extra-curricular activities on the evident applicability of mathematics in the real world.

e) A qualitative study should also be done to explore potential causes of the observed gender differences analysing classroom interactions, teacher guides and pupil textbooks for gender bias and other extra-school societal variables.

f) An in depth analysis should be done on the subjects and courses girls take and those they avoid, at the upper secondary level, especially with reference to mathematics and its related fields.

g) Explore the attitudes of pupils, teachers, parents, curriculum developers and other education officials toward gender issues with a view to sensitisation.

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APPENDIX A-1:

QUESTIONNAIRE

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DEAR STUDENT!

You are kindly invited to fill this questionnaire. Your opinion related to the statements in this questionnaire can be helpful in improving the teaching and learning of mathematics. Refusal to participate, you are free to do so and it will not involve any kind of implications on your schooling. In this way it will be good if you can answer seriously Please circle the number that best represents your feelings on each statement.

- If you strongly agree	**5**
- If you agree	**4**
If you nor agree nor disagree	**3**
- If you disagree	**2**
- If you strongly disagree	**1**

All the information obtained from this questionnaire will be treated anonymously and used only for the research purpose.

Maputo, July 1999

//

School: ____

Name: ____

Grade: | 8ª | 9ª | 10ª | **Class:** | |

Gender | Boy | | Girl | **Age** | |

//

QUESTIONNAIRE

N.		Statement	
1	U	The study of mathematics helps to develop logical reasoning	1 2 3 4 5
2	MD	Males are not naturally better than females in mathematics.	1 2 3 4 5
3	T	I am called on by the teacher to answer questions	1 2 3 4 5
4	T	My teachers think advanced mathematics will be a waste of time for me	1 2 3 4 5
5	MD	Women certainly are smart enough to do well in mathematics	1 2 3 4 5
6	U	Taking mathematics is a waste of time	1 2 3 4 5
7	MD	I would have more faith in the answer for a mathematics problem solved by a man than a woman.	1 2 3 4 5
8	C	I am not good in mathematics	1 2 3 4 5
9	T	Getting a teacher to take me seriously in mathematics is a problem	1 2 3 4 5
10	T	I have a hard time getting teachers to talk seriously with me about mathematics	1 2 3 4 5
11	T	Mathematics teachers have made me feel I have the ability to go on in mathematics	1 2 3 4 5
12	C	I am sure that I can learn mathematics	1 2 3 4 5
13	A	Mathematics makes me feel uncomfortable and nervous	1 2 3 4 5
14	T	I feel that mathematics teacher ignores me when I try to talk about something serious	1 2 3 4 5
15	MD	I would trust a female just as much as I would trust a male to solve important mathematics problems.	1 2 3 4 5
16	U	I see mathematics as something I will not use very often when I get out of school	1 2 3 4 5
17	U	I do not expect to use much mathematics when I get out of school	1 2 3 4 5
18	T	I would talk to my mathematics teacher about a career that uses mathematics	1 2 3 4 5
19	MD	I would expect a woman mathematician to be a forceful type of person	1 2 3 4 5
20	MD	Women who enjoy studying mathematics is a little strange.	1 2 3 4 5
21	U	Mathematics is not important for my life	1 2 3 4 5
22	MD	It is hard to believe a female could be a genius in mathematics.	1 2 3 4 5
23	C	I am sure I could do advanced work in mathematics	1 2 3 4 5

24	U	Mathematics will not be important to me in my life's work	1 2 3 4 5
25	A	If I miss a mathematics class, I felt behind to the others students	1 2 3 4 5
26	T	My teachers would not take me seriously if I told them I was interested in a career in science and mathematics	1 2 3 4 5
27	U	I study mathematics because I know how useful it is.	1 2 3 4 5
28	U	I will need a good understanding of mathematics for my future work	1 2 3 4 5
29	C	I think I could handle more difficult mathematics	1 2 3 4 5
30	T	My teachers think I am the kind of person who could do well in mathematics.	1 2 3 4 5
31	U	A knowledge of mathematics is helpful in understanding today's world	1 2 3 4 5
32	U	Doing well in mathematics is not important for my life	1 2 3 4 5
33	MD	Women can do just as well as men in mathematics	1 2 3 4 5
34	MD	Studying mathematics is just as good for women as for men.	1 2 3 4 5
35	C	I know I can do well in mathematics	1 2 3 4 5
36	C	Mathematics has been my worst subject	1 2 3 4 5
37	T	My teachers want me to take all the mathematics I can	1 2 3 4 5
38	C	I solve a problem by working hard	1 2 3 4 5
39	C	I am not the type to do well in mathematics	1 2 3 4 5
40	C	I can get good grades in mathematics	1 2 3 4 5
41	MD	Females are as good as males in geometry	1 2 3 4 5
42	A	When the teacher ask me a question I am worried with the possibility to do it poorly	1 2 3 4 5
43	C	I do not think I could do advanced mathematics	1 2 3 4 5
44	MD	Males are naturally more capable to succeed in mathematics than females	1 2 3 4 5
45	C	I would rather memorise a list of things than try to solve a problem.	1 2 3 4 5
46	A	Taking mathematics tests scares me.	1 2 3 4 5
47	T	It is hard to get my mathematics teachers to respect me.	1 2 3 4 5
48	A	I enjoy exercises that challenges me	1 2 3 4 5
49	T	My teachers have encouraged me to study more mathematics	1 2 3 4 5
50	U	Mathematics is a worthwhile, necessary subject	1 2 3 4 5
51	U	Knowing mathematics will help me earn a living	1 2 3 4 5
52	C	I am sure of myself when I do mathematics	1 2 3 4 5

U=usefulness; C=confidence; MD=male domain; T=teacher attitude; A=anxiety

APPENDIX A-2 **OBSERVATIONAL GRID**

School: ________________________________
Grade: _____ **Class:** _____
Number of Pupils: *(Boys)* _____ *(Girls)* _____.
Date: ___/____/ 1999
Time: *Start* ________ *End* ________

Classroom Organisation: *Rows* _____ *Groups* _____
Composition of the Groups:

	g-1	g-2	g-3	g-4	g-5	g-6	g-7	g-8
Boys								
Girls								

	Pupil Activity													Other calls	
	Gender		Questioned				Answer					Initiate talk			
N.			Specif		Volunt		+	±	–	0	Not adequate				
	B	G	*d*	*b*	*d*	*b*								B	G

Teacher Activity											
Reaction to the pupil's answer					Gave answer	Repeated quest.	Clue	Asked other Pupil	New quest	Other Interact.	
++	+	0	–	– –							
										B	G

PUPIL ACTIVITY

B	=	Boy
G	=	Girl
Specif	=	Specific pupil nominated by the teacher
Volunt	=	Volunteer for answering a question selected by the teacher
+	=	Correct answer
±	=	Incomplete or partially correct answer
–	=	Wrong answer
0	=	No response
Not Adequate	=	Pupil said that he/she does not know
b	=	Pupil solved exercise on the board
d	=	Pupil gave answer at the desk
Other Calls	=	Other pupil gave the answer spontaneously

TEACHER ACTIVITY

+ +	=	Teacher praised the answer (TPri)
+	=	Teacher simply said correct (SCor)
–	=	Teacher simply said wrong (SW)
– –	=	Teacher criticized the answer (TCri)
0	=	Teacher gave no reaction (NoR)
Gave answer	=	Teacher gave the answer (TGA)
Other interactions	=	Non-Mathematics Content Interaction
Clue	=	Teacher gave a clue (TGC)
Repeated quest	=	Teacher repeated the question (TRQ)
New quest	=	Teacher addressed a new question to the same pupil

APPENDIX A-3

CLASS MAP

School: ______________________________

Grade: ________ / Class: ________

		1.	2.		3.	4.		5.	6.		7.	8.
		9.	10.		11.	12.		13.	14.		15.	16.
		17.	18.		19.	20.		21.	22.		23.	24.
		25.	26.		27.	28.		29.	30.		31.	32.
		33.	34.		35.	36.		37.	38.		39.	40.
		41.	42.		43.	44.		45.	46.		47.	48.