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UNIVERSITY OF THE WITWATERSRAND
Faculty of Science
School of Science Education

# GENDER PERFORMANCE AND ATTITUDES TOWARD MATHEMATICS IN BUSCEP STUDENTS AT UNIVERSIDADE EDUARDO MONDLANE

Bhangy Cassy

A dissertation submitted to the Faculty of Science, University of the Witwatersrand, Johannesburg, in fulfilment of the requirements for the degree of Master of Science

Johannesburg, 1997

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# DECLARATION

I declare that this Dissertation is my own, unaided work. It is being submitted for the Degree of Master of Science in the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in any other University.

Bhangy Cassy
Bhangy Cassy

25th day of November 1997

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I am particularly indebted to the Dutch Government (NL) who funded the Staff Development Program of the BUSCEP project, at Universidade Eduardo Mondlane, under the supervision of the Vrije University Amsterdam (VUA).

# Abstract

After Mozambique became independent from Portugal, the main aim of the government policy towards education was to create equity of opportunity to enter the formal education system for different social, gender and age groups. However, females are still under-represented in higher education particularly in courses which require an extensive mathematical background. Thus, the purpose of this study was, to explore possible gender differences in performance and attitudes toward mathematics among 1996 BUSCEP students at Universidade Eduardo Mondlane. Those students were tested on several affective and cognitive variables using a questionnaire and tests. The results suggested that gender performance and attitudes towards mathematics tend to be similar, and the inequalities found, were more evident in the participation in mathematics related careers. These findings emphasise the need to further examine the interrelationships between gender and career choices which should be conducted with students from the secondary school.

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# Chapter 1

# INTRODUCTION

## 1.1. BACKGROUND TO THE STUDY

For more than three decades, studies in gender differences in performance and attitudes toward mathematics and science subjects have been carried out, especially in English speaking countries. During this preceding period much has also been done in these countries about the low participation of females in the scientific and engineering careers which require an extensive mathematical background.

Mozambique is one of the Southern African countries and became independent from Portugal in 1975. In 1995 the population was estimated at 17.4 million people, with an average annual population growth rate of 2.7 percent (Direcção Nacional de Estatística, Maputo, 1995) and, the ratio between the number of males to females is estimated at 14 to 15.

### 1.1.1. The Mozambican Education System

After independence, the main aim of the government policy towards education was to create equity of opportunity to enter the formal education system for different social, gender and age groups. In the twenty year period, the index of illiteracy dropped from 90% to 70%, and the number of students in formal education increased at all levels compared with that before independence, (Direcção de Planificação, 1994).

However there are a large number of females who have never had the opportunity to enter some levels of the formal education system or who have dropped out along the way, particularly in post-primary education, (Direcção de Planificação, 1994).

In 1983, a new National Education System (Sistema Nacional de Educação - SNE) was established. As far as general education is concerned, the (compulsory) primary cycle covers 7 years (grades 1-7) and the secondary cycle covers 5 years, with grades 8-10 being lower secondary, and grades 11 and 12 upper secondary or pre-university. Vocational and technical training includes three levels. All schools in Mozambique are co-educational.

Table1.1 shows the growth of the participation of both gender in the secondary educational system in Mozambique, from 1990 to 1994.

**Table 1.1:** Percentage of male and female secondary school population from 1990 to 1994

| | Lower Secondary | | Upper Secondary | |
|---|---|---|---|---|
| | Males | Females | Males | Females |
| 1990 | 67% | 33% | 70% | 30% |
| 1991 | 67% | 33% | 64% | 36% |
| 1992 | 63% | 37% | 68% | 32% |
| 1993 | 61% | 39% | 70% | 30% |
| 1994 | 59% | 41% | 63% | 37% |

As can be seen, females are still underrepresented in secondary education in Mozambique. This situation can be explained, perhaps, by what Megarry (1984:15) claimed: "in some countries girls still have less secondary education than boys, and there are still systems in which girls are under represented in primary education. At one level these patterns are a consequence of individual and family decisions. At another level differential enrolment reflects decisions by governments as to what kinds and amounts of education are to be provided for girls".

Besides the technical and vocational training institutes (Agricultural, Commercial and Industrial Institutes with an entry level equivalent to grade 10 in the SNE), historically, there are three other institutions to be mentioned as being of relevance with respect to further training. The first is the Universidade Pedagógica (UP), where secondary school teachers receive their pre-service training. The second is the Instituto Superior de Relações Internacionais (ISRI), where training takes place for officials of

the Ministry of Foreign Affairs. The third training institute for post secondary education is the Universidade Eduardo Mondlane (UEM), founded in 1962 during the colonial era.

Since 1994, three other tertiary institutions were created, (the Universidade Católica, the Instituto Superior Politécnico e U ersitário, and the Instituto Superior de Ciências e Tecnologia de Mc ambique). However these institutions run under private administration and their contribution to the post-secondary training is still very little.

### 1.1.2. The Universidade Eduardo Mondlane - UEM

The UEM offers 21 degree programmes in 9 faculties. The duration of these programmes is 5 years (except Medicine what is 7 years) and leads to the *'Licenciatura'* degree. Courses are offered in the following faculties: Agronomy and Forestry, Architecture, Science, Law, Economics, Engineering, Arts, Veterinary Science and Medicine. Students have to pass entrance examinations in certain key-subjects before entering the university. The academic year starts on August 1, and is divided in two semesters: the first semester covers the period August-December and the second semester runs from February to June. Both semesters include 16 weeks of active teaching, followed by a period of examinations.

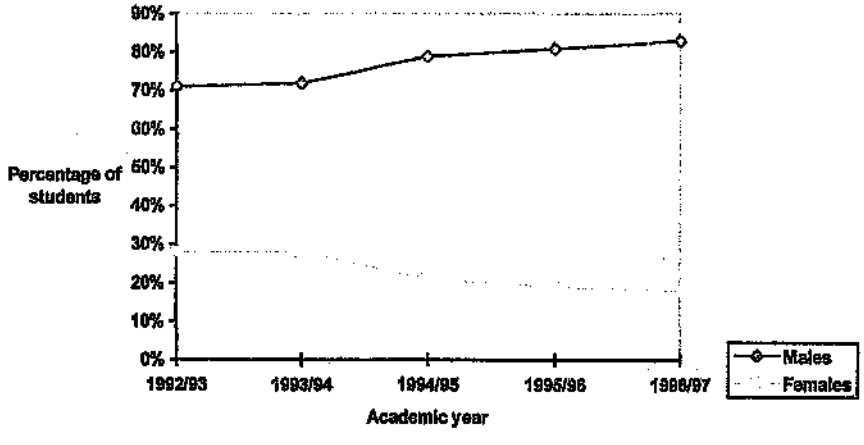
To improve the standards in mathematics and science of first year students in courses such as **Life science** (Agronomy and Biology); **Engineering** (Civil, Chemical, Electrotechnical and Mechanical) and **Science** (Geology, Physics and Chemistry), a remedial education programme was established in 1986 for the first semester at UEM, before

students start their own specific university courses. This programme is designated as Basic University Science Course - Experimental Project (BUSCEP).

The BUSCEP project is carried out in Maputo at the UEM as part of the inter-university co-operation between the Universidade Eduardo Mondlane (UEM) and the Vrije Universiteit Amsterdam (VUA) in the Netherlands. BUSCEP receives annually about 40% of the total number of incoming students at the Universidade Eduardo Mondlane (UEM).

At UEM, from the total number of incoming students in every academic year, only a small percentage are females. In figure 1.1, the growth of the number of the new students entering the UEM courses in the last five academic years by gender is shown, (Gabinete de Planificação, 1996).

**Figure 1.1: Percentage of new students at UEM, from the academic year 1992/1993 to 1996/1997 by gender**



Twenty years after independence, females are also still under-represented in higher education in Mozambique and the percentage of new students at UEM is continuously decreasing for females while consequently the percentage of males increases slightly in every academic year.

The Mozambican experience is consistent with other societies. According to some authors, (Catsambis, 1995; Maple and Stage, 1991; De Boer, 1986; Fennema and Peterson., 1985; Megarry, 1984; Meece et al., 1982; Fennema and Sherman, 1977), despite a world-wide increase in women's participation in higher education, the total number of women continues to lag behind that of men, especially in the university sector.

### 1.1.3. The Mathematics Curriculum

Mathematics is an interesting and valuable subject because it involves the study of everyday life. A strong mathematical background is a prerequisite to many career and job opportunities in this technological world of today.

In Mozambique, mathematics is taught as a compulsory subject from the beginning of primary school to the upper secondary school level. The mathematics syllabus taught at secondary school involves Algebra, Euclidean Geometry, Trigonometry, Statistics and Analytical Geometry. In Table 1.2 the distribution of the time spent on teaching mathematics at secondary school, is presented.

Table 1.2: Distribution of the time spent on teaching mathematics syllabus at secondary school

| | Lower Secondary | | Upper Secondary | | Total | |
|---|---|---|---|---|---|---|
| | Hours | % | Hours | % | Hours | % |
| Algebra | 300 | 62 | 197 | 64 | 497 | 63 |
| Euclidean-Geomet | 108 | 23 | - | - | 108 | 13 |
| Analytical-Geomet | - | - | 28 | 9 | 28 | 4 |
| Trigonometry | 38 | 8 | 35 | 11 | 73 | 9 |
| Statistics | 34 | 7 | 28 | 9 | 62 | 8 |
| Others | - | - | 22 | 7 | 22 | 3 |
| TOTAL (Hours) | 480 | 100% | 310 | 100% | 790 | 100% |

## 1.2. AIM OF THE STUDY

The purpose of this study is to explore possible gender differences in performance and attitudes toward mathematics on 1996 BUSCEP students. To this end, the following two main questions were addressed:

1. Do females perform mathemat[illegible]t a lower level than males at Universidade Eduardo Mondla[illegible]

2. Do attitudes toward mathe[illegible] differ across gender in BUSCEP students at Universidade Eduardo Mondlane?

The study will examine whether gender differences exist in performance and attitudes toward mathematics among BUSCEP 1996 students at UEM.

## 1.3. IMPORTANCE OF STUDY

The results obtained in the studies from many countries, especially in the English speaking world, cannot, be readily transferred to the situation in Mozambique, as there are large differences between the school system and its underlying educational philosophy, the economical development and the dynamic of the population.

The research is expected to provide statistical information about the 1996 BUSCEP students' mathematics performance and attitudes toward mathematics as a subject, and whether these attitudes played an influence on the performance in mathematics.

The knowledge which should be gained by this study could be used by UEM teachers in their evaluations and the selections of the learning and teaching methodologies to be used in the classroom, in order to improve at this level, the performance of both female and male students in mathematics, in university courses at Universidade Eduardo Mondlane.

The expected findings of this study should also suggest a need for the attention to the improvement of achievement tests based on what should be learned, not what is currently being learned. It has been hoped that, with the findings from this research it may be possible to contribute to the debates about the roles of decreasing the gender differences in mathematics performance and in attitudes toward mathematics. Thus, females might be encouraged in particular in enrolling in university courses that require extensive mathematics background.

## 1.4. LIMITATIONS AND DELIMITATIONS OF THE STUDY

Certain limitations of the present study need to be noted. The results of this study should only generalised to include students who have similar background in mathematics and similar academic levels as those have in Mozambique. In terms of this research this is not considered a limitation, because this study was specially aimed, for Post-secondary students in Mozambique.

The study involved university students for the reasons that they really start to follow their intended careers. Although only BUSCEP students took part in the study, the sample size was sufficient for the study, and representative of the university students in Mozambique as BUSCEP comprises all first year students for the faculties of Engineering, Sciences, and Agronomy which correspond to 40% of the total number of the new students at UEM.

The problems which are inherent in attitudinal studies cannot be totally excluded. According to Galfo, (1975) some of them are: subjects who are not eager to reveal their true feelings, the information collected can be wrongly interpreted, the statements may fail to measure the attitudes it seeks to measure, the instrument may not be appropriate for the intended group.

## 1.5. THE STRUCTURE OF THE DISSERTATION

This Dissertation is divided into Chapters as follow:

**Chapter 1:** "***Introduction***", provides an overview of the context in which the research was carried out. The purpose of the research questions as well as the limitations for the study are presented in this Chapter.

**Chapter 2:** "***Literature Review***", comprises a brief review of the relevant literature on gender-related differences in mathematics performance and attitudes toward mathematics; and, also the definitions of important terms used in the Dissertation.

**Chapter 3:** "***Methodology***", shows how the research was carried out. All the measuring instruments used and the procedures as well as the statistics techniques applied in the data analysis are also described.

**Chapter 4:** "***Results and Discussion***". In this Chapter, relevant results of the study are presented and discussed. Firstly, gender differences on the mathematics achievement tests are taken as a measures for mathematics performance. Secondly, gender differences in the attitude towards mathematics and gender differences on the approaches to learning mathematics, are taken as measures for affective variables.

Finally, the last **Chapter 5:** "***Conclusions and Recommendations***", attempts to summarise all the previous one. In this Chapter, the implications of the findings are discussed and several recommendations are made.

# Chapter 2

# LITERATURE REVIEW

## 2.1. GENDER-RELATED DIFFERENCES

A Review of the literature reveals that gender-related differences in achievement vary considerably both within and between countries. An inconsistent research findings on gender differences in mathematics achievement with males performing better in some studies and females in others, has been found.

Leder (1992), stated that, there is much overlap in male and female performance with between group differences overshadowed by within gender group differences. The extent and direction of gender differences can depend on the age of students, and on the type, the format, and the content of the measures administered, (Hilton and Berglund, 1974; Hyde, Fennema and Lamon, 1990; Leder, 1992).

Some studies indicate that males' achievement in mathematics is better than females' at some point in high school but that the size of this difference varies a great deal (Maccoby and Jacklin, 1974; Meece, et al,1982; Fennema, 1985). Among precocious adolescents, the differences

favouring males are larger and appear earlier than in a normal population (Benbow and Stanley, 1980; Benbow and Stanley, 1982).

According to authors such as Hall and Hoff (1988), Kaelley (1988), Levin, Sabar and Libman (1991), Kaiser-Messmer (1993), 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.

Fennema and Sherman (1977), found that when students with similar mathematics background were compared, (i.e., only those enrolled in mathematics), the data do not support either the expectations that males are invariably superior to females in mathematics achievement or the idea that differences between genders increase with age.

Few consistent gender-related differences are found at the primary school level, however, some gender differences in mathematics, perhaps not present at younger ages, have been reported to appear as soon as the students become adolescents (Hyde, Fennema and Lamon, 1990). For Leder (1985), there is a substantial body of evidence to suggest that by the beginning of secondary school level, males frequently perform better than girls in mathematics.

According to Hilton and Berglund (1974), the absence of gender difference in mathematics achievement at grade 5 level is consistent with the hypothesis of gender-typed interest if it is assumed that most such interests emerge during adolescence. At subsequent grade levels (grades 7, 8, 9 and 11) males have higher mean scores than females and the differences between the genders increase with age.

As claimed by Becker (1990), 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. Feingold (1994), on the other hand, stated that the absence of gender differences in mean scores may sometimes conceal greater variability of one of the groups, which actually represents a gender difference. Values of the ratio of these variance close to 1 represent similar variability of the two gender groups with regard to performance in mathematics.

Fennema and Sherman (1977), stated that the differences between male and female groups in mathematics achievement are small and where differences do occur, they suggest the influence of socio-cultural factors.

Other studies indicate that gender differences are limited to certain areas of mathematics (Hanna, 1986; and Hanna, 1989). Some researchers 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 (Fennema and Carpenter, 1981; Cheung, 1989; Fennema, Peterson and Carpenter, 1990; Hanna, Kundiger and Larouche, 1990; Fennema and Hart, 1994).

Of all the cognitive tasks, mathematics performance has been thought to show the largest differences in avour of males; these differences, not usually evident in grade school, are thought to emerge during adolescence (Maccoby and Jacklin, 1974).

In one meta-analysis carried out by Hyde, Fennema and Lamon (1990), it was shown that males generally achieved better than females at high cognitive level mathematics tasks. Male superiority in mathematics is found especially in performance on tasks of high cognitive complexity such as true problem solving (Fennema and Peterson, 1985; Hall and Hoff 1988; Battista, 1990 and Barnard and Cronjé, 1996). Meanwhile, Fennema and Sherman (1978) comparing mathematical tasks at several

levels of cognitive complexity, as, knowledge of concepts and problem solving found no gender-related differences for their sample of grades 6-8 pupils.

Leder, (1990b) also found that, on average, females do not score as high as males do on mathematics tests, especially if those tests involve higher level cognitive tasks. If gender differences are found for young children, they tend to favour females (Armstrong, 1981; Hyde, Fennema and Lamon, 1990) in knowledge and skills (Fennema and Carpenter, 1981). When the differences favour males, it is in the areas of understanding and application (Fennema and Carpenter, 1981) and problem solving (Tartre, 1990; Tartre and Fennema, 1995).

However, Seegers and Boekaerts, (1996) have concluded that males outperformed females on mathematics tasks using a test that reflected classroom content. These differences can be considered substantial, particularly in view of the fact that Kimball (1989) argues that females are in a disadvantageous position when standardised tests are given but not when doing tests that reflect classroom content.

In recent research, Barnard and Cronjé, (1996), studying gender differences in Euclidean geometry, found that the popular belief is that, where differences exist, they occur from adolescent onwards and favour males in achievement and participation in mathematics.

The differences in performance, between males and females, were more pronounced when the difficulty of the items increased, (Cronjé, 1995; Seegers and Boekaerts, 1996. Other meta-analyses indicate that the gender gap in performance has closed over time (Friedman, 1989).

In another study Becker and Forsyth, (1994) found that males generally performed better at the upper percentile levels of the score distribution in mathematics problem solving and science, while females closed the gap and, in some instances, outperformed males at the lower percentile levels. Fennema (1980), on the other side, considered that:

> "Since mathematics is a cognitive endeavour, the logical place to begin to look for explanatory variables of sex-related differences in mathematics performance is in the cognitive area. It is within this area that the most important variable can be found, that is, the amount of time spent studying mathematics".
>
> (Fennema, 1980:83)

Cronjé, (1995), argued that even though some contradiction exist, gender differences in mathematics performance are seldom found and, when they are found, they are relatively small.

A considerable body of research also highlights the key of the affective dimension in learning style preferences and attitudes towards mathematics including:

- how much ability the students felt they had in mathematics as a subject,
- how hard they worked in the school mathematics courses,
- how much they felt luck influenced their performance,
- how difficult they felt the subject was,
- which type of tasks they like in mathematics tests,
- what influence was played by mathematics performance in their career choice at university, and
- how they self-rate their previous results in mathematical performance, etc.

In studies by Seegers and Boekaerts, (1996) and Relich (1996), it has been claimed that the greatest differences between males and females can be found in their attitudes to and self-confidence in mathematics rather than in actual achievement.

Little's study (1985) identified 18 categories either from the attribution literature or from the responses themselves, to categorise the explanations which students presented for success or failure. These include 'effort', 'luck', past difficulties', 'help from others', 'mood', 'motivation', 'time spent', 'age', and 'facilities'. On the other hand, Little (1985) claimed that 'effort', 'interest' and 'performance ability' were the most frequently used explanations.

Moreover, differences in the affective domain seem to appear at an earlier age than differences in the cognitive domain with regard to mathematics. The differences are almost always to the disadvantage of females. (Cronjé, 1995).

Studies by Fennema (1985), suggest 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. She also claims that differential course-taking can occur in high schools where no ability differences are found.

Related to the usefulness of mathematics, according to Leder (1993), who found that males agreed more strongly than females that mathematics was useful, that it was enjoyable, and that they were confident about getting good grades in the subject. More often than females, males "attributed their success to ability". However, according to Seegers and

Boekaerts (1996), this discrepancy cannot be explained in terms of males' higher mathematics achievement because the difference remained when differences in performance were accounted for.

In addition, "statistics show that not only do girls drop out of mathematics in greater numbers than boys when the choice of mathematics course becomes available, but that only a very small percentage of all students, male or female, take the subject at higher levels". (Rodgers, 1990:29).

Leder (1982), Leder (1987), Leder (1990a) and Becker (1990) argued that, during lessons, females in co-educational schools are at a quantitative and qualitative disadvantage regarding the attention given to them by the teachers as well as the number and quality of questions asked.

Becker (1981), Jungwirth (1991), and Kaiser-Messmer (1993), claimed that there are gender differences in patterns of interaction between teachers and females or males, in which the pattern of interaction practised for males is more likely to make them appear more competent in mathematics.

As stated by Forgaz (1995), teacher variables correlated with mathematics attitude more strongly for female students than for males. Meanwhile, Fennema, Peterson and Carpenter (1990), claimed that one component of the external influences which affect the development of gender differences, is the teacher influence on both students' internal motivational beliefs and on students participation in classroom learning activities.

In a review that covered many publications, Fennema and Hart (1994), found that the research findings show the following trends:

1. Gender differences in mathematics may be decreasing.
2. Gender differences in mathematics still exist in
   - the learning of complex mathematics,
   - personal beliefs in mathematics,
   - career choices that involve mathematics.
3. Gender differences in mathematics vary
   - by socio-economic status and ethnicity,
   - by school,
   - by teacher.
4. Teachers tend to structure their classrooms in ways that favour male learning.
5. Interventions can achieve equity in mathematics.

(Fennema and Hart, 1994:650-651)

According to Bohlin (1994), females also suffer the consequences of traditional instruction and assessment practices. Proficiency in the rote memorisation of algorithms may result in short-term success.

Some researchers, (Bohlin, 1994; Mji and Glencross, 1996), argued that males and females have different mathematics learning styles (autonomous and rote respectively), and females perform better relative to males on items that require the application of a familiar algorithm (e.g., classroom tests).

Fennema (1979) suggests that if the amount and quality of time spent on learning mathematics can be somehow equated for males and females, educationally significant gender-related differences in mathematics performance will disappear.

On one hand, Jungwirth (1991), in a study on interaction and gender, claimed that students' beliefs about their abilities in mathematics and their developing attributions for success and failure in mathematics may be influenced by the way in which they interact with their teachers.

On the other hand, Fennema and Peterson (1985), found that the classroom environment is different for males and females. Males interact more with teachers than females, who have many more days in which they do not interact at all with teacher. Males initiate more contacts with teachers than do females. Males receive more discipline contacts, and more praise. High confidence males interact at higher levels with their teachers more often than high confidence females.

Peterson and Fennema (1985), reported that a competitive classroom climate promotes academic achievement more in males than in females. And, Fennema (1985), stated that there is also evidence that male students are more inclined to interpersonal competition than females. Perhaps, because as referred by other researchers, (Bohlin, 1994; Barnard and Cronjé, 1996), males on the other hand, have more experience in mathematics and science-related activities outside the class than do females.

Seegers and Boekaerts (1996), found that in learning intention females reported that they were more prepared to invest effort in the mathematics task than males, while a significant difference between males and females was only found for attributing success to capacity. On the other hand, Boekaerts, Seegers and Vermeer (1995) found that males attributed their result more frequently to capacity and to the investment of effort.

As referred by Solar (1995), some researchers in Canada, indicate that females have less confidence in their skills than males, and, that females tend to attribute success more to hard work than to abilities. Joffe and Foxman (1986), report that females are more unsure of their mathematical capability than males.

Armstrong (1985), considers a positive attitude towards mathematics and belief in its usefulness in later life as the most important influential factors. As stated by Fennema and Sherman (1977), the perception of the value of mathematics or mathematics-related careers have emerged a significant predictors of both achievement and course plans in the majority of studies.

Regarding ability ratings in science and mathematics courses, DeBoer (1986), reported that male students rated themselves higher than female students even in the absence of superior course performance on the part of the males. In Forgaz and Leder study's (1996), it was reported that among other variables, self-confidence and importance of mathematics correlated positively with grade 7 students mathematics attitudes.

Leder (1993), found that for grade 7 students, there was no gender difference in mathematics achievement, but more males than females rated themselves above-average in mathematics ability compared with their classmates. According to other researchers, (Meyer and Koelher, 1990; Tartre and Fennema, 1995), since females have tended to be less confident in their ability to do mathematics than males are it is reasonable to hypothesise that confidence is an important variable to investigate.

On the other hand many others writers (for example, Fennema and Carpenter, 1981; Kaiser-Messmer, 1993; Bohlin, 1994), have concluded that, from the beginning of the secondary school stage, females perceive their mathematical ability to be lower than that of males.

Some other authors, (Sherman, 1980; Bohlin, 1994; Seegers and Boekaerts, 1996 and Relich, 1996), stated that females' attitudes declined as measured on the confidence in learning mathematics which is important because of its relationship to performance.

According to some authors (Fox and Cohn, 1980; Fennema, 1985; Kaiser-Messmer,1993; Bohlin, 1994), there are many factors responsible for gender differences in mathematics performance. Aiken (1970), points ou that, the relationship between attitudes and performance is certainly the consequence of a reciprocal influence, in that, attitudes affect achievement and achievement in turn affects attitudes. In other words, greater achievement results from an increase in interest and greater interest results from greater achievement.

Moreover, according to other authors such as, Gamoran, 1987; Braddock, 1990; Catsambis, 1995, students' level of achievement and grades may also affect students' socio-psychological makeup and attitudes toward academic subjects.

Hyde, Fennema and Lamon (1990), noted that it is somewhat premature to conclude that affect and attitude are not important influences on gender differences in performance and participation in mathematics. With this regard, Forgasz (1995), on the other hand, argued that the study of gender differences can be focused on: gender differences in mathematics

learning outcomes, affective variables, classroom environments and attitudes to mathematics.

According to Meyer and Koehler (1990), affective variables have been examined as they relate to mathematics achievement. For example, several studies have found that confidence in one's ability to learn mathematics is positively correlated with mathematics achievement. Fennema and Sherman (1977), found confidence in learning mathematics almost as strongly related to achievement.

Many other affective variables have been examined for their possible relationship to mathematics achievement. Among those affective factors which have been found to be related to mathematics learning and in which gender differences have been found are: how useful mathematics is perceived to be, the perceived role of teacher in learning mathematics (Fennema and Sherman, 1977; Sherman 1980; Bohlin, 1994; Seegers and Boekaerts, 1996; Relich, 1996).

Relationships between classroom climate and achievement, and between affect and achievement have received more research attention than has the relationship between learning environments and attitudes to mathematics. Leder's study (1993), found that males had more contacts with their teachers, dominated public interactions, and were involved in more disciplinary exchanges than were females.

Gender has a very substantial effect on students' career choices. But, the gender differences in science career choice cannot be explained by differences in achievement levels, attitudes toward science, or social background characteristics. (Woolnough, 1994; Catsambis, 1995).

During the preceding 20-25 years much has also been written in the English speaking countries about the low participation of females in the scientific and engineering careers. "Despite a world-wide increase in females' participation in higher education, the total number of females continues to lag behind that of males, especially in the university sector" (Megarry, 1984:15).

According to some authors, (Fennema and Sherman, 1977; De Boer, 1984, Megarry, 1984; Armstrong, 1985, Fennema, 1985; De Boer, 1986; Dick and Rallis, 1991; Maple and Stage, 1991), 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. Females are also under-represented in advanced mathematics courses, college majors and careers that involve mathematics.

Megarry, (1984), also reported that in some countries females still have less secondary education than males, and there are still systems in which females are under represented in primary education. At one level these patterns are a consequence of individual and family decisions. At another level differential enrolment reflects decisions by governments as to what kinds and amounts of education are to be provided for females.

Why do less females choose Engineering and Science courses? As suggested by some authors, (Eccles, 1986; Dick and Rallis, 1991), it is impossible to consider this question without examining gender differences in mathematics performance and academic course selection. For example, Young and Fraser (1994), found that in Australian schools the problem of under-representation of females in science is often attributed to their poor performance.

During the compulsory years of schooling, according to Leder and Forgasz (1992) in Australia, the participation rate of students in mathematics is very high. For the most demanding elective mathematics courses at the post-compulsory years of schooling and at the tertiary level, females' participation rates have persistently remained lower than males.

Fennema and Carpenter (1981), stated that the data that do exist, suggest that gender-related differences in course participation emerge in the most advanced mathematics courses, however other researchers argued that females are succeeding as well as males in mathematics (Hanna, 1989; Solar, 1995), yet they participate much less in mathematics-related careers. Just because females can succeed in mathematics does not ensure that they will choose to pursue careers in this field.

## 2.2. DEFINITIONS OF IMPORTANT TERMS

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

### 2.2.1. Achievement Tests

Schumacher and McMillan (1993:42), claimed that the term "tests" refers to the use of test scores as data, and this technique involves subject response to either written or oral questions to measure knowledge, ability, aptitude, or some other trait.

**Achievement** has just been defined simply as a measure of one's performance at a given task. Thus in most educational researches involving students' performance the indices are in most cases achievement tests administered.

**Achievement Test** is a systematic procedure for measuring a set of representative sample of learning tasks, (Ebel and Frisbie, 1991; Gronlund, 1993).

In the normal classroom situation, mathematics achievement is measured by tests and examinations conducted, either by the class teacher or an external examination bodies.

### 2.2.2. Assessment

Goldstein and Lewis (1996), argued that to make sense of assessment it is illuminating to ask questions about its purposes. On the other side, Broadfoot (1996), claimed that assessment in education has many potential purposes. It is an integral part of the teaching-learning process providing feedback for both teachers and students which can guide decisions concerning future learning goals, (Crooks, 1988; Broadfoot, 1996). In addition to its central role in the curriculum, assessment also has a key role to play in communicating information about students' achievement more formally through, for examples, school reports and certificates.

### 2.2.3. Attitude statements

According to Oppenheim, (1992), an attitude statement is a single sentence that express a point of view, a belief, a preference, a judgement, an emotional feeling, a position for or against something.

These definitions are extended by Aiken (1976), Aiken (1979), and deal with the aspects of the students' attitudes toward mathematics. The aspects are: - the enjoyment of mathematics, - the importance of mathematics, their motivation in studying mathematics and freedom from fear of mathematics.

### 2.2.4. Item analysis for norm-referenced tests

The item analysis procedure for norm-referenced tests provides the following information:

i) The difficulty of the item
ii) The discriminating power of the item
iii) The effectiveness of each alternative

The **difficulty index** of a question is the index for measuring the easiness or difficulty of a test question. **Discrimination index** of a question is an indicator showing how significantly a question discriminates between "high" and "low" students, (Guilbert 1981; Ebel and Frisbie, 1991; Gronlund, 1993). The calculation of the difficulty and discrimination indeces follows the steps suggested in Guilbert (1981) and Gronlund (1993).

Steps to be used for calculation of the difficulty and discrimination indices:

1. award of a score to each student
2. ranking in order of merit by gender
3. identification of groups: high and low within each gender group
4. calculation of the difficulty and discrimination indices of a question, for each gender group and for the whole sample, using the formulas:

$$Diff = \frac{H+L}{N} \times 100 \;\; ; \;\; Disc = \frac{2 \times (H-L)}{N}$$

where,

- *Diff* is the numerical value of the Difficulty index of a question.
- *Disc* is the numerical value of the Discrimination index of a question.
- $H$ is the number of correct answers in the
- high group.
- $L$ is the number of correct answers in the low group.
- $N$ is the total number of students in both groups.

(Guilbert, 1981 and Gronlund, 1993)

5. Critical evaluation of each question related to specific gender performance:

i) The Difficulty index of a question, can vary from 0 to 100%, the higher the index the easier the question; a question with a difficulty index lying between 30% and 70% is acceptable. If for a test where used a group questions with indices in the range 30%-

70%, the mean index will be around 50%. It has been shown that a test with a difficulty index in the range of 50%-60% is very likely to be reliable as regards its internal consistency or homogeneity, (Guilbert, 1981; Ebel and Frisbie, 1991; Gronlund, 1993).

Ebel and Frisbie (1991), have stated that the difficulty of a test item affects its contribution to score reliability. They also claim that items of intermediate difficulty are all capable of contributing much to reliability of the test than the item that is extremely easy or extremely difficulty. (see section 2.3.5.).

ii) The Discrimination index of a question is an indicator showing how significantly a question discriminates between "high" and "low" students, varies from -1 to +1. Using the index, we can judge questions as follows:

- 0.35 and over - Excellent question;
- 0.25 to 0.34 - Good question;
- 0.26 to 0.24 - Marginal question (revise);
- under 0.15 - Poor question (most likely discard).

(Guilbert, 1981; Ebel and Frisbie, 1991; Gronlund, 1993).

Thus, item-analysis information can tell us if a norm-referenced item was too easy or too hard, how well it discriminated between high and low group scorers on the test, and whether all of the alternatives functioned as intended, (Gronlund, 1993). The frequency with which each incorrect answer is chosen may reveal common errors and misconceptions, which can provide a focus for remedial work, (Guilbert, 1981; Ebel and Frisbie, 1991; Gronlund, 1993).

As stated by Ebel and Frisbie, (1991:90), "the difficulty of a test item affects its contribution to score reliability. An item that all examinees answer correctly, or all miss, contributes nothing to reliability. An item that just about half of the examinees answer correctly is potentially capable of contributing more to test-score reliability than item that is extremely easy or extremely difficulty. Items of intermediate difficulty, that is, from about 40 to 80 percent of correct responses, are all capable of contributing too much to reliability. Items that more than 90 percent or fewer than 30 percent of the examinees answer correctly can not possible contribute as much". (p.90).

## 2.3. VALIDITY AND RELIABILITY

With respect to validity and reliability, Gronlund (1993), states that the two most important questions to ask about a test or other assessment procedure are:

(1) To what extent will the interpretations of the scores be appropriate, meaningful, and useful? And

(2) To what extent will the scores be free from errors of measurement?

The first question is concerned with validity, the second with reliability.

According to authors such as, Ebel and Frisbie (1991), Schumacher and McMillan (1993), in the context of research design, the term validity means the degree to which scientific explanations of phenomena match the realities of the world.

### 2.3.1. Test Validity

Test validity is the extent to which inferences made on the basis of scores from an instrument are appropriate, meaningful, and useful.

Validity is a judgement of the appropriateness of a measure for specific inferences or decisions that result from the scores that are generated. In other words, validity is a situation-specific concept: validity is dependent on the purpose, population, and environmental characteristics in which measurement takes place.

It has been argued that an inference is valid or invalid, not a test. A test by itself is not valid or invalid because it can be used for different purposes. In general, it is important to keep in mind that instruments including tests and questionnaires, are valid for some groups and in some situations, and invalid for other subjects or in other situations, (Cronbach, 1990; Ebel and Frisbie, 1991; Gronlund, 1993; Schumacher and McMillan, 1993).

### 2.3.2. Type of Validity

The traditional view that were several different types of validity, (content, criterion related, and construct), has been replaced by the view that validity is a single, unitary concept that is based on various forms of evidence: '***Content-related evidence***'; '***Criterion-related evidence***'; and, '***Construct-related evidence***', (Gronlund, 1993).

Schumacher and McMillan (1993), stated that there are two types of design validity in quantitative research. One is internal validity which express the extent to which extraneous variables have been controlled or accounted for. The other one is the external validity that refers to the generalisation of the results, or, the extent to which the results and conclusions can be generalised to other people and settings.

### 2.3.3. Factors that lower the Validity of achievement scores

There are various factors that should affect the validity of achievement scores:

- Test items that provide an inadequate sample of the achievement to be measured.
- Test items that do not function as intended, due to use of improper item type, lack of relevance, ambiguity, clues to answer, bias, inappropriate difficulty, or similar factors.
- Improper item arrangement and unclear directions for the test
- Too few items for the types of interpretation to be made.
- Improper test administration, such as inadequate time limits, excessive interruptions, seat arrangements that permit cheating, and testing just before an important school event.
- Scoring that is subjective or contains computational errors.

(Gronlund, 1993)

### 2.3.4. Reliability

Reliability refers to the consistency of test scores - that is, how consistent they are from one measurement to another. Reliability measures provide an estimate of how much variation we might expect under different conditions. The reliability of test scores is typically reported by means of a reliability coefficient or the standard error of measurement that is derived from it, (Gronlund, 1993; Schumacher and McMillan, 1993).

### 2.3.5. Test Reliability

Test Reliability refers to the consistency of measurement, the extent to which the results are similar over different forms of the same instrument or occasions of data collection. The goal of developing reliable measures is to minimise the influence of chance or other variables unrelated to the intent of the measure. The classical definition of score reliability makes use of the idea of the coefficient of correlation and equivalent tests given by Ebel and Frisbie (1991):

> "The Reliability coefficient for a set of scores from a group of examiners is the coefficient of correlation between that set of scores and another set of scores on an equivalent test obtained independently from members of the same group".
>
> (Ebel and Frisbie, 1991:77).

## 2.3.6. Interpretation of Reliability Coefficients

There are several factors that should be considered in interpreting reliability coefficients:

- The more heterogeneous a group is on the trait that is measured, the higher the reliability.
- The more items there are in an instrument, the higher the reliability.
- The greater the range of scores, the higher the reliability.
- Achievement tests with a medium difficulty level will result in a higher reliability than either very hard or very easy tests.
- Reliability, like validity, is usually based on a norming group and, strictly speaking, the reliability is demonstrated only for subjects whose characteristics are similar to those of the norming group.
- The more that items discriminate between high and low achievers, the greater the reliability of the test.

Thus an alternative procedure giving the researcher an impression of internal reliability can be via good item discrimination and difficulty, (Cronbach, 1990; Ebel and Frisbie, 1991; Schumacher and McMillan, 1993).

# Chapter 3

# METHODOLOGY

## 3.1. SAMPLE

The sample for this study consisted of 226 university students who passed the entrance examination for Agronomy, Biology, Engineering and Science courses (Chemistry, Physics, and Geology) at Universidade Eduardo Mondlane (UEM), and were registered and enrolling the Basic Mathematics course in BUSCEP program. These subjects have similar mathematical background, because they took the same mathematics school program at secondary level, and, they enrolled on mathematics course at BUSCEP in the same educational environment. The students were taught in 15 different group-classes by 8 experienced teachers (3 females and 5 males).

The quality of mathematics teaching at BUSCEP is considered generally homogenous for all the teachers because of their joint weekly preparation to the lessons to be given to students. The ratio of males to females taking mathematics as a subject differed within the different courses and for the overall sample there was 175 to 51.

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The quality of mathematics teaching at BUSCEP is considered generally homogenous for all the teachers because of their joint weekly preparation to the lessons to be given to students. The ratio of males to females taking mathematics as a subject differed within the different courses and for the overall sample there was 175 to 51.

In the study students were grouped in two sections according to the amount of mathematics required by the course enrolled. The first group, composed of the Engineering and Science courses, (i.e., Chemistry, Physics and Geology), where mathematics is taught over more than four semesters, it is labelled as **SCIENCE**. The second group, comprising the Agronomy and Biology courses, where mathematics is taught for less than four semesters, it is labelled as **BIOLOGY**.

In Table 3.1 is shown the frequency distribution of the BUSCEP students in 1996 by section and gender.

**Table 3.1**: Frequency distribution of 1996 BUSCEP students by section and gender

| | Males | Females | Total |
|---|---|---|---|
| SCIENCE | 120 | 16 | 136 |
| BIOLOGY | 55 | 35 | 90 |
| Total | 175 | 51 | 226 |

Only the data of those students who have been present at the first day-class, at BUSCEP and have responded to the questionnaire and the pre-test, were used. Together, the two sections at BUSCEP supplied 310 new students. A number of these students were excluded from the study because they were not officially registered to enrol in the courses at UEM, and the researcher was unable to gather all the data of those students.

## 3.2. MEASURING INSTRUMENTS

The language of instruction in the Educational System in Mozambique is the official language, **Portuguese**. Hence this language was also used for the testing procedures. And, for the purpose of presentation all the instruments were after translated from **Portuguese** to **English** by the researcher, as well as the data collected from the students responses to those instruments involved in the research.

In this study, the students were tested on several cognitive and affective factors related to gender differences in performance and attitudes towards mathematics. Demographic data gathered for this study included personal details (name, sex, age, course enrolled and class of attendance), scores on secondary school, scores on entrance examination, scores on Pre-test and achievement tests, students' interest, approaches to learning and attitudes toward mathematics of 1996 BUSCEP students. Race and ethnicity were not recorded.

### 3.2.1. Cognitive Measures

Under the cognitive domain the study intended to explore possible gender differences in mathematical performance in 1996 BUSCEP students, which was measured through the following achievement tests:

- Pre-test set by the researcher at the beginning of the academic year;
- the first and the second intermediate tests done at BUSCEP,
- the *Mini-tests* and the
- Final Result for mathematics at BUSCEP.

The scores achieved by the students at the secondary school mathematics and entrance examination were also used in order to compare the initial level of attainment which they brought into their university education.

### 3.2.2. Affective Measures

Under the affective domain the study intended to explore possible gender differences in attitudes toward mathematics and possible gender differences in the approaches to learning mathematics of BUSCEP students at UEM.

The assessment of attitudes in any study is difficult, since attitudes cannot be observed directly, and, it is argued that a conclusion about an attitude can be made through inference based on the study of a set of responses which are observable, (Oskamp, 1977 and Oppenheim, 1992).

Corcoran and Gibb (1961), have listed several techniques such as:

- Observational methods;
- Interviews;
- Self-report methods which includes questionnaires, attitude scales, sentence completion, projective techniques, and content analysis of essays.

Thus, in this research, the affective factors were measured by using a researcher designed questionnaire. The decision to use questionnaires and tests was also reinforced by reference to previous studies, where effective data collection was carried out by these types of instruments, as referred

to, by Schumacher and McMillan (1993:42), "the questionnaire is a very common technique for collecting data in educational research". And, according to Galfo (1975), questionnaires are the most used and misused method of educational research.

On the other side, Cohen and Manion (1985), claim that, the argument for the use of questionnaire is that, to each respondent the same set of questions as everybody else in the same sample was given, phrased in exactly the same way; and the data obtained from questionnaires are more comparable than information obtained by means of interviews.

## 3.3. PROCEDURES

The measuring instruments (Pre-test and questionnaire) were administered to students at BUSCEP, by their teachers, in August 1996, during a regular class period. The questionnaire was completed first to avoid any possible influence arising from the students' performance in the Pre-test, which was written two hours later; because, poor performance in the Pre-test could have lead to false responses in the questionnaire.

Another advantage of administering the questionnaire personally was to increase the validity and reliability of the research, as the weaker students generally tend not to reply to questionnaires "sent by post", and the replies from only the brighter students can give biased results, (Schumacher and McMillan, 1993).

The two instruments, Pre-test and questionnaire were administered in two different periods according to the students' time table. The BIOLOGY students were tested during the morning while the SCIENCE students

completed the testing in the afternoon. Testing process and all data collection at BUSCEP was completed by December 1996.

All test material was treated confidentially by the lecturers. Prior to test and questionnaire administration, the researcher met with the staff of BUSCEP to review the administration procedures.

### 3.3.1. The cognitive variables

The pre-test consisted of 9 multiple-choice items, each with four options, taken from the previously used standardised tests of the secondary school examination certificate, UEM entrance examination, and from the BUSCEP tests and textbooks used for mathematics in the Basic Science Course.

The items covered three mathematics topics: Algebra, Trigonometry and Geometry. Problems in all topics, range from relatively easy, requiring recall of simple rules at the cognitive level of knowledge and, to the more difficult, at the cognitive level of understanding, and more complex problems involving multi-step mathematical reasoning in the cognitive level of application or problem solving according to the "Taxonomy of Educational Objectives", (Bloom,1956; Holcomb and Garner, 1973; Smith et al., 1996).

Table 3.2 shows the distribution of the allocated percentages of the item marks on the pre-test by content area and cognitive level.

Table 3.2: Distribution of the Pre-test items by topic and cognitive levels.

| Topics | Knowledge | Understanding | Application | Total |
|---|---|---|---|---|
| Algebra | 10.0% (q1) | 10.0% (q3) | 12.5% (q2) | 32.5% |
| Geometry | 10.0% (q5) | 15.0% (q6) | 10.0% (q4) | 35.0% |
| Trigonometry | 12.5% (q7) | 10.0% (q9) | 10.0% (q8) | 32.5% |
| Total | 32.5% | 35.0% | 32.5% | 100% |

(q1 - q9 indicate the item number taken for each topic and cognitive levels).

There are several taxonomies that one could use, depending on the purpose. One of the best known is the Bloom's taxonomy, (Bloom, 1956), which gives a hierarchy of concepts. In this taxonomy, Bloom (1956), states that the cognitive domain includes those objectives which deal with the recall or recognition of knowledge and the development of intellectual abilities and skills. The levels of thought which are present in the classroom are represented in the taxonomy.

Bloom's taxonomy is good for structuring assessment tasks, but does have some limitations in the mathematical context, thus, Smith et al., (1996), in "Constructing mathematical examinations to assess a range of knowledge and skills" proposed a modification of Bloom's taxonomy, "the MATH taxonomy (Mathematical Assessment Task Hierarchy) for structuring of assessment tasks", (Smith et al., 1996:67). This adapted taxonomy is very close to that presented by Holcomb and Garner (1973).

In Holcomb and Garner (1973), it is proposed a modified classification system derived from that of Bloom (1956), and designed more specifically for use in the preparation of achievement tests for students, considering the levels as following:

1. Knowledge
   - *Recall*
   - *Recognition*
2. Understanding
3. Solving of a routine problem
   - *Interpretation of data*
   - *Application*
4. Solving of an unfamiliar problem
   - *Analysis of data*
   - *Special application*
5. Evaluation
6. Synthesis

(Holcomb and Garner, 1973)

Research has convincingly established that the first three cognitive levels, (1) **Knowledge**; (2) **Understanding**; and (3) **Application or problem solving**, are probably enough for the purpose of defining educational objectives and student evaluation because the majority of the classroom verbal behaviour occurs at the knowledge and understanding levels, and seldom at the level of application or problem solving, (Holcomb and Garner, 1973; Guilbert, 1981, Smith et al., 1996).

The first two levels, (knowledge and understanding), are mainly concerned with the conveyance of information to students, that clearly indicates a lack of questions which involve students in critical thinking skills in classroom discussions, (Holcomb and Garner, 1973; Guilbert, 1981; Smith et al., 1996).

According to Smith et al., (1996), students enter tertiary institutions with most of their learning experience in the tasks requiring the level of knowledge, with some experience with tasks in the level of understanding. Their experience in applications tasks in mathematics is severely limited or non-existent. So, one of the aims of tertiary education in mathematics should be to develop skills at all three levels.

Concerning the Pre-test designed by the researcher, three experienced teachers of mathematics at BUSCEP were selected and involved in the classification of the items of the Pre-test under the considered cognitive levels and their conclusions or opinions about each item demonstrated near perfect consistency. The few inconsistent items were agreed by consensus.

The Pre-test was marked and scored by the researcher for the entire group. The items were scored dichotomously (either right or wrong) and therefore the maximum score for the test was 100%.

The following are the specifications of the skills required in the Pre-test items, according to the considered cognitive levels:

**i) Cognitive level of knowledge:**

- The assumption in the items of this level is that students have met the exercises before in the form required for the answer.
- Students would have been expected to have worked on problems using the required procedures in drill exercises.
- Students are required to bring to mind previously learned information in the form that it was given.

**ii) Cognitive level of understanding:**

- For the items on this cognitive level it is assumed that various routine skills needed to do the exercises are familiar to the students, and that they have done drill work in similar but not identical exercises.
- Students should be able to use a previously acquired knowledge or skills.
- Requires the ability to use material in a way which goes beyond the recall of simple rules.
- Students may recognise the applicability of a formula or method in different or unusual context.

**iii) Cognitive level of application or problem solving:**

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

Performance criteria were also used to find out possible gender differences in the level of students' achievement in the Pre-test and intermediate

achievement tests and Final results at BUSCEP considering the following intervals:

i) **Lower performance criterion** - scores under 50% in achievement, (i.e., score < 50);
ii) **Middle performance criterion** - scores from 50% and under 70%, (i.e., 50 ≤ score < 70), and;
iii) **Upper performance criterion** - scores of 70% and over, (i.e., score ≥ 70).

According to UEM rules, **lower performance criterion** corresponds to the students who are not permitted to write the exam, and the **middle performance criterion** refers to those students achieving adequate marks and are allowed to write the exam. The **upper performance criterion** corresponds to those students performing at higher level of achievement and who are given credit without writing the exam.

Scores obtained at Secondary school and Entrance Examination were also analysed according to these performance criteria, although the range was different, because, the lowest scores for these variables was 50 (or nearly), which represents the minimum score necessary to obtain the school leaving certificate and to be admitted to the university course.

With respect to these levels, the three performance criteria correspond to:

i) **Weak students** - for scores less than 60%, (i.e., score < 60);
ii) **Medium students** - for scores from 60% to less than 70%, (i.e., 60 ≤ score < 70), and;
iii) **Strong students** - for scores from 70% and over, (i.e., score ≥ 70).

As has been argued by authors such as Becker (1990) and Feingold (1994), the absence of mean differences in the performance of different groups is not sufficient evidence for a conclusion that such differences do not exist. Thus, in this study, the difficulty and discrimination indices of each Pre-test item were calculated according to the procedure proposed in Gronlund (1993), and Guilbert (1981), as presented in section 2.2.4.

In the study, as the distribution and range of scores for male students was different to that of female students, (see section 4.3.2.1. and appendix C), it was decided to use different 'cut-offs' for the calculation of the difficulty and discrimination indices for the total sample and for each gender separately. The 'cut-offs' corresponded to the top and bottom 27% of each respective group.

The differences between males and females in the difficulty and discrimination indices were tested using the test for differences of two proportions, with the significance level at $\alpha = 1\%$, (Hays, 1994).

Two other tests based on the mathematics curriculum for BUSCEP courses were administered by the BUSCEP mathematics' lecturers in the assessment process. These Intermediate tests consisted of open-ended questions, and the content covered by the tests includes arithmetic, algebra, geometry, trigonometry and pre-calculus. The questions related to algebra geometry and trigonometry for those intermediate tests were set by the researcher in agreement with the BUSCEP mathematics lecturers.

These Intermediate achievement tests were hand marked, first, by the BUSCEP mathematics teachers and then the researcher remarked them.

The emphasis during the remarking process was on the correct mathematical reasoning and students were given partial credit.

The two intermediate tests were combined with the results from the means scores of the students' systematic continuous assessment (labelled Mini-test) which play a role in the calculation of the Final-Result at BUSCEP, in order to determine if the student may pass without writing the exam, fail or get a right to write the exam in this subject.

Mini-test is the name given to the short achievement tests comprising two to three questions assessing the contents which had been covered during the previous period of approximately sixteen hours in the classroom teaching-learning process. Students must write this type of test during the first 20 minutes of a class in which the mathematics teachers introduce a new topic according to the BUSCEP mathematics syllabus.

During the semester all students must write four such tests without any previous warning. These tests were set by the same lecturers, but differ from group to group. In the study, the term Mini-test correspond to the mean of the scores achieved by the students on those tests. The Final result is calculated using the following formula:

$$F = 0.4T_1 + 0.4T_2 + 0.2M_M;$$

where,

- $F$ represents the Final result (or end-of-semester result);
- $T_1$ represents the mark achieved by the students in the first intermediate test;
- $T_2$ represents the mark achieved by the students in the second intermediate test, and;
- $M_M$ represents the mean of the scores achieved by the students in the Mini-tests.

### 3.3.2. The affective variables

The instrument used to measure the affective variables was the questionnaire designed by the researcher. The questionnaire consisting of 40 briefly stated items, to which each student would respond as checklist items or ranked-items, were then set up as shown in Appendix B. The questionnaire would allow the students to express their opinions and attitudes toward mathematics because, the students who had another preference had the freedom and space to write their own option or suggestion, (see Appendix B). None of the students added a new or different opinion, thus the statements presented in the researcher designed questionnaire were adequate and sufficient for measuring their attitude toward mathematics before entering the university.

According to Cohen and Manion (1985), the use of questionnaires in data collection is an objective method, because it is less human situation whereby people are more likely to express aspects of thoughts, feelings and values, and it is more economical than the interview in terms of money and time. However, if it is anonymous, motivation of respondents cannot be checked, and it becomes difficult to judge the validity of their responses, (Cohen and Manion, 1985).

In this study, the students were required to put down their names in order to be able to compare their attitude responses from the questionnaire with their achievement scores obtained from the achievement tests.

Before the research started, the pre-test and the questionnaire were used in a pilot study which led to refinement of some of the questions and to a better time allocation for both instruments. The number of questions included in each test was determined largely by the amount of time available for it, (see section 3.3.1. and appendices A-1, A-2, A-3). For the pre-test 50 minutes, were allowed, because that is the scheduled length of the class period at BUSCEP and according to BUSCEP rules, special testing schedules might provide periods of 120 minutes for each of the achievement tests. Most, of the students had sufficient time to complete the tests.

The questionnaire was also first submitted to the BUSCEP mathematics lecturers well-known for their experience and expertise in the mathematics education system of Mozambique. Their suggestions were used to improve the original design and the questionnaire was only finalised after agreement with those teachers. On the basis of recommendations received from this group of teachers, three questions were modified slightly to avoid double-meanings and biased statements and/or terms.

To simplify statistical manipulation and presentation, of the attitude measurements, the responses of all rank-order items were after scored from 1 to 4 from the least preferred to most preferred. And, in order to facilitate further analysis, the responses were then classified into two categories, as follow:

i) Category One:

- The ratings of 1 and 2 corresponding to the two last choices were interpreted as **Low preference**, and designated by the sign "-", meaning that it is less used or never preferred.

ii) Category Two:

- The frequency of 4 and 3 ratings, corresponding to the first and second choice, were added together and this combined frequency was used to rank the **High preference** of the statement, and it was designated by the sign "+".

## 3.4. ANALYSIS

A statistical data analysis using the "SPSS 7.0" - Statistical Package for the Social Sciences, for Windows 95, was carried out.

Following Schumacher and McMillan (1993), who say that since the basis of inferential statistics is the probability of estimation, then accepting the null hypothesis is also related to probability or chance, and Campbell (1994), who states that in case of a large sample test, the critical values for the significance should be at 5% or 1% level. In this study, the researcher decided to consider the level of significance of $\alpha = 1\%$, in order to control the Type I error, and, because of possible error in sampling and measurement.

Pearson's Correlation Coefficients and the General Linear Model was carried out. Analysis of variance (ANOVA) was used to access the statistical significance of the differences among mean performance of the two genders in the tests administered to the subjects. Two-way ANOVA were also used to compare the means of the categories of two independent variables, gender and section, with the overall mean for the entire data set.

According to some authors, (Schumacher and McMillan, 1993; Campbell, 1994, Hays, 1994), the use of ANOVA rather than multiple "t-test" is acceptable as the "t" statistic squared is the same as the "F" statistic with the appropriate degree of freedom. And, they further argue that if multiple t-test were used, the researcher would increase the likelihood of finding a significant difference by chance where none exists.

Further analysis in the study, uses the analysis of covariance (ANCOVA) to adjust students' difference in the intermediate achievement tests and in the scores of the Final result based on the initial differences from the Pre-test, which was related to the mathematics knowledge gained before entering the university.

With the analysis of covariance the researcher wishes to remove some of the variances that can be attributed to some extraneous factors other than what were expected by the researcher to be influencing the variability in attainment. The second purpose of covariance analysis was to increase the power of statistical test to find differences between males and females.

The difference in the difficulty and discrimination indices was tested using the test for differences of two proportions; that is, a Bonferroni adjustment to the significance level, (Hays, 1994), was made, so that each item of the Pre-test was tested at $\alpha = 1\%$, (see sections 3.3.1. and 4.2.3.5.).

Chi-squared tests were also computed to determine if gender-related differences exist in the scores distribution by performance criterion.

All the Chi-squared scores were computed using the actual frequencies but the reported tables are in percentage as the sample sizes are so vastly different.

## 3.5. VALIDITY AND RELIABILITY

To examine validity and reliability of the instruments used in the research, the Pre-test and questionnaire were submitted to the BUSCEP lecturers of mathematics who are experienced in the mathematics education system at secondary schools in Mozambique.

For content-related validity, all of the 8 teachers involved in the study agreed that the Pre-test and the others achievement tests covered the prescribed syllabus for mathematics for BUSCEP students at UEM and were at the appropriate cognitive levels. The questionnaire covering the possibilities of attitudes and approaches to learning mathematics, was only administered after agreement with them.

The evaluation of reliability used in this study is the one which makes use of the idea of correlation and equivalent tests given by Ebel and Frisbie (1991:77).

> "The reliability coefficient for a set of scores from a group of examinees is the coefficient of correlation between that set of scores and another set of scores on an equivalent test obtained independently from members of the same group".
>
> (Ebel and Fribie, 1991:77)

Reliability was also assessed by inter-rater agreement, and by the difficulty and discrimination indices displayed by the Pre-test items.

The method of using the difficulty and discrimination indices to assess reliability and validity is supported by authors such as Cronbach, 1990; Ebel and Frisbie, 1991; and Schumacher and McMillan, 1993, as yet mentioned in section 2.3.6).

# Chapter 4

# RESULTS AND DISCUSSION

## 4.0. INTRODUCTION

In this chapter the results of the study will be presented. Firstly, gender differences on the mathematics achievement tests, as a measure of mathematics performance, will be described and discussed. Secondly, gender differences in the attitude towards mathematics and gender differences on the approaches to learning mathematics, will also be described and discussed.

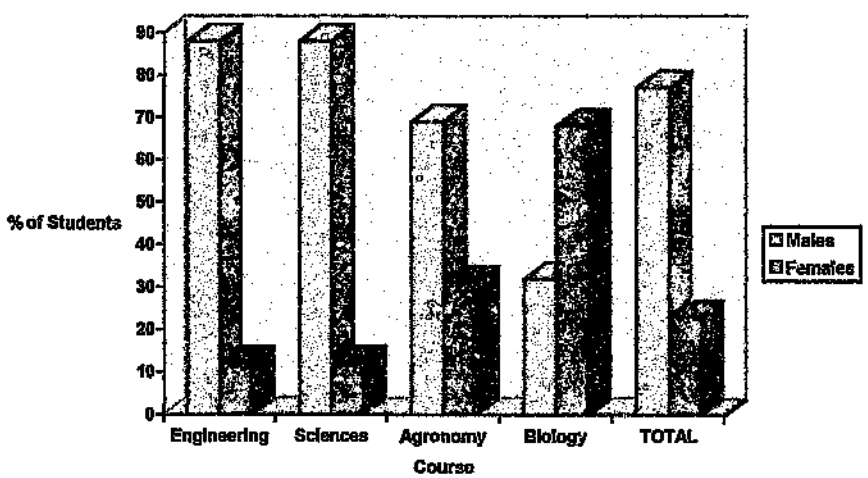
## 4.1. GENERAL RESULTS OF SAMPLE

The first result obtained in the study was related to the characteristics of the sample used. These sample consisted of 226 first year university students who passed the entrance examination for Agronomy, Biology, Engineering and Science courses, (Chemistry, Physics, and Geology), at Universidade Eduardo Mondlane (UEM), and have been registered and enrolling the Basic Mathematics course in BUSCEP program in 1996.

The mean age of the final sample used was 22 years old, ranging from 17 to 33 for both genders. The mean age for each gender was 21 and 22 years old for females and males respectively. Most of the students were from Maputo, at 62.3% of males and 84.3% of females, in contrast to the percentage of all students from upcountry at 37.7% and 15.7% of males and females respectively.

Figure 4.1 illustrates the distribution of the sample by course enrolled by the 1996 BUSCEP students. As can be seen, the percentage of females was remarkably less than that of males in all the courses except in Biology where, by contrast, the number of females students is higher than that of their counterpart males.

**Figure 4.1:Percentage of 1996 BUSCEP students within course by gender**




In spite of the same mathematics curriculum taught, at UEM, for Agronomy and Biology students, it is evident that both courses are

enrolled by female and male students in opposite proportions. Perhaps the cause is the influence of mathematics in the entrance examination in both courses, because Biology is free of mathematics in the entrance examination while Agronomy has mathematics as a key subject.

**Table 4.1**: Frequency distribution of 1996 BUSCEP students by course and gender

| | Males | | Females | |
|---|---|---|---|---|
| | N | % | N | % |
| Engineering | 99 | 56.6 | 13 | 25.5 |
| Sciences | 21 | 12.0 | 3 | 5.9 |
| Agronomy | 49 | 28.0 | 22 | 43.1 |
| Biology | 6 | 3.4 | 13 | 25.5 |
| Total | 175 | 100.0 | 51 | 100.0 |

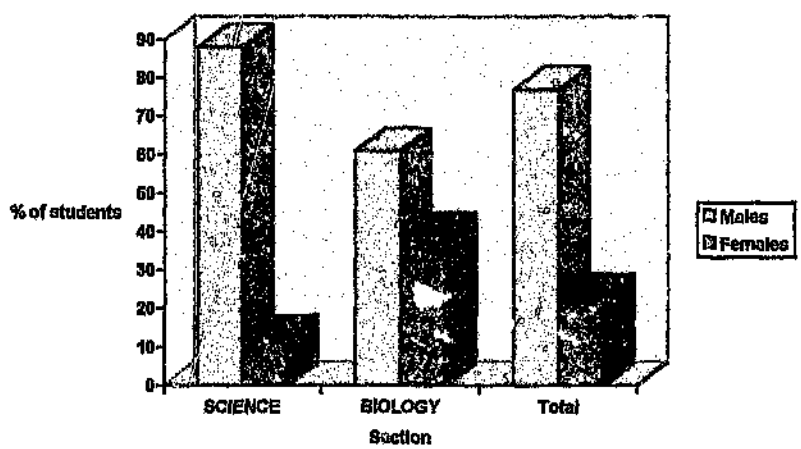
If the percentage distribution of the sample was taken considering the percentage within gender, it is noticeable that a high percentage of males was found in Engineering (56.6%) against the 3.4% of males enrolling in Biology course, (see Table 4.1). The females distribution shows that Science courses are enrolled by a low percentage of them in contrast of Agronomy. However, Engineering and Biology are enrolled by the same percentage of females. In the study, students were grouped in two sections, (SCIENCE and BIOLOGY), and within the sections, they were sorted by gender. Table 4.2 shows the distribution within gender by section.

**Table 4.2:** Number and percentage of 1996 BUSCEP students by section and gender

| | Male | | Female | |
|---|---|---|---|---|
| | No: | % | No: | % |
| SCIENCE | 120 | 68.6 | 16 | 31.4 |
| BIOLOGY | 55 | 31.4 | 35 | 68.6 |
| Total | 175 | 100 | 51 | 100 |

The percentage of females in SCIENCE section was 31.4%; clearly lower than that in BIOLOGY section (68.6%). By contrast, the percentage of males was exactly the opposite, being 68.6% in SCIENCE and 31.4% in BIOLOGY. Figure 4.2 illustrates the percentage distribution within section by gender.

**Figure 4.2 : Percentage of 1996 BUSCEP students within section by gender**



As can be seen, females are still under-represented in higher education in Mozambique, particularly in Science and Engineering courses, which require extensive mathematical training. The Chi-squared test of independence for the two variables gender and the relationship of enrolling in a career involving a large amount of mathematics is highly significant, $x_1^2 = 22.803$; $p<0.001$; i.e. there is a gender- typical influence on the option to enter such career at University. This finding can also be confirmed further in section 4.3.1.3, where students responses to the question related to the influence of mathematics in career choice are reported.

The problem related to the low participation of females in Engineering and Science courses is a world wide phenomena, and as suggested by some authors, (Eccles, 1986; Dick and Rallis, 1991), it is impossible to consider this question without examining gender differences in mathematics performance and academic course selection. For example, Young and Fraser (1994), said that in Australian schools the problem of under-representation of females in science is often attributed to their poor performance.

Of course, this problem of under-representation of females in scientific careers is an unfavourable situation for educational research as the investigation of gender differences in attitudes and performance in most studies, in the field of mathematics at university level, suffers very different sample sizes.

## 4.2. GENDER-RELATED DIFFERENCES ON PERFORMANCE

The mathematics performance of students is one of the major dependent variables studied. It was measured through the secondary school mathematics results, the entrance examination scores, the achievement tests done at BUSCEP, (the Pre-test, Test-1, Test-2 and the Mini-test), and the Final results in mathematics at BUSCEP. To determine and interpret the inter-relationship between the tests, correlation coefficients were calculated. In this study, correlation coefficient can also be reported as a predictive validity.

### 4.2.1. Instrument Correlation

Pearson's product-moment correlation coefficient was computed with data from all sample, between the tests, and the results are shown in Table 4.3.

In the Table 4.3, the measures of mathematical performance were all positively correlated with the Pre-test. When the data were analysed by gender, the results were, in general significant. Meanwhile, the negative correlation observed for females, between the self-reported mathematics scores from secondary school and the multiple-choice Pre-test could explain the difficulties experienced by them with respect to the Pre-test, which was elaborated in an unusual form of presenting questions in tests at secondary school. The relatively high correlation between the intermediate tests and the Final result exists because the Final-result is a linear combination of the intermediate tests and the Mini-test.

**Table 4.3:** Pearson's product-moment Correlation-Coefficients between the tests.

| | Males | | Females | | Total | |
|---|---|---|---|---|---|---|
| | N | r | N | r | N | r |
| Mat.Sec./Ent. Ex. | 169 | .238** | 38 | .102 | 207 | .206** |
| Mat.Sec/Pre-Test | 175 | .181* | 51 | -.073 | 226 | .129 |
| Mat.Sec./Tes-1 | 172 | .038 | 51 | .250 | 223 | .098 |
| Mat Sec./Test-2 | 170 | .313** | 51 | .273 | 221 | .301** |
| Mat.Sec./Minitest | 171 | .121 | 51 | .166 | 222 | .130 |
| Mat.Sec./Final | 172 | .194* | 51 | .315* | 223 | .222** |
| Ent.Ex./Pre-Test | 169 | .233** | 38 | .296 | 207 | .253** |
| Ent.Ex/Test-1 | 166 | .231** | 38 | .300 | 204 | .260** |
| Ent.Ex./Test-2 | 164 | .332** | 38 | .547** | 202 | .383** |
| Ent.Ex./Minitest | 165 | .169* | 38 | .284 | 203 | .167* |
| Ent.Ex./Final | 166 | .329** | 38 | .519** | 204 | .374** |
| Pre-test/Test-1 | 172 | .141 | 51 | .215 | 223 | .197** |
| Pre-test/Test-2 | 170 | .231** | 51 | .323* | 221 | .314** |
| Pre-test/Mini-test | 171 | .163* | 51 | .438** | 222 | .207** |
| Pre-test/Final | 172 | .291** | 51 | .377** | 223 | .335** |
| Test-1/Test-2 | 170 | .405** | 51 | .450** | 221 | .448** |
| Test-1/Mini-test | 171 | .176* | 51 | .290* | 222 | .174** |
| Test-1/Final | 172 | .769** | 51 | .858** | 223 | .805** |
| Test-2/Mini-test | 170 | .357** | 51 | .481** | 221 | .361** |
| Test-2/Final | 170 | .831** | 51 | .797** | 221 | .831** |
| Mini-test/Final | 171 | .530** | 51 | .559** | 222 | .502** |

* Correlation is significant at the 5% level (two-tailed).

** Correlation is significant at the 1% level (two-tailed).

### 4.2.2. The secondary school and entrance examination results in mathematics

The first step in the analysis was to compare the mathematics mean scores that males and females obtained in the secondary school and entrance examination.

#### 4.2.2.1. Gender Differences on means

The students mathematics scores achieved in the entrance examination and at the secondary school were computed for possible gender differences. As can be seen in Table 4.4, the self-reported scores obtained in the secondary school mathematics and, in the entrance examination have a lowest score of 50 (or nearly), because it is the minimum score necessary to obtain the school leaving certificate and to be admitted to the university courses.

**Table 4.4:** Means, standard deviations and range scores of the 1996 BUSCEP students in the secondary school mathematics and entrance examination by gender

| | Sec. School Mathematics | | | Entrance Examination | | |
|---|---|---|---|---|---|---|
| | Males N=175 | Females N=51 | Total N=226 | Males N=169 | Females N=38 | Total N=207 |
| Mean | 61.0 | 60.3 | 60.8 | 56.9 | 54.0 | 56.3 |
| St. D. | 10.6 | 11.1 | 10.7 | 9.2 | 8.9 | 9.2 |
| Minimum | 50.0 | 50.0 | 50.0 | 47.5 | 47.5 | 47.5 |
| Maximum | 95.0 | 90.0 | 95.0 | 83.0 | 83.0 | 83.0 |

The differences in mean scores percent obtained by the students at both variables, favoured males by at most 1% in secondary school mathematics and 3% in the entrance examination scores.

The ratios of variability between males and females for mathematics achievement at secondary school and entrance examination were 0.95 and 1.03 respectively. According to Feingold (1994), it represents a similar variability of the two gender groups.

An analysis of variance (ANOVA) wa culated for the statistical significance of the difference and the results (F=3.160, df=1;205, p=0.077) for the entrance examination, and (F=0.170, df=1;224, p=0.680) for the scores achieved at secondary school, found that the differences were also statistically non-significant.

If the sections were considered, the difference in mean performance in the entrance examination, (3% in SCIENCE, and 2% in BIOLOGY), still favouring males, (see Appendix C). At secondary school mathematics, males and females performed equally in SCIENCE, and the difference of 3% in favour of males was also observed in BIOLOGY. However these differences were also statistically non-significant.

#### 4.2.2.2. Gender Differences on the Pre-BUSCEP Performance-Criterion

The previous analysis suggests that examining differences only in means cannot provide a clear picture of the gender differences. A better understanding of these differences in the secondary school mathematics

results, and entrance examination can be achieved by comparing the distribution of males and females by performance criteria, as yet defined in section 3.3.1.

**Table 4.5**: Percentage distribution of males and females by Performance-Criterion in the secondary school mathematics and entrance examination

| | Sec. School Maths | | Entrance Examination | |
|---|---|---|---|---|
| | Males | Females | Males | Females |
| Weak | 49 | 53 | 66 | 82 |
| Medium | 20 | 20 | 23 | 13 |
| Strong | 31 | 27 | 11 | 5 |

When the analysis was done at the performance criterion the results display some small differences only in the entrance examination where the percentage of females, (82%), scoring at lower level was greater than that of males (66%). In contrast the percentage of males, in the middle and upper performance criteria, exceed that of the females. It means that the females performance was comparatively weaker than that of their counterpart males.

The Chi-squared test was done and, non-significant dependence of the distribution of scores by performance criterion based on gender was found, ($\chi_2^2 = 0.322; p = 0.851$ for secondary school and $\chi_2^2 = 3.445; p = 0.179$ for entrance examination).

## 4.2.3. The Pre-test

### 4.2.3.1. Gender Differences on Means

As shown in Table 4.6, the mean scores of the male was 50.6 and that of females was 43.8. The difference of 6.8 between males and females in the Pre-test performance was found to be statistically non-significant at $\alpha = 0.01$ level when the analysis of variance was done; (F=5.708, df=1;224, p=0.018).

**Table 4.6: Means and Standard deviations achieved by the 1996 BUSCEP students in the Pre-test by gender and section**

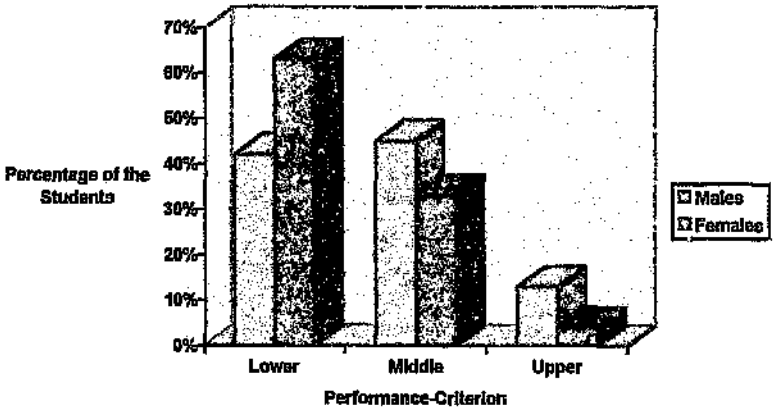
| | Total Sample | | SCIENCE | | BIOLOGY | |
|---|---|---|---|---|---|---|
| | Male | Female | Male | Female | Male | Female |
| N | 175 | 51 | 120 | 16 | 55 | 35 |
| Mean | 50.6 | 43.8 | 50.5 | 48.4 | 50.8 | 41.6 |
| St. D. | 18.3 | 16.6 | 18.7 | 15.1 | 17.7 | 17.0 |

When comparison was done within the sections, the mean scores of the SCIENCE students were 50.5 for males and 48.4 for females, while in BIOLOGY the difference was more stressed (9.2), however, the ANOVA test still found the difference to be statistically non-significant (F=5.910, df=1;88, p=0.017). On the other hand, the variance ratio of males to females in the Pre-test was 1.04, meaning that both genders had a similar variability in terms of mathematics performance also in the Pre-test.

### 4.2.3.2. Gender Differences on the Performance-Criterion

A comparison between males and females achievement at performance criteria, (see section 3.3.1.), was also [illegible]. A lower percentage of females, compared to that of males, achieved the highest Pre-test scores, i.e., only 4% of the females compared to 13% of the males gain the scores at the upper performance criterion. However, the differences in performing at specific performance criterion were statistically non-significant at 1% level, when Chi-squared test was computed ($x_2^2$= 7.747, p=0.021). This implies that achieving scores at specific performance criterion in the Pre-test was also not related to gender. Figure 4.3 gives a graphical illustration of these distribution.

**Figure 4.3 : Percentage distribution of the Pre-test scores of the 1996 BUSCEP students by Performance-Criteion and gender**




As can be seen, the percentage of females in each performance criterion decreases from the lower to the upper. However for males, the percentage in the middle performance-criterion is the highest compared to the lower

and upper performance criteria, contrasting the distribution of their counterpart females who are more and over represented than males at the lower performance criterion.

### 4.2.3.3. Gender Differences on Cognitive levels

The mathematical content in the Pre-test was broken down into the cognitive levels of Knowledge, Understanding and Application, for the investigation purposes. Table 4.7 displays the means and standard deviation achieved by the BUSCEP students according to those cognitive levels.

**Table 4.7**: Means and Standard deviation of the 1996 BUSCEP students in the Pre-test by cognitive levels and gender

| | Knowledge | | Understanding | | Application | |
|---|---|---|---|---|---|---|
| | Males | Females | Males | Females | Males | Females |
| **N** | 175 | 51 | 175 | 51 | 175 | 51 |
| **Mean** | 52.9 | 38.9 | 46.6 | 41.9 | 52.6 | 50.7 |
| **St. D.** | 27.6 | 25.5 | 31.4 | 28.7 | 28.6 | 25.2 |

Males generally scored higher than females at all three cognitive levels. But, when an ANOVA test was carried out the differences were found to be statistically significant at 1% level for knowledge only, with F=10.503, df=1;224, p=0.001. (See Appendix C).

Taking into account the section and gender as independent variables, for the analysis of variance, the results indicate that section variable and the interaction, have not statistically significant effect for all the cognitive levels of the Pre-test, (see Table 4.8). However, the variable gender was statistically significant for knowledge only, ($F=8.700$, $df=1;222$, $p<0.01$).

Table 4.8: Two-way ANOVA for cognitive levels by section and gender.

| | F | df | p |
|---|---|---|---|
| **Knowledge** | | | |
| Section | 0.015 | 1;222 | 0.903 |
| Gender | 8.700 | 1;222 | 0.004 |
| Interaction | 0.013 | 1;222 | 0.910 |
| **Understanding** | | | |
| Section | 0.617 | 1;222 | 0.433 |
| Gender | 0.363 | 1;222 | 0.547 |
| Interaction | 2.486 | 1;222 | 0.116 |
| **Application** | | | |
| Section | 1.056 | 1;222 | 0.305 |
| Gender | .700 | 1;222 | 0.990 |
| Interaction | .72 | 1;222 | 0.603 |

The results obtained contradict the results of other researchers such as, Fennema and Carpenter (1981), Tartre (1990), Tartre and Fennema (1995). They found that the achievement differences between females and males increased with the cognitive level, and when the differences favour males, it is in the areas of understanding and application, contrasting with the results of this study.

On one hand, this situation can be explained in terms of the differences on the characteristics of the sample used in this study compared to the other studies. On the other hand, the statistically significant difference found for knowledge, in this study, can be justified by the fact that most of the female students did not study mathematics for about six months after the secondary school because this subject it was not evaluated in the entrance examination for their courses, (see section 4.1). Thus, the time lag between the end of the secondary school and the start of the university studies could have affected more this group in the capacity of remembering simple rules which were required for the solution of the exercises on this cognitive level.

Other studies report that male superiority in mathematics is found especially in performance on tasks of high cognitive complexity such as true problem solving (Fennema and Peterson, 1985; Hall and Hoff, 1988; Barnard and Cronjé, 1996). Meanwhile, Fennema and Sherman (1978), comparing mathematical tasks at several levels of cognitive complexity, such as, knowledge of concepts and problem solving found no gender-related differences for their sample of grades 6-8 pupils.

Leder, (1990b) also found that, on average, females do not score as high as males on mathematics tests, especially if those tests involve higher level cognitive tasks. If gender differences are found for young children, they tend to favour females (Hyde, Fennema and Lamon, 1990; Armstrong, 1981) in knowledge and skills (Fennema and Carpenter, 1981).

According to others, when the differences favour males, it is in the areas of understanding and application (Fennema and Carpenter, 1981) and problem solving (Tartre, 1990; Tartre and Fennema, 1995).

Maccoby and Jacklin (1974), on the other side argue that of all the cognitive skills, mathematics performance has been thought to show the largest differences in favour of males; these differences, not usually evident in grade school, are thought to emerge during adolescence.

#### 4.2.3.4. Gender Differences on Topics

When the data were aggregated by topics, gender-related differences were apparent in all three topics (Algebra, Geometry and Trigonometry). Although, males performed better than females in all the topics, and the differences were more evident in Algebra and Trigonometry. Table 4.9 shows gender's mean scores, and standard deviations related to each mathematics topics.

**Table 4.9**: Means and Standard deviations of the Pre-test by topics and gender

| | Algebra | | Trigonometry | | Geometry | |
|---|---|---|---|---|---|---|
| | Males | Females | Males | Females | Males | Females |
| N | 175 | 51 | 175 | 51 | 175 | 51 |
| Mean | 63.91 | 51.73 | 37.63 | 30.47 | 50.29 | 48.74 |
| St. D. | 28.93 | 33.28 | 27.88 | 21.70 | 28.93 | 30.93 |

There were considerable but non-significant gender related differences in Algebra (12.6), which was strongly emphasised in school, (about two thirds of the total time for mathematics at secondary school is spent on teaching Algebra). The differences were smaller for Trigonometry and Geometry 7.2 and 1.6 respectively.

Those differences are interesting as these topics receive respectively less time at school, (see section 1.1.3.). However, the analysis of variance did not show the mean differences to be significant. (Appendix C).

Table 4.10 provides a summary of the two-factor, (section and gender), having the mathematics topics scores as the dependent variables. And, for all topics, (Algebra, Geometry and Trigonometry), there were no significant main effects for section and gender, as well as no significant interaction effects.

**Table 4.10:** Two-way ANOVA for the Pre-test mathematics topics by section and gender

| | F | df | p |
|---|---|---|---|
| **Algebra** | | | |
| Section | 0.838 | 1;222 | 0.361 |
| Gender | 4.097 | 1;222 | 0.044 |
| Interaction | 0.131 | 1;222 | 0.718 |
| **Trigonometry** | | | |
| Section | 1.927 | 1;222 | 0.167 |
| Gender | 0.044 | 1;222 | 0.834 |
| Interaction | 1.086 | 1;222 | 0.298 |
| **Geometry** | | | |
| Section | 0.250 | 1;222 | 0.618 |
| Gender | 3.073 | 1;222 | 0.081 |
| Interaction | 0.562 | 1;222 | 0.454 |

This result is similar to that of Swafford (1980), using a sample composed equally by males and females in first year College Algebra. Other studies indicate that gender differences are limited to certain areas of mathematics (Hanna, 1986; Hanna, 1989). Some researchers 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 (Fennema and Carpenter, 1981; Cheung, 1989; Hanna, Kundiger and Larouche, 1990; Fennema, Peterson and Carpenter, 1990; Fennema and Hart, 1994).

#### 4.2.3.5. Gender differences on item level

The analysis of mean performances of males and females in the Pre-test did not disclose any statistically significant gender difference, (see section 4.2.3.4). It may be possible that such analysis excludes more specific gender differences because the test as a whole is taken as point of departure.

As, has been argued by authors such as Becker (1990), and Feingold 1994, (see section 3.3.1), 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. Thus, an analysis of each multiple-choice item can also provide more information on the performance of males and females on mathematics performance in the Pre test.

Therefore, in this study, an analysis of the differences on item level of the Pre-test was also done to find out whether there were any differences between males and females on that level. The values of the Difficulty and Discrimination indices for the overall sample and for each gender group

are displayed in Table 4.11. Those values were calculated using the following formulas, (presented in section 2.2.4):

$$Diff = \frac{H+L}{N} \times 100 \;\; ; \;\; Disc = \frac{2 \times (H-L)}{N}$$

where,

- *Diff* is the numerical value of the Difficulty index of a question.
- *Disc* is the numerical value of the Discrimination index of a question.
- $H$ is the number of correct answers in the high group.
- $L$ is the number of correct answers in the low group.
- $N$ is the total number of students in both groups.

(Guilbert, 1981 and Gronlund, 1993)

**Table 4.11:** Difficulty and Discrimination indices of the Pre-test items by gender

| | Difficulty index - % | | | Discrimination index | | |
|---|---|---|---|---|---|---|
| | Males | Females | Total | Males | Females | Total |
| Item 1 | 80 | 57 | 82 | 0.35 | 0.47 | 0.48 |
| Item 2 | 52 | 37 | 54 | 0.51 | 0.33 | 0.59 |
| Item 3 | 60 | 43 | 66 | 0.62 | 0.33 | 0.61 |
| Item 4 | 53 | 63 | 58 | 0.25 | 0.33 | 0.35 |
| Item 5 | 63 | 53 | 66 | 0.49 | 0.40 | 0.65 |
| Item 6 | 35 | 50 | 42 | 0.54 | 0.47 | 0.54 |
| Item 7 | 24 | 13 | 27 | 0.37 | 0.13 | 0.39 |
| Item 8 | 68 | 57 | 68 | 0.47 | 0.33 | 0.61 |
| Item 9 | 25 | 23 | 28 | 0.27 | 0.07 | 0.33 |
| Mean | 51 | 44 | 54 | 0.43 | 0.32 | 0.51 |

It is of certain interest, in the study, to note that the values of the difficulty and discrimination indices were calculated using different parameters (see section 3.3.1), according to the started differences on the range of scores of males and females (see Appendix C).

The mean value for the difficulty index related to all sample was 54%. The difference between males and females in the mean values of the difficulty index is 7%. When the values of the difficulty index of the males and females were compared it is clear that for seven of the nine items, males have higher difficulty indices than females. It means that seven items were relatively more easy for males than for females.

Although, differences are small, the mean values for difficulty indices show that, in general, females experienced more difficulties in the Pre-test than did males. Both males and females found the item 1 as the easiest, with the difficulty index of 82% for the overall sample, and 80% for males and 57% for females; however, the same value for females was found on item 8. By contrast the items 4 and 6 were experienced as much more difficulty by males than by females. It is interesting to note that the two questions 4 and 6 on which females surpassed males were both geometrical exercises on the cognitive levels of understanding and application respectively. These questions will then be discussed with more details later, in this section.

The mean value for the discrimination indices shows that the test was in general above average discrimination index (0.51) for both genders, (males, at 0.43; and females, at 0.32), although, the differences were also small. Seven of the discrimination indices, were higher for males than for females, meaning that those items discriminate better between high and low performers, for males than for females. Item 1 and item 4 which discriminate better among females were taken with different assumptions

in the Pre-test. For item 1, the assumption was that students have met the type of this exercise before, in the form required for the answer, while for item 4, the assumption was that, the students have not met the type of exercise in the form given in the Pre-test and, it was required the ability to extrapolate a known procedure to a new situation.

The differences, between the two genders, in the difficulty and discrimination indices were tested using the test for differences of two proportions. A Bonferroni adjustment to the significance level was made, so that each item was tested at $\alpha = 0.01$, (se section 3.3.1). Meanwhile no statistically significant differences were found on item difficulty and discrimination between males and females.

According to some authors (Guilbert, 1981; Ebel and Frisbie, 1991; Gronlund, 1993), it has been argued that a test with a difficulty index in the range of 50% to 60% is very likely to be reliable as regards to its internal consistency or homogeneity, (see sections: 2.3.6; 3.3.1 and 3.4). Hence, the results obtained in this study can also be reported as an assessment procedure for validity and reliability of the Pre-test.

On the other hand, authors such as, Guilbert (1981), Ebel and Frisbie (1991), Gronlund (1993), state that a question with a difficulty index lying between 30% and 70% is acceptable, (see sections: 2.3.6 and 3.3.1). Thus, the difficulty indices for item 7, (24% for males and 13% for females), and item 9 (25%) for males and 23% for females lay outside the acceptable bounds.

In Table 4.12, the distribution of the students' answers by alternatives presented for each item is shown. As can be seen the frequency of choice was remarkable on the correct answer except for items 6, 7 and 9 in which the students preferred not to choose. This situation may be because the

items are related to Geometry (item 6) and Trigonometry (items 7 and 9) which according to the mathematics curricula, receive less attention during the secondary school, (see section 1.1.3), and it did not allow the students the pleasure to do any guessing.

**Table 4.12:** Percentage distribution of the students choices of the option in the items of the Pre-test by gender

| Item | Gender | Option A | Option B | Option C | Option D | Not answered |
|---|---|---|---|---|---|---|
| 1 | Males | 78* | 1 | 2 | 0 | 19 |
| | Females | 63* | 4 | 2 | 2 | 29 |
| 2 | Males | 7 | 46* | 14 | 12 | 21 |
| | Females | 6 | 41* | 21 | 18 | 14 |
| 3 | Males | 24 | 3 | 68* | 2 | 3 |
| | Females | 27 | 12 | 58* | 6 | 2 |
| 4 | Males | 18 | 58* | 4 | 16 | 4 |
| | Females | 21 | 63* | 6 | 10 | 0 |
| 5 | Males | 65* | 1 | 3 | 8 | 23 |
| | Females | 51* | 2 | 2 | 4 | 41 |
| 6 | Males | 5 | 5 | 36* | 3 | 51 |
| | Females | 2 | 12 | 39* | 4 | 43 |
| 7 | Males | 10 | 4 | 23* | 4 | 59 |
| | Females | 19 | 4 | 12* | 10 | 55 |
| 8 | Males | 4 | 10 | 68* | 7 | 11 |
| | Females | 8 | 15 | 63* | 12 | 2 |
| 9 | Males | 24* | 13 | 23 | 11 | 29 |
| | Females | 22* | 12 | 23 | 18 | 25 |

(* denotes the correct answer of each question)

According to authors such as Guilbert (1981), Ebel and Frisbie (1991), Gronlund (1993), the frequency with which each incorrect answer is chosen may reveal common errors and misconceptions, which can provide a focus for remedial work.

In item 1 the distracters did not played any influence on guessing for both genders, perhaps because of the high level of facility experienced by the students of both gender groups. And as yet reported, females also found items 4 and 6 more easy than did males, thus in the degree of guessing, gender differences were small.

In the following items new pointers will be discussed:

**Item 1:** Simplify $\frac{xy-3x^2y^2+(xy)^2}{xy-2x^2y^2}$

A. 1

B. $\frac{xy-x^2y^2}{xy}$

C. $\frac{1-2(xy)^2}{x^2y^2}$

D. $(xy+xy)(xy-xy)$

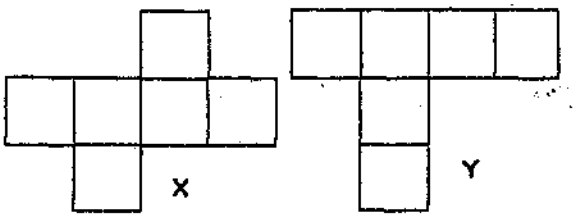
N.B.: The correct answer is A.

This item is related to Algebra which is strongly emphasised at secondary school. The assumption in this item was that students have met the exercise before in the form required for the answer.

In spite of the more difficulty experienced by females (57%) than males (80%), both males and females found the item 1 as the easiest, with the difficulty index of 82% for the overall sample. The item 1 also discriminate

better between the low and high performers for females (*Disc*=0.47) than for males (*Disc*=0.35).

Item 4: Can these shapes form a cube?



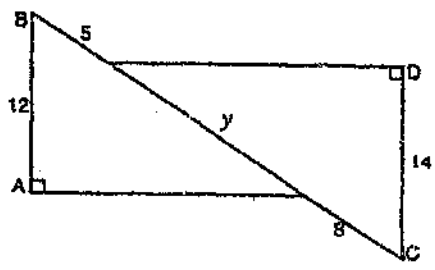

A. Both X and Y can
B. X can but Y cannot
C. Y can but X cannot
D. Neither X nor Y can

N.B.: The correct answer is B

Item 4 whose the difficulty index reveals to be a easier question for females (*Diff*=63%) than for males (*Diff*=53%), also discriminate better between the low and high performers for females (*Disc*=0.33) than for males (*Disc*=0.25). In this item the assumption was that the students have not met this type of exercise. The students are required to do an extrapolation of known procedures to a new situations. The choice of the alternatives shows a similar distribution for both genders.

**Item 6:** In the following picture, AB and CD are parallels. Considering the given values in that picture, the value of y will be:

A. 21
B. 26
C. 13
D. 18




N.B.: The correct answer is C

This exercise req[illegible]e ability to use skills in a way which goes beyond recall of simple rules. The students was required to recognise the applicability of geometrical formula in an unusual contexts. Here, it was assumed that various routine geometrical skills needed to do the exercise are familiar to the students, and that they have done drill work in similar but not identical exercises.

The result shows that a large proportion of the sample did not answer this item. It should mean that students were not secure with their skills in solving geometrical problems, perhaps, because of the less emphasis given to this *topic* at secondary school. Although, more females (39%) than males (36%) chose the correct answer. But, among the choices non-significant gender differences were disclosed. This item had an excellent discrimination for both genders.

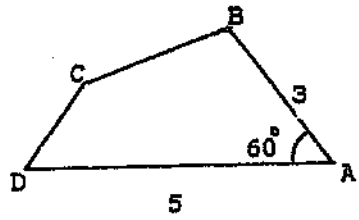
Item 7: Determine the value of BD in the given figure ABCD.

A. $\sqrt{34}$

B. 8

C. $\sqrt{19}$

D. $15\sqrt{3}$




N.B.: The correct answer is C.

Here it was assumed that students have done drill in tasks similar to that. And, the only skill required was to bring to mind previously learned information in the form that it was given, that was required a recall of simple rules. The difficulty index for item 7, was 24% for males and 13% for females, lying outside the acceptable bounds.

Item 9: Knowing that $\alpha$ is an angle in the third quadrant and, $\sin\alpha = -2/3$, the angle $2\alpha$ will be located in the following quadrant:

A. First

B. Second

C. Third

D. Fourth

N.B: The correct answer is A

For item 9 which is related to the cognitive level of understanding, it was assumed that pre-university students of Mozambique would have the technical skills needed to solve the exercise, but in fact the majority of the BUSCEP students had the difficulty with this item, perhaps, because of the less emphasis given to this topic at secondary school and the way in which it has been taught for secondary students that focuses on the rote and memorisation of formulas.

Items 7 and 9 which were also found to be difficult for both genders and it seems to have a very low discrimination index. However, item 9 was the poorest question for discriminating between low and high performers for females, while item 7 displayed a marginal discrimination which means that it was also an inadequate question for this group.

### 4.2.4. The intermediate Test-1

#### 4.2.4.1. Gender differences on Means

Table 4.13, displays the results achieved by males and females in the intermediate Test-1. The mean scores for the males and females, were 63.3 and 49.7, respectively. In terms of variability, the variance ratio of males to females indicates that females were found to be more variable than males, (ratio=0.82), in Test-1. In the ANOVA test computed for the whole sample, the difference, on mean, of 13.6 in favour of males was found to be statistically significant, at the 1% level ($F=22.373$, $df=1;221$. $p<0.01$).

Table 4.13: Means and Standard deviations achieved in Test-1 by gender and section

| | Total Sample | | SCIENCE | | BIOLOGY | |
|---|---|---|---|---|---|---|
| | Males | Females | Males | Females | Males | Females |
| N | 172 | 51 | 118 | 16 | 54 | 35 |
| Mean | 63.3 | 49.7 | 69.0 | 68.2 | 51.0 | 41.2 |
| St. D. | 17.2 | 20.9 | 14.0 | 13.0 | 17.3 | 18.3 |

When the sample was sorted by section the analysis of variance which was carried out, found that, the differences were statistically non-significant with F=0.047, df=1;132 and p=0.829 for SCIENCE, and F=6.545, df=1;87 and p=0.012 for BIOLOGY. Meanwhile, if a two-way ANOVA was done for Test-1 with section and gender as independent variables the result shows that for Test-1 significant main effect was found only for section as can be seen in table 4.14.

Table 4.14: Two-way ANOVA for Test-1 by section and gender

| | F | df | p |
|---|---|---|---|
| Section | 70.980 | 1,219 | 0.000 |
| Gender | 3.968 | 1,219 | 0.048 |
| Section * gender | 2.864 | 1,219 | 0.092 |

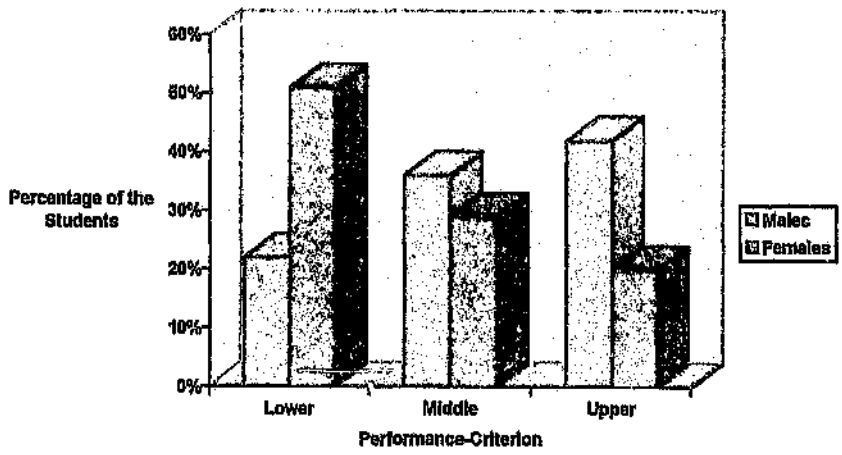
In the analysis of covariance (ANCOVA) of the test scores, using the Pre-test as the covariate, a significant main effect for gender (F=18.831, df=1;220, p<0.01) was found, while the Pre-test was not statistically significant at 1% level; F=5.627, df=1;220, p=0.019, (see Appendix C). It means that although students enrolled in the same mathematics classes

the differences in performance between males and females existed in Test-1 with females showing lower attainment, even with the adjustment of the initial difference in the Pre-test considered.

### 4.2.4.2. Gender Differences on the Performance-Criterion

When the analysis were done on the performance criterion, the dependence of achieving at specific level on gender was statistically significant ($x_2^2 = 17.371$, $p<0.001$), with a higher percentage of males (42.4%) than that of females (19.6%) achieving at the upper performance criterion. The opposite situation occurs in the lower performance criterion where the percentage of females (51%) is higher compared to that of males (22%). In the middle performance criterion the distribution was similar between the two genders. This situation is better illustrated in the graph in Figure 4.4.

**Figure 4.4: Percentage distribution of the Test-1 scores of the1996 BUSCEP students by Performance-Criterion and gender**



## 4.2.5. The intermediate Test-2

### 4.2.5.1. Gender Differences on Means

In Test-2 the mean scores achieved by the males was at 49.1 percent and that for females was at 41.1 percent, (Table 4.15).

**Table 4.15:** Means and Standard deviations of Test-2 by gender and section

| | Total Sample | | SCIENCE | | BIOLOGY | |
|---|---|---|---|---|---|---|
| | Males | Females | Males | Females | Males | Females |
| **N** | 170 | 51 | 117 | 16 | 53 | 35 |
| **Mean** | 49.1 | 41.1 | 49.6 | 44.4 | 48.8 | 39.5 |
| **St. D.** | 16.0 | 15.0 | 16.6 | 20.0 | 14.8 | 12.1 |

In the analysis of variance (ANOVA) the differences in mean performance favouring males, were found to be statistically significant at 1% level, ($F=10.221$, $df=1;219$, $p=0.002$). (See Appendix C). However, the variance ratio of 1.06 of males to females shows a similar variability of both gender groups with regard to the mathematics performance in Test-2.

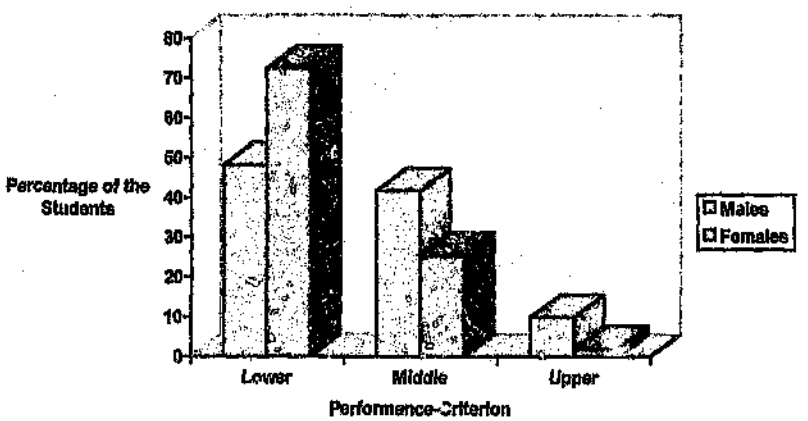
When section variable were taken into account, the related gender differences favouring males continues to be statistically significant at 1% level in BIOLOGY only, ($F=8.005$, $df=1;86$, $p=0.006$). In SCIENCE the results show that males and females performed similarly. The main effect for gender and section as independent variables was found to be statistically non-significant and there were no interaction effects, (see Appendix C).

In the analysis of covariance, (ANCOVA), it was found that, the Pre-test was statistically significant, ($F=19.939$, $df=1;218$, $p<0.01$). The main effect of gender was found to be statistically non-significant at 1% level, with $F=6.523$, $df=1;218$, and $p=0.011$. This results means that, if the initial difference in the Pre-test was controlled, the enrolment in mathematics is still producing similar achievement for both males and females.

### 4.2.5.2. Gender Differences on the Performance-Criterion

In Figure 4.5, it is illustrated the distribution of the achievement scores of the students on Test-2 by performance criteria and gender. Here, it can be seen that a small percentage of students, mainly males, achieved the highest scores (scores of 70 and over). The percentage of females overtake that of males only at lower level of performance.

**Figure 4.5: Percntage distribution of the Test-2 scores of the 1996 BUSCEP students by Performance-Criterion and gender**




The chi-squared test confirms that the dependence of that achievement distribution by performance criterion on gender is highly significant ($x_2^2 = 10.154, p = 0.006$).

## 4.2.6. The Mini-Test

### 4.2.6.1. Gender Differences on Means

Gender performance in the Mini-Test is presented in the following Table 4.16. Females outperformed males in the Mini-test, however this difference was not statistically significant when the analysis of variance was carried out (F=1.007, df=1;220, p=0.317).

**Table 4.16:** Means and Standard deviations of the Mini-Test by gender and section

| | Total Sample | | SCIENCE | | BIOLOGY | |
|---|---|---|---|---|---|---|
| | Males | Females | Males | Females | Males | Females |
| N | 171 | 51 | 117 | 16 | 54 | 35 |
| Mean | 63.8 | 66.0 | 60.4 | 64.3 | 71.1 | 66.8 |
| St. D. | 13.7 | 13.8 | 11.7 | 8.0 | 14.9 | 15.8 |

Even when the sample was grouped by section, the difference of 4%, favouring females remains in SCIENCE, while in BIOLOGY the same difference was in favour of males. But none of these differences were statistically significant.

Despite the non-significant gender difference in favour of the female students, it is evident that females tend to outperform males in such kind of tests that reflects a classroom contents. This result can be confirmed later in section 4.3.3.2, where the frequency of studying mathematics, of

males and females is presented, with females being more regular than males by studying mathematics everyday.

This finding is in agreement to what some researchers, (Bohlin, 1994; Mji and Glencross, 1996), found that males and females have different mathematics learning styles (autonomous and rote respectively), and females perform better relative to males on items that require the application of a familiar algorithm (e.g., classroom tests).

The analysis of covariance (ANCOVA) by gender and section with Pre-test as covariate found a statistically significant main effect for section ($F=11.092$, $df=1;217$, $p=0.001$) and for the Pre-test ($F=13.626$, $df=1;217$, $p<0.001$). There were no interaction effects. These results favoured the BIOLOGY students who appeared to have a more regular work pattern of studying mathematics.

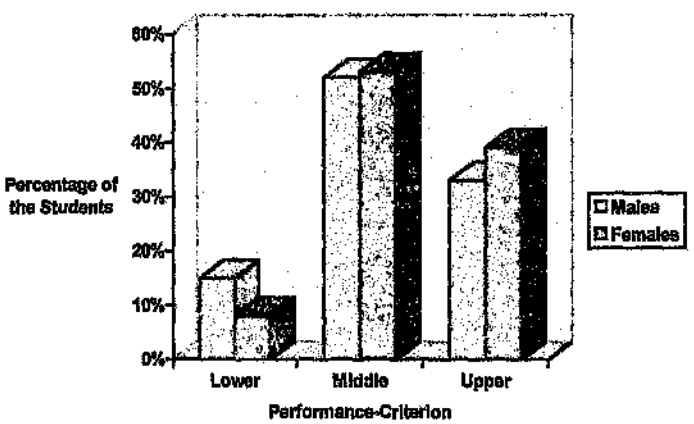
In the classroom tests (Mini-test), females advantage was seen, which means that females performed slightly higher in the systematic assessment. According to Kimball (1989), females are in disadvantageous position when standardised tests are given but not when doing tests that reflect classroom content, but Seegers and Boekaerts (1996), have concluded that males outperformed females on mathematics tasks using a test that reflected classroom content.

The comparison done in terms of the variance ratio of males to females found a value of 0.99, which represents a similar variability of both gender groups in the mathematics performance in the Mini-test.

### 4.2.6.2. Gender Differences on the Performance-Criterion

Gender differences in the Mini-Test were also observed when the distribution of scores by performance criteria were considered, with 39% of females achieving the highest scores against 33% of males. At lower performance criterion, the percentage of males (15%) was a double of the percentage of females (8%). For both gender groups, the highest percentage was found at the middle performance criterion, (see section 4.6).

**Figure 4.6: Percentage distribution of the Mini-test scores of the 1996 BUSCEP students by Performance-Criterion and gender**




However, none of the differences, presented in the figure 4.6, was confirmed by the Chi-squared test ($x_2^2 = 1.779$, p=0.411), computed for the statistical significance.

## 4.2.7. The Final Result

### 4.2.7.1. Gender Differences on Means

Table 4.17 shows the mean scores obtained by the students at the end of the BUSCEP course. In the analysis of variance (ANOVA) that was done, gender difference in favour of males was found to be statistically significant with F=13.304, df=1;221 and p<0.001, for the whole sample. However, the results indicate a similar variability of the two gender groups, hence when the variance ratio was calculated found the value of 0.95.

**Table 4.17:** Means and Standard deviations of males and females in the Final Result by section

| | Total Sample | | SCIENCE | | BIOLOGY | |
|---|---|---|---|---|---|---|
| | Male | Female | Male | Female | Male | Female |
| N | 172 | 51 | 118 | 16 | 54 | 35 |
| Mean | 57.7 | 50.3 | 59.4 | 58.4 | 54.1 | 46.6 |
| St. D. | 12.7 | 13.3 | 12.0 | 09.4 | 13.4 | 13.2 |

When the means performance were compared within sections, it was found that in BIOLOGY the difference in favour of males was statistically significant at 1% level, (F=6.909, df=1;87, p=0.010). While, in SCIENCE these differences on means were found to be not statistically significant between the two genders. The analysis of covariance of the scores of the Final result by gender with Pre-test as covariate found a statistically significant main effect for gender (F=9.047, df=1:220, p<0.01), and for the Pre-test, (F=23.272, df=1;220, p<0.01). A gender-section analysis of covariance of these scores using Pre-test as covariate, found that there was a significant main effect for section (F=14.625, df=1;218, p<0.001). The gender-section interaction was not statistically significant.

If the gender-section analysis of covariance o these scores was done using the Pre-test cognitive levels (knowledge, understanding and application) as the covariate variables a significant main effect for section was found for knowledge ($F=16.882$, $df=1;218$, $p<0.001$), understanding ($F=15.591$, $df=1;218$, $p<0.001$), and application ($F=14.803$, $df=1;218$, $p<0.001$). In similar analyses of covariance when the Pre-test mathematics topics were taken as the covariate variables, a main effect for section but not for gender was found for all topics, (see Table 4.18).

Table 4.18: ANCOVA for Final Result by Gender x Section with Pre-test mathematics topics as covariate

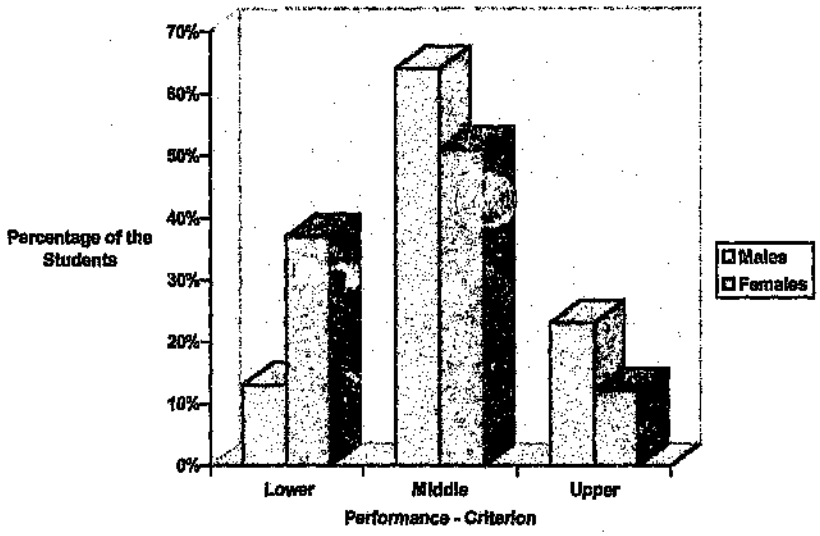
| | F | df | p |
|---|---|---|---|
| **Algebra** | 14.561 | 1,218 | 0.000 |
| Section | 15.031 | 1,218 | 0.000 |
| Gender | 2.334 | 1,218 | 0.128 |
| Interaction | 2.328 | 1,218 | 0.129 |
| **Trigonometry** | 2.339 | 1,218 | 0.128 |
| Section | 16.519 | 1,218 | 0.000 |
| Gender | 3.257 | 1,218 | 0.073 |
| Interaction | 2.226 | 1,218 | 0.137 |
| **Geometry** | 9.568 | 1,218 | 0.002 |
| Section | 14.133 | 1,218 | 0.000 |
| Gender | 4.450 | 1,218 | 0.036 |
| Interaction | 1.918 | 1,218 | 0.168 |

These results could be due to the fact that the Final Result is a linear combination of the intermediate tests that provided a statistically significant difference, and a similar variability of both gender on the mathematics performance.

### 4.2.7.2. Gender Differences on the Performance-Criterion

The percentage of females (37%) who failed the subject (achieving at the lowest performance criterion) before the exam was about three times of the percentage of males (13%). At upper performance criterion females were also less represented than males, (see Figure 4.7).

**Figure 4.7: Percentage distribution of the Final results of the 1996 BUSCEP students by Performance-Criterion and gender**




Females are also less represented in the middle performance criterion (51%) against their counterpart males (64%), as illustrated in Figure 4.7. The chi-squared test confirms a gender influence on the distribution of the achievement scores on the performance criteria of the Final result, ($x_2^2 = 15.43$, $p<0.001$).

### 4.2.8. General discussion on cognitive level

The previous comparison of the mean scores showed a constant males advantage, in all standardised tests. However in the classroom tests (Mini-test), females advantage was seen, which means that females performed slightly higher in the systematic assessment. Despite the non-significant gender difference in favour of the female students, it is evident that females tend to outperform males in such kind of tests that reflects a classroom contents. This finding is in agreement to what some researchers, (Bohlin, 1994; Mji and Glencross, 1996), found that males and females have different mathematics learning styles (autonomous and rote respectively), and females perform better relative to males on items that require the application of a familiar algorithm (e.g., classroom tests).

Although, from all the tests scores considered in this study, there were negligible differences in the mean scores between males and females when found in the mathematics scores from the secondary school, the entrance examination and the Pre-test; in the intermediate tests (Test-1 and Test-2), and the Final Result, which were written during the BUSCEP course, the differences favouring males, were found to be significant at the 1% level.

According to Kimball (1989), females are in a disadvantageous position when standardised tests are given but not when doing tests that reflect classroom content, but Seegers and Boekaerts (1996), found that males outperformed females on mathematics tasks using a test that reflected classroom content.

In the present research the variance ratio of males to females are: 1.04; 0.82; 1.06; 0.99; and 0.95 for the Pre-test, Test-1, Test-2, Mini-test and the Final result, respectively. These values so close to 1 represent similar variability of the two gender groups with regard to mathematics performance in the Pre-Test, Test-1, Test-2, Mini-test and the Final Result. (See sections 2.1; 4.2.3; 4.2.4; 4.2.5; 4.2.6; 4.2.7).

Feingold (1994), argued that absence of gender differences in mean scores may sometimes conceal greater variability of one of which actually represents a gender difference. As found by (1988), that the generalised belief that females cannot do mathematics is not supported by the results from this study. results obtained here contradict the findings of some other studies. According to authors, such as Hall and Hoff, (1988), Levin, Sabar and Libman (1991), Kaiser-Messmer (1993), males perform better than females at mathematics, and the differences between the genders increase with age.

Gender differences in mathematics performance were also observed when performance criteria were considered. Therefore, the gender-based differences on achieving at specific performance criterion were statistically significant at 1% level, for Test-1, Test-2 and the Final result where males were better represented at the highest performance criterion, contrary to the lowest performance criterion where the females representation was higher.

Males generally scored higher than females at all three cognitive levels. In spite of the male students outperforming the female students, in all cognitive levels. But, when an ANOVA test was carried out the differences were found to be statistically significant at 1% level for knowledge only,

with F=10.503, df=1;224, p=0.001. (See Appendix C). These results are supported by the results from study of Becker and Forsyth (1994), who found that males generally performed better at the upper percentile levels of the score distribution in mathematics problem solving and science, while females closed the gap and, in some instances, outperformed males at the lower percentile levels.

On one hand, this situation can be explained in terms of the differences on the characteristics of the sample used in this study compared to the other studies. On the other hand, the statistically significant difference found for knowledge in this study, can be justified by the fact that most of the female students did not study mathematics for about six months after the secondary school because this subject it was not evaluated in the entrance examination for their courses. (see section 4.1). Thus, the time lag between the end of the secondary school and the start of the university studies could have affected more this group in the capacity of remembering simple rules which were required for the solution of the exercises on this cognitive level.

There were considerable but non-significant gender related differences in Algebra (12.6), which was strongly emphasised in school, (about two thirds of the total time for mathematics at secondary school is spent on teaching Algebra). The differences were smaller for Trigonometry and Geometry 7.2 and 1.6 respectively. Those differences are interesting as these topics receive respectively less time at school, (see section 1.1. ). However, the analysis of variance did not show the mean differences to be significant. (Appendix C).

## 4.3. GENDER-RELATED DIFFERENCES ON THE AFFECTIVE DOMAIN

The students completed a two-page questionnaire in ass that asked them questions about their learning style preferences and attitudes towards mathematics before entering to the university, including:

- how much ability they felt they had in mathematics as a subject,
- how hard they worked in the school mathematics courses,
- how much they felt luck played a part in their performance,
- how important they felt the subject was,
- which type of questions they like in mathematics tasks,
- what influence was played by mathematics performance in their career choice at university,
- how they self-rate their previous results in mathematics,
- which factors they felt that they influenced their mathematics performance during the secondary education, and
- how interesting they felt the mathematics is.

### 4.3.1. Gender differences in Attitude Towards Mathematics

#### 4.3.1.1. Choice of career at University

With the intention to find out if there were any differences on career choice among 1996 BUSCEP students based on gender, students were asked to write down their most preferred course to enrol at the University,

and, the data displayed that the majority of females list Agronomy as the course that interests them the most. Table 4.19 summarises the preferred university courses by gender of the BUSCEP students in 1996.

**Table 4.19**: Preferred First Choice University Course by Gender

| | Males | | Females | |
|---|---|---|---|---|
| | N | % | N | % |
| Engineering | 103 | 59 | 10 | 20 |
| Sciences | 6 | 3 | 3 | 6 |
| Agronomy | 46 | 26 | 20 | 38 |
| Biology | 2 | 1 | 5 | 10 |
| Medicine | 4 | 2 | 5 | 10 |
| Veterinary | 0 | 0 | 2 | 4 |
| Maths and Computer | 10 | 7 | 2 | 4 |
| Architecture | 0 | 0 | 2 | 4 |
| No Answer | 4 | 2 | 2 | 4 |

Clear gender differences were found, with Engineering being the most popular course among males (59%), but unpopular for females (20%). In contrast, Biomedical Sciences (Biology, Medicine and Veterinary Science) were nominated by the females at 24%, whilst they were preferred by 3% of the males. Similar results were also found by Dick and Rallis (1991), with a lower proportion of females than males choosing a career in Engineering.

Overall, it is noticeable that for the students enrolling in the BUSCEP program, courses such as Sciences and Mathematics were equally less

interesting for both genders, with 10% of females and 10% of males, nominating this as the course of their preference. The percentage of males interested in enrolling in a Mathematics career was slightly higher when compared to their interest in Science careers such as Physics, Chemistry and Geology (3%). For females, the results show a slightly different picture with 6% choosing Science courses against 4% choosing Mathematics. Overall, the differences were significant in terms of gender, as confirmed by the Chi-squared test, $\chi_3^2 = 44.557, p < 0.001$. It means that, for the 1996 BUSCEP students, the choice of career at university was highly influenced by gender.

According to some authors, (Fennema and Sherman, 1977; Megarry, 1984; Armstrong, 1985, Fennema, 1985; DeBoer, 1984, DeBoer, 1986; Leder, 1990b; Maple and Stage, 1991, Dick and Rallis, 1991), 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. Females are also under-represented in advanced mathematics courses, college majors and careers that involve mathematics.

Catsambis, (1995), on one hand, found that by grade eight, females already begin to show less interest in science courses than males. Overall, gender differences in science related attitudes and interests are much stronger than gender differences in science achievement. On the other hand, Leder and Forgasz, (1992) stated that during the compulsory years of schooling in Australia the participation rate of students in mathematics is very high. For the most demanding elective mathematics courses at the post-compulsory years of schooling and at the tertiary level, females' participation rates have persistently remained lower than males).

### 4.3.1.2. Importance of Mathematics

To both genders, the importance of mathematics seemed to be beyond question with a similar percentage of males and females demonstrating a great believe in the importance of mathematics for their careers. As can be seen in Table 4.20 only 2% in both genders stated that mathematics is unimportant in the career in which they are enrolling.

**Table 4.20:** Percentage of 1996 BUSCEP students assessing the importance of mathematics in their career by gender.

| | Males (%) | Females (%) |
|---|---|---|
| Important | 98 | 98 |
| Unimportant | 2 | 2 |

### 4.3.1.3. Influence of Mathematics on Career choice

As stated by Fennema and Sherman (1977), perception of the value of mathematics or mathematics-related careers have emerged as a significant predictor of both achievement and course plans in the majority of studies. Therefore, in this study one question was addressed to the students asking their opinion about the influence of mathematics performance in their career.

With regard to the influence played by the students' mathematics performance on their career choice, the study found that a greater

percentage of males (75%) than females (67%) had the opinion that their career choice was influenced by their mathematical performance.

**Table 4.21**: Percentage of the 1996 BUSCEP students' responses concerning to the opinion about the influence of mathematics on career choice by section and gender

| | SCIENCE | | BIOLOGY | |
|---|---|---|---|---|
| | Males % | Females % | Males % | Females % |
| Maths influenced | 78 | 69 | 71 | 66 |
| Maths not influenced | 22 | 31 | 29 | 34 |

Though, as the expected cell frequencies were too small to allow for a Chi-square analysis, Fisher's Exact Test was used to measure the statistically significance of the difference and the result showed that there was no relationship between the variables gender and the opinion about the influence of mathematical performance on career choice, ($p = 0.213$).

The differences can also be detected when the comparison between the two genders was done within the section enrolled as is showed in Table 4.21. However, Fisher's Exact Test still found that there was no significant gender-based influence of mathematics performance on career choice in both sections: ($p = 0.530$ for SCIENCE, and $p = 0.645$ for BIOLOGY).

Considering the opinion about the influence of mathematics on career choice as the independent variable, and the Final result as the dependent

variable, the ANOVA test that was carried out, found non-significant dependence between the variables, ($F=0.182$, $df=1;222$, $p=0.650$).

Despite the statistically non-significant gender difference found, with respect to the fluence of mathematics achievement on career choice, there was a remarkable difference between males and females on the course to enrol at UEM (see section 4.1), hence, the proportion of females was higher than that of males in Biology course only, which is unique in that it does not include mathematics in the entrance examination. It should means that independently of what the student answered in the questionnaire, it was found that gender differences in mathematics attitudes and interest are stronger when they must take any decision with respect to mathematics. These findings add to the existing literature which reports similar findings for older students, (Catsambis, 1995).

#### 4.3.1.4. Self-rating of Mathematical Performance at Secondary School

According to some researchers, (Meyer and Koelher, 1990; Tartre and Fennema, 1995), females have tended to be less confident in their ability to do mathematics than are males. Hence, it is reasonable to hypothesise that confidence is an important variable to investigate. In this study, members of both genders were asked how would they rate their previous mathematics performance.

Table 4.22 describes the responses of all the BUSCEP students to the question on self-rating of their performance at secondary school by gender.

**Table 4.22:** Percentage of 1996 BUSCEP students' self-rating of mathematical performance at Secondary School by gender

| | Males (%) | Females (%) | Total (%) |
|---|---|---|---|
| Poor | 1 | 6 | 2 |
| Fair | 62 | 67 | 63 |
| Good | 37 | 27 | 35 |

Here, the most remarkable difference on students self-rating of their mathematical performance was at the higher estimation with 37% of males and 27% of females self-rating their performance in mathematics as good. But, the Chi-squared test of dependence of the two variables self-rating of mathematical performance and gender is statistically non-significant, ($\chi_2^2 = 5.225; p = 0.073$).

The students' self-rating their previous mathematics performance was compared to the Performance-Criteria of the secondary school performance in mathematics. Eleven percent of the females compared to 26% of males, in the weak students' group, rated themselves higher in mathematics than their self reported mathematics grades from the secondary school. For both gender groups, the Chi-squared t , shows that the students self-rating of performance was highly related to the performance criteria of the school mathematics grades defined by the researcher, ($\chi_4^2 = 18.140; p = 0.001$ for males; $\chi_4^2 = 20.630; p < 0.001$ for females).

However, when the analysis was done using the performance criteria of the Final result the Chi-squared test displays a non-statistically significant relationship, with $\chi_4^2 = 4.829; p = 0.305$ for males and, $\chi_4^2 = 11.651; p = 0.020$ for females.

These results support other works with respect to ability ratings in science and mathematics courses. DeBoer (1986), for example, reported that male students rated themselves higher than female students even in the absence of superior course performance on the part of the males. Leder, (1993) also found that for grade 7 students, there was no gender difference in mathematics achievement, but more males than females rated themselves above-average in mathematics ability compared with their classmates.

#### 4.3.1.5. Factors Influencing on Students' Mathematical Performance

The following set of statements was given to the students and then they were asked to check the option that indicates the factor that influenced the most in their mathematical performance:

A. Inclination to work in mathematics
B. Investment of effort
C. Lack of inclination
D. Influence played by the mathematics teachers
E. Availability of materials
F. Other factor? _____ Which? _____

The students opinion about the possible factors that might have influenced their previous mathematical performance, is displayed in Table 4.23.

**Table 4.23**: Percentage of the 1996 BUSCEP students' responses related to the factors that influenced their previous mathematical performance

| | Males % | Females % | Total % |
|---|---|---|---|
| A | 22 | 14 | 20 |
| B | 50 | 55 | 51 |
| C | 2 | 8 | 4 |
| D | 14 | 19 | 15 |
| E | 12 | 4 | 10 |

In answering the question addressed , the majority of the students of both genders (more than 50%), considered that the investment of effort was the most important factor that contributed to their mathematical performance. However the remained factors were checked in a different sequence by each gender. Although, it is important to note that despite the freedom given to the students to write down other factors which are not covered by the statements presented in the questionnaire, none of them used this chance, perhaps, because the statements proposed by the researcher were adequate and enough to characterise all the possible factors that should influenced their previous mathematics performance.

Females considered the influence played by their mathematics teacher as the second most important factor ahead of the inclination to work in mathematics, while males stressed the importance of inclination rather

than the influence of the teachers. This result confirms that of Boekaerts, Seegers and Vermeer (1995), who found that males attributed their result more frequently to capacity and to invested effort.

Only about 8% of females and 2% of males showed a stronger tendency to ascribe failure to lack of inclination, (see Table 4.23). The difference between males and females was also found for attributing success to availability of materials for study. This result confirms that referred in Little's study (1985).

The differences on selection of the factors influencing mathematical performance by gender were statistically non-significant at 1% level, as displayed by the Chi-squared test ($\chi_4^2 = 8.320, p = 0.081$).

Despite the non-significant difference between the two gender groups, the results found in this study were similar to the findings of some researchers, such as, Seegers and Boekaerts (1996), who found that females reported that they were more prepared to invest more effort in the mathematics' task than males, while a significant difference between males and females was only found for attributing success to capacity.

Solar (1995), on the other hand, reported that in Canada, females have less confidence in their skills than males and, that females tend to attribute success more to hard work than to abilities. Joffe and Foxman (1986), also have reported that females are more unsure of their mathematical capability than males.

When the sample was examined by gender, the Chi-squared test did not show the relationship between the factors selected by the students as having influenced their mathematics performance, and the performance criteria of the secondary school grades and the Final result at the end of

BUSCEP course. When the same comparison was done on the whole sample, between the primary factor selected by the students and the Performance-Criteria of their secondary school mathematics grades, it was found that the relationship was statistically significant, ($\chi_8^2 = 27.282; p = 0.001$).

There was also found that the factors selected by the students as have influenced their mathematics performance and the students self-rating of the previous mathematics performance were highly related for the whole sample, ($\chi_8^2 = 22.711; p = 0.004$).

## 4.3.2. Gender differences on Interest in Mathematics

Five questions related to students interest in mathematics were addressed. The questions were related to: enrolment in mathematics as an optional subject, the inclusion of mathematics in the entrance examination for every courses at university, reasons for enrolling in mathematics, specific mathematics topic to study and the kind of mathematics tasks most preferred in mathematics tests.

### 4.3.2.1. Enrolment in mathematics

Table 4.24 shows no statistically significant differences between males and females. The Chi-squared test confirms the no gender-based dependence of enrolment in mathematics ($\chi_1^2 = 1.194, p = 0.275$).

**Table 4.24**: Percentage of the 1996 BUSCEP students' responses about their interest in studying mathematics

| | Males (%) | Females (%) | Total (%) |
|---|---|---|---|
| Interested | 91 | 86 | 90 |
| Not interested | 9 | 14 | 10 |

When the comparison between males and females was done within the sections, the study found that, in SCIENCE, there was a tendency in showing a greater interest in studying mathematics by both genders, about 93% of males and all the females (100%) expressed their interest in the subject. In BIOLOGY, this percentage decreased to 89% and 83% for males and females respectively. However, Chi-squared test found that these differences based on gender were statistically non-significant: $\chi_1^2 = 0.719; p = 0.396$.

### 4.3.2.2. Inclusion of mathematics in the entrance examination

Among a set of four science subjects (mathematics, biology, chemistry and physics), males and females were asked to select two of them as part of the entrance examination. The following Table 4.25 displays the results of this question taking into account the inclusion, (or not), of mathematics. In spite of the higher interest shown by both genders in working with mathematics as a subject in a chosen career, only 11% of males and 20% of females who showed no interest in this subject in the entrance

examination. However, the Chi-squared test shows that the observed gender differences are statistically non-significant, ($\chi_1^2 = 2.295; p = 0.130$).

**Table 4.25**: Percentage of the 1996 BUSCEP students' responses about the inclusion of mathematics in the entrance examination

| | Males (%) | Females (%) | Total (%) |
|---|---|---|---|
| Maths included | 89 | 80 | 87 |
| Maths not included | 11 | 20 | 13 |

Taken into account the section variable, the percentage of females selecting mathematics for the entrance examination is higher (100%) compared with that of males (90%) in SCIENCE, while in BIOLOGY, the percentage of males who agreed with the inclusion of mathematics in the entrance examination is at 86% against that of females (71%), however, none of the differences is statistically significant, $\chi_1^2 = 1.755; p = 0.185$ for SCIENCE, and $\chi_1^2 = 2.630; p = 0.105$ for BIOLOGY.

These results confirm that of Rodgers (1990), who claimed that, statistics show that not only do girls drop out of mathematics in greater numbers than boys when the choice of mathematics course becomes available, but that only a very small percentage of all students, male or female, take the subject at higher levels.

Although, there were 145 males (83%) and 38 females (76%) who showed an interest in studying mathematics and would agree with its inclusion as a key subject in the entrance examination, only ten males and three

females who were not interested in studying mathematics agreed with the inclusion of mathematics in the entrance examination. (See Table 4.26).

**Table 4.26:** Frequency distribution of the 1996 BUSCEP students' responses according to their interest in studying mathematics and its inclusion in the entrance examination

| | Interested in studying maths | | | |
|---|---|---|---|---|
| | Males (N=175) | | Females (N=51) | |
| | Yes | No | Yes | No |
| Maths included | 145 | 10 | 38 | 3 |
| Maths not included | 15 | 5 | 7 | 3 |

Fisher's Exact Test showed that there was no relationship between the interest in studying mathematics and its choice as entrance examination subject, for males $p = 0.017$ or for females $p = 0.081$.

On the other hand, an analysis of variance considering the effect of the choice of mathematics as part of the entrance examination on the Final result at the end of BUSCEP course, a statistically significant difference favouring males was found, ($F=17.276$, $df=1;222$, $p<0.001$).

### 4.3.2.3. Reasons for interest in mathematics

More than 40% of all those students questioned stated that the reason for their interest in mathematics was related to its importance in their future career, and the same percentage of males and females (49%) linked their interest to study mathematics to their enjoyment of the subject.

In SCIENCE, the percentage of females (69%) choosing the reason for their interest in studying mathematics as based in the factor that they like mathematics, is greater than that of males (51%). In this section none of the females and a few of the males (4%) stated that they dislike mathematics. In BIOLOGY, 47% of females and 41% males mentioned that they like mathematics. In contrast, 12.5% of females and 9.4% of males said that they dislike mathematics. About 2% of males and females referred to mathematics as useless for their actual courses enrolled. The Chi-squared test show that none of these differences were statistically significant; $\chi_3^2 = 1.409; p = 0.704$ for SCIENCE, and $\chi_3^2 = 0.318; p = 0.957$ for BIOLOGY.

#### 4.3.2.4. Interest in specific Mathematics Topic

The most enjoyable Mathematics Topic to study, according to the whole group was Algebra, selected by 57% of the students. This was followed by Trigonometry, selected by 30% and finally Geometry, selected by 13% of the students. Taking into account the gender variable, the results of this study show that males and females have similar preferences, with Algebra being more preferred among females (59%) compared to 56% of males. For both gender groups, Trigonometry was the second preference selected by 30% of males and 29% of females, while, Geometry was the least favourite choice being selected by 14% of males and 12% of females.

The same sequence was found on the mean scores achieved by the students on the topics taken in the Pre-test, (see section 4.2.3.4). These findings, perhaps, can be explained in terms of the amount of time spent on teaching each topic during the upper-secondary school, hence 64% of the total time at upper-secondary school level was spent on Algebra, 11% on Trigonometry and Euclidean Geometry is not part of the mathematics

syllabus at this level. Analytical Geometry which is introduced in the place of Euclidean geometry represents 9% of the time spent on teaching mathematics at this level, (see section 1.1.3). However, it did not take part on the scope of this research because this topic, in general, it is never taught during the secondary school, because of its location in the mathematics curriculum which is reserved to the end of the academic year.

When the sample was sorted by sections, as shown in table 4.27, the tendency of choice still have the same sequence as for the whole sample. However, in SCIENCE the difference were more evident in Algebra which was most preferred among females than males. Although, the Chi-squared test did not produce a statistical significant gender-based influence on the topic preferred in mathematics in both sections; $\chi_2^2 = 1.539; p = 0.463$ for SCIENCE, and $\chi_2^2 = 0.642; p = 0.725$ for BIOLOGY.

**Table 4.27**: Percentage of the 1996 BUSCEP students' responses in the selection of mathematics topics by section and gender

| | | Males (%) | Females (%) |
|---|---|---|---|
| SCIENCE | Algebra | 54 | 69 |
| | Geometry | 16 | 6 |
| | Trigonometry | 30 | 25 |
| BIOLOGY | Algebra | 60 | 54 |
| | Geometry | 9 | 14 |
| | Trigonometry | 31 | 32 |

Although, the results from other studies indicate that gender differences are limited to certain areas of mathematics (Hanna, 1986; and Hanna,

1989), some researchers have found that there are no statistically significant differences among gender groups in mean percent correct for Algebra, Arithmetic and Statistics, while such differences were observed in Geometry and Measurement (Fennema and Carpenter, 1981; Cheung, 1989; Fennema, Peterson and Carpenter, 1990; Hanna, Kundiger and Larouche, 1990; Fennema and Hart, 1994).

#### 4.3.2.5. Interest in specific kind of tasks in mathematics tests

Males and females were asked to rank in order of preference the following type of tasks, and the answers are displayed in Table 4.28:

A. Algorithmic problems
B. Familiar problems
C. Demonstrations/Proofs
D. Real-World problems

**Table 4.28**: Percentage of the 1996 BUSCEP students' responses concerning to the preferred type of mathematics tasks in tests by gender

| | Males N=175 | | Females N=51 | | Chi-square df=1 |
|---|---|---|---|---|---|
| | + | - | + | - | |
| A | 67 | 33 | 69 | 31 | 0.026 NS |
| B | 55 | 45 | 63 | 37 | 1.000 NS |
| C | 39 | 61 | 28 | 72 | 2.222 NS |
| D | 38 | 62 | 39 | 61 | 0.014 NS |

("+" for High preference, "-" for Low preference; NS = not significant)

As can be see, for both genders, algorithmic problems were the kind of mathematics tasks highly preferred in tests, followed by familiar problems. Problems based on demonstrations and proofs were more preferred among males (39%) than among females (28%). Real-world problems are extremely unpopular, being the least preferred task by both genders.

The Chi-squared test that was computed found a statistically non-significant gender difference between males and females. It should be related to the fact that both males and females had a similar enrolment in mathematics during their secondary school.

The responses to the questionnaire are some what contradictor to the finding obtained in the analysis of the distribution of the sample by course enrolled when the key subjects in the entrance examination were considered. Although the lack of significant gender difference on the students interest to mathematics, the findings of this study clearly show that there is more evident that females are inclined to work in careers that do not require so much mathematics (see sections 4.2 and 4.3.1).

## 4.3.3. Approaches to Learning Mathematics

### 4.3.3.1. Learning style of mathematics

On the approaches to learning mathematics, the 1996 BUSCEP students were asked to rank in a sequential order of preference the following methods of studying mathematics that they used during their secondary school:

A. Reading notes from the class
B. Solving familiar problems/homework
C. Solving new problems/non-routine problems
D. Looking for Real-World problems
E. Other method? _____ Which?_____

Table 4.29 shows the percentage of the distribution of the students' responses to the related question. The results reveal that males and females enrolling in 1996 BUSCEP courses had the same sequential order of preference on the approaches to learning mathematics. In terms of low preference, males and females still have the same attitude, with real world-problems being the less preferred method of studying mathematics. Even when the students were given a chance to write down another methods if different to those suggested in the questionnaire, males and females continue to have a similar behaviour in not suggesting or adding a new other alternative.

**Table 4.29**: Percentage of the 1996 BUSCEP students' responses on the approaches to Learning Mathematics by gender

| | Males N=175 | | Females N=51 | | Chi-square df=1 |
|---|---|---|---|---|---|
| | + | - | + | - | |
| A | 49 | 51 | 57 | 43 | 0.942 NS |
| B | 69 | 31 | 65 | 35 | 0.358 NS |
| C | 66 | 34 | 59 | 41 | 0.962 NS |
| D | 15 | 85 | 20 | 80 | 0.504 NS |

("+" for High preference; "-" for Low preference; NS = not significant)

From the Table 4.29, it is also evident, that studying mathematics by solving familiar problems or doing homework exercises was the most popular method used in previous studies of mathematics, followed by solving new or non-routine problems. Of interest however, is the fact that the percentage of females (57%) choosing to study by reading notes from the class is slightly higher than that of males (49%). Learning by solving familiar problems is also another way of developing such kind of skills, on memorisation of the procedures in order to reproduce in tests. In fact, the two approaches most chosen by both gender groups are quite related to each other.

The approaches which should reflect the intention to gain a relational understanding of the theory and its applications to new situations was chosen by both gender as the last preference. It should reflect the kind of mathematics lessons that are given to the students during the secondary education, that are directed to the development of skills using exercises mostly directed to the first two cognitive levels of the taxonomy of educational objectives, knowledge and understanding, (see section 3.3.1).

The findings obtained here, can be related to the female advantage in the Mini-Test performance making a direct link between the most preferred method of studying mathematics and the type of tests which in fact females might perform highly, (see section 4.2.6). Researchers such as, Bohlin, (1994), Mji and Glencross, (1996), also found that males and females have different mathematics learning styles (autonomous and rote memorisation respectively), and females perform better relative to males on items that require the application of a familiar algorithm (e.g., classroom tests).

Thus, according to Bohlin (1994), females also suffer the consequences of traditional instruction and assessment practices. Proficiency in the rote memorisation of algorithms may result in short-term success.

### 4.3.3.2. Frequency of studying mathematics

The following Table 4.30 displays the results obtained from the students' responses to the questions related to their frequency of studying mathematics during their secondary school.

**Table 4.30**: Percentage of the 1996 BUSCEP students' responses according to the frequency of studying mathematics by gender

| | Males (%) | Females (%) |
|---|---|---|
| Everyday | 55 | 65 |
| Weekly | 27 | 29 |
| Week before | 10 | 2 |
| Day before | 8 | 4 |

Here, there is a majority of students claiming to have a systematic study, i.e., 65% of females and 55% of males study mathematics daily, and 29% of females and 27% of males study weekly. The Chi-squared test shows that the small difference found in the frequency of studying mathematics were not statistically significant, ($\chi_3^2 = 4.635; p = 0.201$). Although, it was evident that the slightly higher females tendency to have a systematic frequency of studying mathematics may have an influence in their mathematics achievement when classroom tests, (in that case, Mini-tests),

are taken as measures of mathematics performance, the only one instrument used that females outperformed their counterparts males. (See section 4.2.6).

According to Fennema (1979), it has also been argued that if the amount and quality of time spent on learning mathematics can be somehow equated for males and females, educationally significant gender-related differences in mathematics performance will disappear.

#### 4.3.3.3. Cope with Learning Difficulties in Mathematics

The following statements were given to the students to be ranked in order with respect to their preferred resources used in coping with learning difficulties in mathematics:

A. Reading Textbooks
B. Studying with colleagues
C. Asking for help from the teachers
D. Asking for more explanations during the class
E. Other resource? _____ Which?_____

Firstly, it is to be mentioned that despite the freedom given to the student to indicate other resources used to cope with learning difficulties in mathematics during the secondary school, (if different to those included in the questionnaire), none of the students added any new suggestion on the statements presented by the researcher, perhaps because the ones presented in the questionnaire were considered enough and adequate to express their opinion with respect to that.

Meanwhile, males and females differed in the way they used to cope with learning difficulties in mathematics. Studying mathematics with colleagues was very popular among males against the resource of asking for more explanation during the class which was found to be the most popular choice by the females, (see Table 4.31).

**Table 4.31:** Percentage of the 1996 BUSCEP students' responses concerning to the resources used to cope with learning difficulties in mathematics by gender

| | Males N=175 | | Females N=51 | | Chi-square df=1 | |
|---|---|---|---|---|---|---|
| | + | - | + | - | | |
| A | 66 | 34 | 57 | 43 | 1.525 | NS |
| B | 77 | 23 | 55 | 45 | 9.716 | p=0.002 |
| C | 22 | 78 | 29 | 71 | 1.303 | NS |
| D | 35 | 65 | 59 | 41 | 9.431 | p=0.002 |

("+" for High preference; "-" for Low preference; NS = not significant)

The Chi-squared test showed that there is a significant gender difference in the method of coping with learning difficulties by studying with colleagues, ($\chi_2^2 = 9.716, p < 0.01$), and asking for more explanation during the class, ($\chi_2^2 = 9.431, p < 0.01$). These results can be related to the findings from studies of various authors such as, Leder (1982), Leder (1987), Leder (1990a) and Becker (1990), who argued that, during lessons, females in co-educational schools are at a quantitative and qualitative disadvantage regarding the attention given to them by the teachers as well as the number and quality of questions asked.

On the other hand, Becker (1981), Jungwirth (1991), an l Kaiser-Messmer (1993), also claimed that there are gender differences in patterns of interaction between teachers and females or males, in which the pattern of interaction practised for males is more likely to make them appear more competent in mathematics.

# Chapter 5

# CONCLUSIONS AND RECOMMENDATIONS

## 5.1. GENERAL OUTCOMES

The purpose of this study was to explore possible gender differences in mathematical performance and attitudes toward mathematics among 1996 BUSCEP students at UEM. To this end, two main questions were addressed and from the results some conclusions are made.

The results of this study suggest that for the 1996 BUSCEP students, gender performance in mathematics and attitudes towards mathematics tend to be similar, and the gender inequalities found, were more evident in the participation in mathematics related careers which was not the focus of this study. It should be because of the characteristics of the sample used, which is a very selected one from the secondary school level, enrolling mathematics in a similar environment with similar purposes for their career.

The problem of females under-representation found in science and engineering courses at UEM is an unfavourable situation for educational research as the investigation of gender differences in attitudes and performance in most studies, in the field of mathematics at university level, suffers very different sample sizes.

The first result obtained in the study was related to the sample used, consisting of 226 first year university students who passed the entrance examination for Agronomy, Biology, Engineering and Science courses, (Chemistry, Physics, and Geology), at Universidade Eduardo Mondlane (UEM), and have been registered and enrolling the Basic Mathematics course in BUSCEP program.

The percentage of females was less than that of males in all the courses except in Biology where, by contrast, the number of females students was higher than that of their counterpart males. However, in spite of the same mathematics curriculum taught for Agronomy and Biology students, it is evident that both courses are enrolled by female and male students in an opposite proportion, (see section 4.1). Perhaps the cause is the influence of mathematics in the entrance examination in both courses, because Biology is free of mathematics in the entrance examination while Agronomy has mathematics as a key subject.

Most of the students were from Maputo, at 62.3% for males and 84.3% for females, in contrast to the percentage of all students from upcountry at 37.7% and 15.7% for males and females respectively.

- ***Do females perform mathematically at a lower level than males at Universidade Eduardo Mondlane?***

The present study does not support the hypothesis of significant gender differences in performance. However, there was a general trend noted in BUSCEP males to perform slightly higher in terms of their mathematical performance compared with females.

The comparison of the mean scores on school mathematics, pre-test, entrance examination, and the intermediate tests showed a constant males advantage. However in classroom tests (Mini-test), a female advantage was found, which means that females performed slightly higher in systematic assessments. Despite the non-significant gender difference in favour of the female students, it is evident that females tended to outperform males in such kind of tests that reflects a classroom content. This finding can be related to the differences in the approaches used to learning mathematics by both gender, as also confirmed by findings of some researchers, (Bohlin, 1994; Mji and Glencross, 1996), who found that males and females have different mathematics learning styles (autonomous and rote respectively), and females perform better relative to males on items that require the application of a familiar algorithm (e.g., classroom tests).

This finding also argues in favour of the results found in Kimball's study (1989), that females are in disadvantageous position when standardised tests are given but not when doing tests that reflect classroom content. But, Seegers and Boekaerts (1996), on the other side, have found that males outperformed females on mathematics tasks using a test that reflected classroom content.

There were also found a considerable but statistically non-significant gender achievement differences in Algebra (12.6%), which was strongly emphasised in school, (about two thirds of the total time for mathematics at secondary school is spent on teaching Algebra). The differences were smaller for Trigonometry and Geometry, 7.2% and 1.6% respectively. Those differences are interesting as these topics receive respectively less time at school, (see section 1.1.3.). However, the analysis of variance did not show the mean differences to be statistically significant. These results are similar to that of Swafford (1980), using a sample composed equally by males and females in first year College Algebra.

Other studies indicate that gender differences are limited to certain areas of mathematics (Hanna, 1986; Hanna, 1989). Some researchers have found that there are non-significant differences among gender groups in mean percent correct for Algebra, Arithmetic and Statistics, while such differences were observed in Geometry and Measurement (Fennema and Carpenter, 1981; Cheung, 1989; Hanna, Kundiger and Larouche, 1990; Fennema, Peterson and Carpenter, 1990; Fennema and Hart, 1994).

On the taxonomy of educational objectives taken, in this research, as measure of the cognitive variables, the achievement differences between females and males decreased with the cognitive level, and the differences in mean performance were in favour of males in all levels. However, the difference was found to be statistically significant at 1% level for Knowledge only.

This result contradicts with the findings of other researchers such as, Fennema and Carpenter (1981), Tartre (1990), Tartre and Fennema (1995). They found that the achievement differences between females and males increased with the cognitive level, and when the differences

favour males, it is in the areas of Understanding and Application, contrasting with the results of this study.

On one hand, this situation can be explained in terms of the differences on the characteristics of the sample used for this study compared to the other studies. On the other hand, the statistically significant difference found for Knowledge, in this study, can be justified by the fact that most of the female students did not study mathematics for about six months after the secondary school because this subject was not evaluated in the entrance examination for their courses (see Section 4.1). Thus, the time between the end of the secondary school and the start of the university studies could have affected females more than males in terms of their capacity to remember simple rules which were required for the solution of the exercises on this cognitive level of Knowledge.

Other studies report that male superiority in mathematics is found especially in performance on tasks of high cognitive complexity such as true problem solving (Fennema and Peterson, 1985; Hall and Hoff, 1988; Barnard and Cronjé, 1996). In the meanwhile, Fennema and Sherman (1978), comparing mathematical tasks at several levels of cognitive complexity, such as, Knowledge of concepts and problem solving found no gender-related differences for their sample of grades 6-8 pupils. Leder, (1990b) also found that, on average, females do not score as high as males on mathematics tests, especially if those tests involve higher level cognitive tasks. If gender differences are found for young children, they tend to favour females (Hyde, Fennema and Lamon, 1990; Armstrong, 1981) in knowledge and skills (Fennema and Carpenter, 1981).

Gender differences in mathematics performance were also observed when Performance-Criteria distribution were considered, (see sections 3.3.1 and 4.2.). The differences in favour of one gender group at lower Performance-Criterion could be cancelled out at other Performance-Criterion, resulting in similar mean performance. Therefore, the gender-based differences on achieving at specific Performance-Criterion were found to be statistically significant at 1% level, as confirmed by Chi-squared tests on Test-1, Test-2 and Final result.

In the present research the variance ratio of males to females are: 1.04; 0.82; 1.06; 0.99; and 0.95 for the Pre-test, Test-1, Test-2, Mini-test and the Final result, respectively. Those values so close to 1 represent a similar variability of the two gender groups with regard to mathematics performance in the Pre-Test, Test-1, Test-2, Mini-test and the Final Result. (See sections 2.1; 4.2.3; 4.2.4; 4.2.5; 4.2.6; 4.2.7).

On the item analysis, the mean values for difficulty index show that, in general, females experienced more difficulties in the Pre-test items than did males. The discrimination index, was higher for males than for females, which means that those items discriminate better between high and low performers, for males than for females. The differences between males and females were small and statistically insignificant.

- ***Do attitudes toward mathematics differ across gender on BUSCEP students at Universidade Eduardo Mondlane?***

With regard to attitudes toward mathematics, there were more similarities found than differences between males and females.

For the 1996 BUSCEP students, the choice of career at university was highly related to gender. The study found, very few differences between genders, so that, a greater percentage of males and females had the opinion that their career choice was influenced by their mathematical performance. Thus, Fisher's Exact Test showed that there was no relationship between the variables gender and the influence of mathematical performance on career choice.

For both genders, the importance of mathematics seemed to be beyond question with a similar percentage of males and females demonstrating a great believe in the importance of mathematics in their careers. And among all 1996 BUSCEP' students females and males reported that they liked mathematics in a similar proportion.

In spite of the females interest in studying mathematics at university, the choice of career indicated that they had a greater preference for courses requiring a lesser amount of mathematics. In contrast, males who are interested in mathematics usually opt for the Engineering and Science courses. It may be that females felt they had to work harder to achieve their success, and that this perception threatened their confidence in their science and mathematics ability, but differences in the ascribed efforts were not related to ability ratings either.

Although the lack of significant gender differences on the students interest to mathematics, the findings of this study clearly show that there is more evidence that females are inclined to work in careers that do not require so much mathematics (see sections 4.2 and 4.3.1). Overall, the differences were significant in terms of gender, as confirmed by the Chi-squared test. This means that, for the 1996 BUSCEP students, the choice of career at university was highly influenced by gender.

According to some authors, (Fennema and Sherman, 1977; Megarry, 1984; Armstrong, 1985, Fennema, 1985; De Boer, 1984,1986; Leder, 1990b; Maple and Stage, 1991, Dick and Rallis, 1991), 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. On the other hand, Catsambis, (1995), found that, by the eighth grade, females already begin to show less interest in science courses than males. Overall, gender differences in science related attitudes and interests are much stronger than gender differences in science achievement.

With regard to the influence played by the students' mathematics performance on their career choice, the study found that a greater percentage of males (75%) than females (67%) had the opinion that their career choice was influenced by their mathematical performance. Though, as the expected cell frequencies were too small to allow for a Chi-square analysis, Fisher's Exact Test was used to measure the statistical significance of the difference and the result showed that there was no relationship between the variables gender and the opinion about the influence of mathematical performance on career choice.

Despite the statistically non-significant gender difference found, with respect to the influence of mathematics achievement on career choice, there was a remarkable difference between males and females on the course they enrol at UEM (see section 4.1), hence, the proportion of females was higher than that of males in Biology course only, which is unique in that it does not include mathematics in the entrance examination.

With respect to the reasons that contributed to their previous mathematical performance, the majority of the students in both gender groups (more than 50%), considered that the investment of effort was the most important factor that contributed to their mathematical performance. However the remaining factors were ranked in a different sequence by each gender. Females considered the influence played by their mathematics teacher as the second most important factor ahead of the inclination to work in mathematics, while males stressed the importance of inclination rather than the influence of the teachers. Lack of inclination was referred mostly by the females compared to the males. The differences in selection of the factors influencing mathematical performance by gender were found to be statistically non-significant at the 1% level.

These results confirm that of Seegers and Boekaerts (1996), Boekaerts, Seegers and Vermeer (1995), who found that males attributed their result more frequently to capacity than to invested effort. Solar (1995) reported that in Canada, females have less confidence in their skills than males, and, that females tend to attribute success more to hard work than to abilities. Joffe and Foxman (1986), ... have reported that females are more unsure of their mathematics capability than males. On the other side, Maccoby and Jacklin (1974), found that males were more independent than females.

In this study it was found that males and females also differed in the way they used to cope with learning difficulties in mathematics at secondary school. Studying mathematics with colleagues was the preferred option among males whilst the preferred method of females dealing with problems was to ask for more explanations during the class. This result should explain the need of the establishment of an interactive environment in mathematics classes that could satisfy also the females expectations in terms of their participation during mathematics lessons.

With respect to the approaches of learning mathematics, solving familiar problems or doing homework exercises was the most popular method used by most of the students in their previous studies. In terms of the low preference, males and females still have the same attitude, with regard to real world-problems being the least preferred method of learning mathematics. This was the least usual method of learning mathematics at secondary school. For both genders, algorithmic problems were found to be the kind of mathematics tasks highly preferred in tests, followed by familiar problems. Real-world problems were extremely unpopular, being the least preferred task by both genders.

## 5.2. CONCLUSIONS

The study was limited to a small university group. It would be beneficial in the future to extend the data to include the secondary school students as well as including a self-reported attitude measures of mathematical achievement for students, parents and school staff.

The current study did not investigate the environmental factors that may have exerted influence on students' mathematics performance and attitudes toward mathematics.

The findings from this study do not appear to show relationships between attitudes toward mathematics and performance in mathematics, unless the variables measured in this study were inadequate indicators of attitudes toward mathematics (i.e., How much ability they felt they had in mathematics as a subject. How hard they worked in the school mathematics courses. How important they felt the subject was. Which type of questions they like in mathematics tasks. What influence was played by mathematics performance in their career choice at university. How they self-rate their previous results in mathematics. Which factors they felt that they influenced their mathematics performance during the secondary education. How interesting they felt the mathematics is; etc.).

The data presented in this study show that gender differences in mathematics and related careers may be due to gender attitudes and career choices and not to their performance in mathematics. Gender attitudes toward mathematics and related careers develop independently of their levels of performance. However, as stated by Catsambis (1995), the females limited interest in enrolling in scientific careers, may cause a decline in their science achievement when enrolment in more advanced mathematics courses is optional.

There can be many explanations for the variation of the present results from the findings of the other researchers. Firstly, the nature of the sample of this study is different from that of the majority of the investigations referred before. In the other studies the participants

invariably have been primary and secondary school children. In this investigation the majority of subjects are adults students with an average age of 22 years for males and 21 years for females. Secondly, some aspects of the mathematics taught in BUSCEP courses are comparable to the mathematics taught at secondary level in other developed countries, at which stage gender-related differences in mathematics performance and attitudes towards mathematics were very small or not existent even there.

Other explanation for the inconsistent gender-related differences in mathematics performance of different genders in the present study was sought by considering their background factor. Some researchers, such as Fennema (1981), believe that if the background of both male and female students are controlled, the gender differences in mathematics performance may decrease or disappear. This is possibly the case at tertiary level in Mozambique because, these students are adults, whilst in other studies the subjects are children or adolescents. Further, the central control of education should yield an equality of educational background. All the students in this curriculum have very restricted curricula and interests, and may be homogeneous.

## 5.3. RECOMMENDATIONS

The findings obtained with the study emphasise the need to further examine the interrelationships between gender and career choices in the efforts to understand the processes leading to the gender inequalities in mathematical performance and in attitudes toward the subject.

It has been hoped that differences in achievement between females and males would disappear when there was equal enrolment in elective courses. Hence as stated by Deboer (1986), the decline in science participation by females is already evident in high school as soon as students have the opportunity to select their own course. So, these findings suggest, that attaining equal achievement in mathematics is a complex problem that requires more than ensuring that females enrol in mathematics courses.

The under-representation of one of the groups can lead to distorted results. This is an unfavourable situation for educational research as the investigation of gender differences in attitudes and performance in the field of mathematics, so that, gender research in mathematics should include samples comparably representative of both gender groups.

The aspect of female under-representation leads to the following important question, and it must be answered by further studies which can be conducted in the field of gender differences in mathematics among students of Mozambique:

> ***Why do females participate in lesser number than males in courses related to mathematics at tertiary education in Mozambique?***

As suggested by some authors, (Eccles, 1986; Dick and Rallis, 1991), it is impossible to consider this question without examining gender differences in mathematics performance and academic course selection. For example, Young and Fraser (1994), said that in Australian schools the problem of under-representation of females in science is often attributed to their poor performance.

Efforts to improve students' mathematics performance and attitudes toward mathematics should begin in the secondary school level and may need to be specifically tailored to the gender of the student being taught.

Similar studies should be conducted with students in secondary school to see if the same results are obtained.

Educational programs should focus on improving females attitudes toward mathematics and increasing their interest in related careers.

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**Appendix - A1: Pre-test**

**UNIVERSIDADE EDUARDO MONDLANE**
**BUSCEP**

**PRE-TEST**
(Mathematics)

Surname: _____
Name: _____
Course: _____
Group: _____

++++++++++++++++++++++++++++++++++

1. Simplify $\frac{xy - 3x^2y^2 + (xy)^2}{xy - 2x^2y^2}$

A. 1

B. $\frac{xy - x^2y^2}{xy}$

C. $\frac{1 - 2(xy)^2}{x^2y^2}$

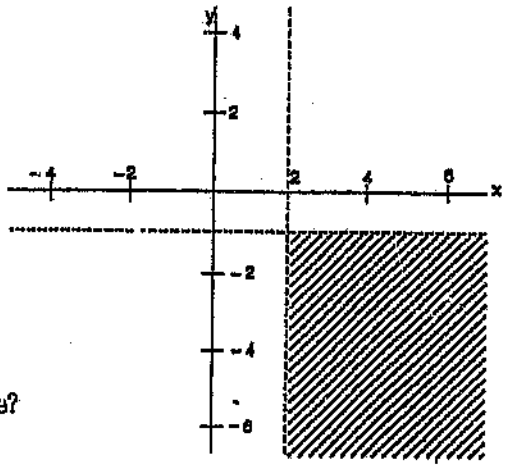
D. $(xy + xy)(xy - xy)$

2. An airline charges passengers 15000 MT (meticais) for each kilogram carried in excess of 20 kgs. A certain passenger's luggage weights L kgs, (L > 20). How many meticais will be charged for the excess weight?

A. 15L-20
B. 15(L-20)
C. 15L+20
D. 15(L+20)

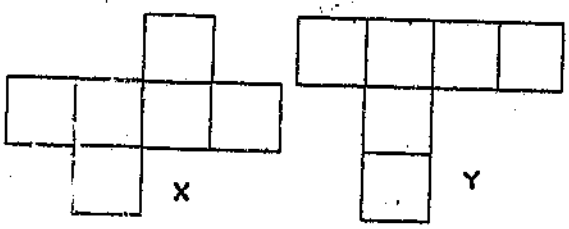
3. On the co-ordinates of a point (x, y) in the shaded region one can say:

A. $x>2$ or $y<-1$
B. $x<2$ and $y>-1$
C. $x>2$ and $y<-1$
D. $x>2$ or $y>-1$



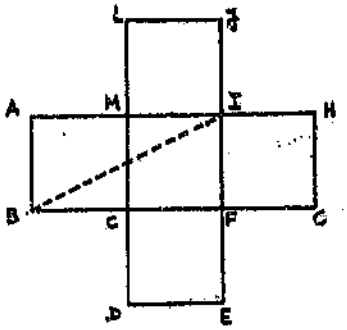

4. Can these shapes form a cube?

A. Both X and Y can
B. X can but Y cannot
C. Y can but X cannot
D. Neither X nor Y can



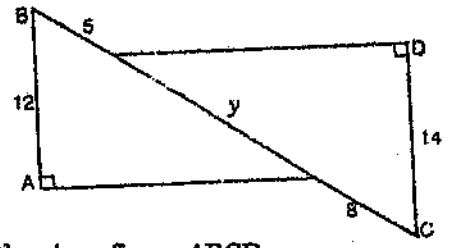

5. The following picture is formed by five congruent squares. Knowing that BI=10 units, the total area will be:

A. 100
B. 50/3
C. 20
D. $2\sqrt{5}$



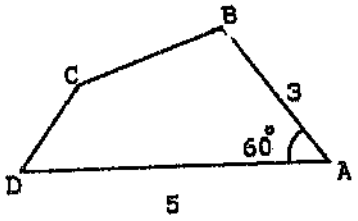
6. In the following picture, AB and CD are parallels. Considering the given values in that picture, the value of y will be:

A. 21
B. 26
C. 13
D. 18




7. Determine the value of BD in the given figure ABCD.

A. $\sqrt{34}$
B. 8
C. $\sqrt{19}$
D. $15\sqrt{3}$




8. Which of the following statements is true:

A. $\cos 70^0 = 2\cos 35^0$
B. If $45^0 < \alpha < 90^0$, then $\sin\alpha < \cos\alpha$
C. In the First quadrant, the high the angle, the high is the respective sin
D. In the First quadrant, the high the angle, the high is the respective cos.

9. Knowing that $\alpha$ is an angle in the third quadrant and, $\sin\alpha = -\frac{2}{3}$, the angle $2\alpha$ will be located in the following quadrant:

A. First
B. Second
C. Third
D. Fourth

## APPENDIX - A2: Intermediate Test-1

TESTE I - VARIANTE 2

1. Um corredor de motos dá voltas num circuito fechado de 4 km. A figura 1 mostra a relação entre a velocidade e a distância durante uma volta completa.

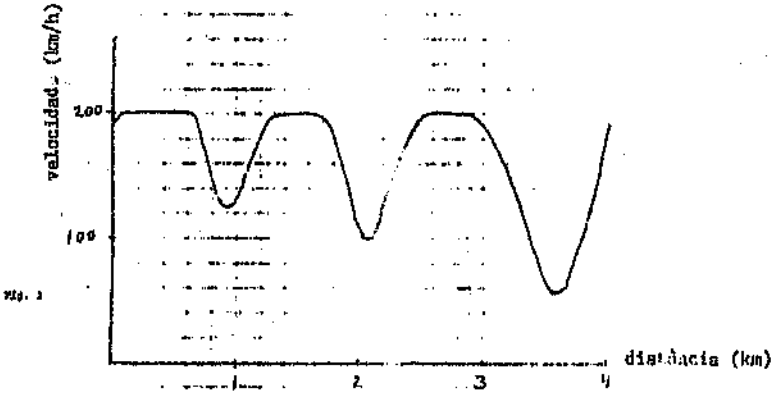



Fig. 1

2. Na figura 2 estão desenhados cinco circuitos diferentes. Qual é o circuito que o motociclista percorreu?

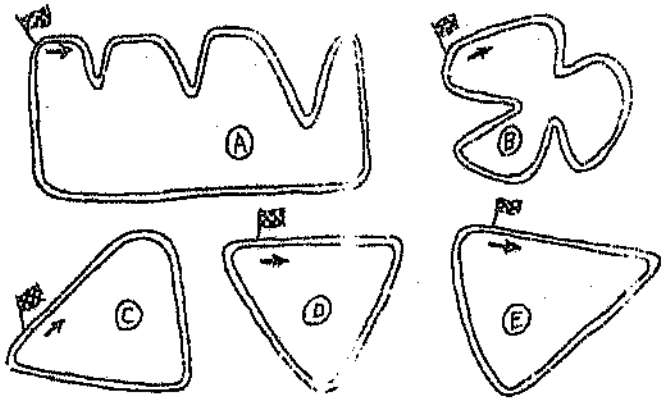
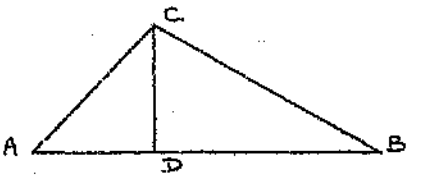



Fig. 2

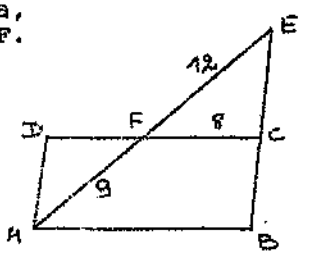
2. Simplifique a seguinte expressão:

$$\frac{16 - x^2}{-3x^2 + 15x} : \frac{x^2 - 8x + 16}{x^2 - 9x + 20}$$

3. CD é perpendicular a AB.
Á A = 45°
Á B = 30°
AD = 10 cm.
   a. Determine o perímetro do triângulo ABC.
   b. Determine a área do triângulo ABC.




4. ABCD é um paralelogramo.
Atendendo aos dados na figura, determine o comprimento de DF.




5. A função $f$ é definida por:

$$\begin{cases} f(x) = \frac{1}{2}x + 2 & \text{para } x \leq 0 \\ f(x) = -x + 2 & \text{para } 0 < x < 3 \\ f(x) = -1 \quad \text{para } x \geq 3 \end{cases}$$

   a. Esboce o gráfico de $f$.
   b. Determine o conradomínio de f.

6. Dada a função $f$ definida por
$f(x) = -2x^2 - 8x - 6$
   a. Represente graficamente a função.
   b. Com a ajuda do gráfico, resolva a inequação: $f(x) \leq 0$.

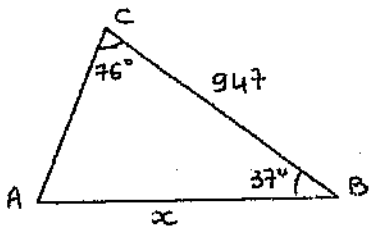
7. Resolve a seguinte equação:

$$\sqrt{1 - x} - \sqrt{1 - x^3} = 0$$

## APPENDIX - A3: Intermediate Test-2

### TESTE 2 - VARIANTE 1

1.




Do ponto C, os pontos A e B são vistos sob um ângulo de 76°.
Em B, os pontos A e C são vistos sob um ângulo de 37°.

A distância BC é igual a 947 m. Determine a distância AB com a precisão de 1 m.

2. Resolva a inequação trigonométrica: $-\frac{\sqrt{3}}{2} < \cos x \leq 0$

3. Resolva <u>graficamente</u> a inequação $\log_{\frac{1}{2}}(x+4) \geq -\frac{2}{3}x - 2$

Escreva a solução sob forma de intervalo(s).

4. Na Baixalândia, o valor da moeda, o florido, em relação ao dólar decresce continuamente. Em Janeiro de 1993, um florido valia 0,20 dólares. Passados 9 meses, valia apenas 0,10 dólares. A função que descreve este valor em função do tempo é uma função exponencial de base inferior a 1.

a. Qual será o valor do florido passados 18 meses? 1 ano? 1 mês? (Dê os resultados com três casas decimais)

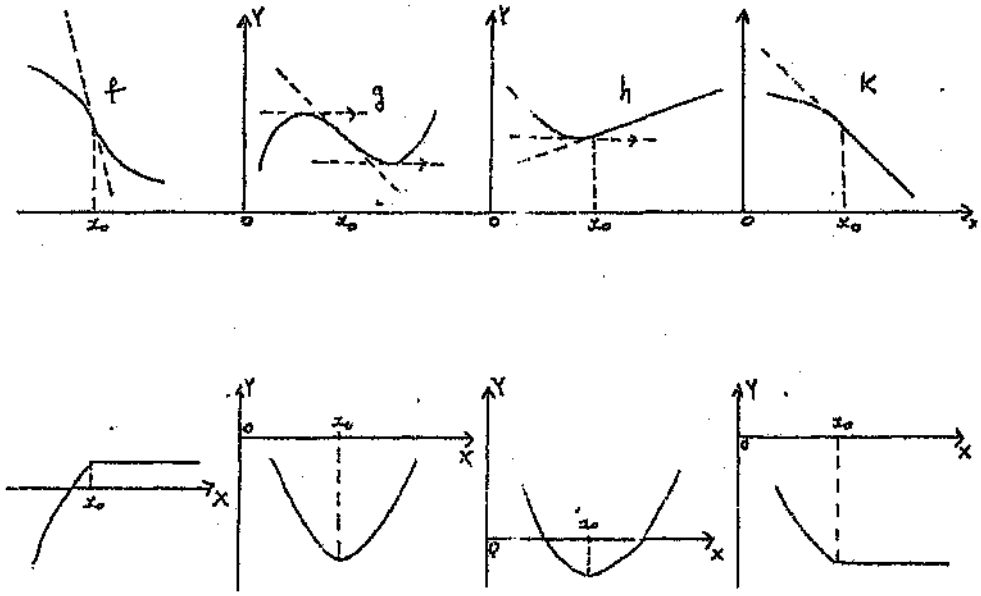
b. Sabendo que a forma geral desta função é $f(t) \quad a.b^{\frac{t}{9}}$, determine os valores de a e de b (Dê os resultados com três casas decimais).

5. Seja f a função definida por:

$$\begin{cases} f(x) = \dfrac{|2x - 1| \cdot 2}{2x - 3} & se \quad x \neq \dfrac{3}{2} \\ f\left(\dfrac{3}{2}\right) = 1 \end{cases}$$

a. Estude a continuidade de f no ponto de abcissa x = 1/2.
b. Estude a continuidade de f no ponto de abcissa x = 3/2.
c. Esboce o gráfico da função f no intervalo [-2 ; 4].

6. Na figura estão esboçados os gráficos de quatro funções f, g, h e k e das suas derivadas. Indique que gráfico representa f', g', h' e k'.



**Appendix - B**

**UNIVERSIDADE EDUARDO MONDLANE**
**BUSCEP**

# QUESTIONÁRIO
(Questionnaire)

Apelido:(surname) _____
Nome:(name) _____
Curso:(course) _____ Turma:(group) _____
Sexo:(sex) M ____ F____ Idade: (age) _____

1. **Indique as notas que obteve durante o ensino pré-universitário nas disciplinas seguintes:** (Write down your previous results in mathematics and science subjects at upper secondary school).

| | 11ªClasse | 12ªClasse |
|---|---|---|
| **Matemática** (Mathematics) | | |
| **Física** (Physics) | | |
| **Química** (Chemistry | | |
| **Biologia** (Biology) | | |

2. **Como auto avalia os seus resultados anteriores na disciplina de matemática?** (How do you self-rate your previous mathemathics results?)

   A. **Bons** (Good)
   B. **Adequados** (Fair)
   D. **Fracos** (Poor)

3. **O factor que determinou o rendimento na disciplina de matemática foi:** (The most important factor which influenced the previous mathematics performance was:)

   A. **Inclinação para a Matemática** (Inclination)
   B. **Esforço individual** (Effort)
   C. **Falta de inclinação para a disciplina** (Lack of inclination)
   D. **Influência dos professores** (Teachers' influence)
   E. **Disponibilidade de material de estudo** (Availability of material for study)
   F. **Outro factor?** (Other factor?)_____ **Qual?** (Which?)

4. **A parte da matemática que mais gosta é:**
   (The most enjoyable topic in mathematics is:)

   A. **Geometria** (Geometry)
   B. **Álgebra** (Algebra)
   C. **Trigonometria** (Trigonometry)
   D. **Outra** (Other) _____

5. **Enumere por ordem de preferência os métodos de estudo que mais frequentemente usou na disciplina de matemática:** (Rank in sequential order of preference the following methods of studying mathematics used at school:)

   A. **Lendo os apontamentos da aula** (Reading notes from the class)
   B. **Resolvendo os exercícios da aula e os mandados como TPC.** (solving familiar problems)
   C. **Resolvendo outros exercícios mais difíceis do que aqueles que foram dados na aula.**
      (Solving new problems/non-routine problems)
   D. **Procurando resolver problemas concretos que tenham aplicação na vida.** (Looking for real-world problems)
   E. **Outro método** (Other method) _____

6. **Como se preparava para as avaliações a matemática no ensino pré-universitário?** (How have you prepared for your assessment in maths at school level?)

   A. **Estudando diàriamente** (Studying daily)
   B. **Estudando semanalmente** (Studying weekly)
   C. **Estudando apenas na semana do teste** (Only in the week of test)
   D. **Estudando apenas na véspera do teste** (in the day before the test)

7. **Enumere por ordem de preferência os tipos de exercícios que mais gosta de encontrar nos testes de matemática?** (Rank in order of preference the following type of mathematics tasks which you preferred the most in tests)

   A. **Exercícios de aplicação directa de fórmulas** (algoritmic problems)
   B. **Exercícios idênticos aos já resolvidos** (Familiar problems)
   C. **Demonstrações** (demostrantios/proofs)
   D. **Exercícios de aplicação** (applications'problems or real-world problems)

8. **Enumere por ordem de preferência os métodos que mais frequentemente adoptou como recurso para superar as suas dificuldades de aprendizagem da matemática:** (Rank in a sequential order of preference the following methods used as resources for coping with learning difficulties).

   A. **Consultando manuais** (reading textbooks)
   B. **Estudando com colegas** (studying with colleagues)
   C. **Pedindo ajuda ao professor** (Asking for help from the teacher)
   D. **Pedindo explicações durante a aula** (asking for more explanation during the class)
   E. **Outro recurso** (Other resource)

9. **Indique o curso superior preferido**
   (Write down the course of your choice at university level)

10. **Na sua opinião acha que o rendimento obtido a matemática teve influência na sua escolha de curso?** (Did the previous mathematics performance influence your career choice?)

    A. **Sim** (yes)
    B. **Não** (no)

11. **Como avalia a importância da matemática no curso que está a seguir?**
    (what do you think of the importance of mathematics in your career choice?)

    A. **Importante** (important)
    B. **Desnecessária** (unimportant)

12. **Se para ingressar em qualquer curso na UEM lhe dessem a oportunidade de escolher as duas disciplinas para as quais faria o exame de admissao, por quais optaria?** (From the given list of science subjects, elect two of them as what you could prefer in the entrance examination)

A. **Matemática** (Mathematics)
B. **Física** (Physics)
C. **Química** (Chemistry)
D. **Biologia** (Biology)

13. **Se a matemática fosse uma disciplina facultativa no plano de estudos do seu curso, inscrever-se-ia nela?** (If maths was a optional subject for your course, could you register in this subject?)

A. **Sim** (yes)
B. **Não** (no)

14. **Dê a sua razão para a resposta dada na pergunta anterior.** (Justify your answer on the above question number 13).

## Appendix-C: Table of Means, Standard deviations and range

**Report**

| SECTION | GENDER | | Pre-Test | Test.1 | Test.2 | MINITEST | Final Result | Entrance Examination | Sec. School Marks |
|---|---|---|---|---|---|---|---|---|---|
| Eng.& Sci. | Male | N | 120 | 118 | 117 | 117 | 118 | 120 | 120 |
| | | Mean | 50.6000 | 68.9873 | 49.6239 | 60.4060 | 59.3771 | 57.3417 | 60.0417 |
| | | Std. Deviation | 16.6650 | 14.0132 | 16.5850 | 11.7561 | 12.0279 | 9.3807 | 10.0732 |
| | | Minimum | .00 | 28.00 | 2.00 | 21.50 | 25.00 | 47.50 | 50.00 |
| | | Maximum | 90.00 | 95.50 | 96.25 | 84.50 | 90.00 | 83.00 | 95.00 |
| | Female | N | 16 | 16 | 16 | 16 | 16 | 16 | 16 |
| | | Mean | 48.4375 | 68.1875 | 44.4531 | 64.2500 | 58.4375 | 54.0937 | 60.3125 |
| | | Std. Deviation | 15.1073 | 13.0459 | 19.9975 | 8.0187 | 9.4373 | 9.4308 | 9.9111 |
| | | Minimum | 20.00 | 44.50 | 20.00 | 53.00 | 45.00 | 47.50 | 50.00 |
| | | Maximum | 77.50 | 86.50 | 94.00 | 86.00 | 75.00 | 83.00 | 85.00 |
| | Total | N | 136 | 134 | 133 | 133 | 134 | 136 | 136 |
| | | Mean | 50.2574 | 68.8918 | 49.0019 | 60.8684 | 59.2649 | 56.9596 | 60.0735 |
| | | Std. Deviation | 16.2454 | 13.8567 | 17.0298 | 11.4165 | 11.7220 | 9.4191 | 10.0162 |
| | | Minimum | .00 | 28.00 | 2.00 | 21.50 | 25.00 | 47.50 | 50.00 |
| | | Maximum | 90.00 | 95.50 | 96.25 | 86.00 | 90.00 | 83.00 | 95.00 |
| Agr.& Bio. | Male | N | 55 | 54 | 53 | 54 | 54 | 49 | 55 |
| | | Mean | 50.8182 | 51.0278 | 46.0330 | 71.1481 | 54.1667 | 55.6633 | 63.0909 |
| | | Std. Deviation | 17.7389 | 17.3378 | 14.8374 | 14.8973 | 13.3784 | 8.5807 | 11.6068 |
| | | Minimum | 10.00 | 6.00 | 14.00 | 34.00 | 20.00 | 47.50 | 50.00 |
| | | Maximum | 85.00 | 8 .00 | 77.25 | 99.00 | 80.00 | 78.00 | 90.00 |
| | Female | N | 35 | 35 | 35 | 35 | 35 | 22 | 35 |
| | | Mean | 41.6429 | 41.2000 | 39.5071 | 66.8000 | 46.5714 | 53.8409 | 60.2857 |
| | | Std. Deviation | 16.9985 | 16.2568 | 12.1441 | 15.8166 | 13.2160 | 8.6016 | 11.7538 |
| | | Minimum | .00 | 7.50 | 18.50 | 22.50 | 20.00 | 47.50 | 50.00 |
| | | Maximum | 77.50 | 75.00 | 85.00 | 95.00 | 75.00 | 80.00 | 90.00 |
| | Total | N | 90 | 89 | 88 | 89 | 89 | 71 | 90 |
| | | Mean | 47.2500 | 47.1629 | 44.6420 | 69.4382 | 51.1798 | 55.0986 | 62.0000 |
| | | Std. Deviation | 17.9303 | 16.2518 | 14.3616 | 15.3258 | 13.7556 | 8.5876 | 11.6792 |
| | | Minimum | .00 | 6.00 | 14.00 | 22.50 | 20.00 | 47.50 | 50.00 |
| | | Maximum | 85.00 | 84.00 | 77.25 | 99.00 | 80.00 | 80.00 | 90.00 |
| Total | Male | N | 175 | 172 | 170 | 171 | 172 | 169 | 175 |
| | | Mean | 50.6000 | 63.3488 | 49.1279 | 63.7982 | 57.7413 | 56.6550 | 61.0000 |
| | | Std. Deviation | 16.3280 | 17.2454 | 16.0336 | 13.7323 | 12.6629 | 9.1698 | 10.6404 |
| | | Minimum | .00 | 6.00 | 2.00 | 21.50 | 20.00 | 47.50 | 50.00 |
| | | Maximum | 90.00 | 95.50 | 96.25 | 99.00 | 90.00 | 83.00 | 95.00 |
| | Female | N | 51 | 51 | 51 | 51 | 51 | 38 | 51 |
| | | Mean | 43.7745 | 49.6667 | 41.0988 | 68.0000 | 50.2941 | 53.9474 | 60.2941 |
| | | Std. Deviation | 16.5859 | 20.9202 | 15.0210 | 13.8141 | 13.2820 | 8.6354 | 11.1091 |
| | | Minimum | .00 | 7.50 | 18.50 | 22.50 | 20.00 | 47.50 | 50.00 |
| | | Maximum | 77.50 | 86.50 | 94.00 | 95.00 | 75.00 | 83.00 | 90.00 |
| | Total | N | 226 | 223 | 221 | 222 | 223 | 207 | 226 |
| | | Mean | 49.0597 | 60.2197 | 47.2658 | 64.3041 | 56.3901 | 56.3213 | 60.8407 |
| | | Std. Deviation | 16.1407 | 18.8953 | 16.1352 | 13.7511 | 13.1557 | 9.1580 | 10.7270 |
| | | Minimum | .00 | 6.00 | 2.00 | 21.50 | 20.00 | 47.50 | 50.00 |
| | | Maximum | 90.00 | 95.50 | 96.25 | 99.00 | 90.00 | 83.00 | 95.00 |

Table of One-way ANOVA

**ANOVA Table**

| | | | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|---|
| Pre-Test * GENDER | Between Groups | (Combined) | 1839.79 | 1 | 1839.79 | 5.708 | .018 |
| | Within Groups | | 72204.2 | 224 | 322.340 | | |
| | Total | | 74043.9 | 225 | | | |
| Test.1 * GENDER | Between Groups | (Combined) | 7363.83 | 1 | 7363.83 | 22.373 | .000 |
| | Within Groups | | 72738.9 | 221 | 329.135 | | |
| | Total | | 80102.7 | 222 | | | |
| Test.2 * GENDER | Between Groups | (Combined) | 2554.34 | 1 | 2554.34 | 10.221 | .002 |
| | Within Groups | | 54728.6 | 219 | 249.902 | | |
| | Total | | 57282.9 | 220 | | | |
| MINITEST * GENDER | Between Groups | (Combined) | 190.437 | 1 | 190.437 | 1.007 | .317 |
| | Within Groups | | 41599.3 | 220 | 189.088 | | |
| | Total | | 41789.7 | 221 | | | |
| Final Result * GENDER | Between Groups | (Combined) | 2181.60 | 1 | 2181.60 | 13.304 | .000 |
| | Within Groups | | 36240.3 | 221 | 163.983 | | |
| | Total | | 38421.9 | 222 | | | |
| Entrance Examination * GENDER | Between Groups | (Combined) | 262.294 | 1 | 262.294 | 3.160 | .077 |
| | Within Groups | | 17014.6 | 205 | 82.998 | | |
| | Total | | 17276.9 | 206 | | | |
| Sec. School Marks * GENDER | Between Groups | (Combined) | 19.677 | 1 | 19.677 | .170 | .680 |
| | Within Groups | | 25870.6 | 224 | 115.494 | | |
| | Total | | 25890.3 | 225 | | | |

**ANOVA**

| SECTION | | | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|---|
| Eng.& Sci. | Pre-Test | Between Groups | 60.055 | 1 | 60.055 | .179 | .673 |
| | | Within Groups | 44880.9 | 134 | 334.932 | | |
| | | Total | 44941.0 | 135 | | | |
| | Test.1 | Between Groups | 9.013 | 1 | 9.013 | .047 | .829 |
| | | Within Groups | 25628.2 | 132 | 193.395 | | |
| | | Total | 25637.2 | 133 | | | |
| | Test.2 | Between Groups | 376.332 | 1 | 376.332 | 1.301 | .256 |
| | | Within Groups | 37905.6 | 131 | 289.35[illegible] | | |
| | | Total | 38281.9 | 132 | | | |
| | MINITEST | Between Groups | 207.982 | 1 | 207.982 | 1.[illegible]3 | .208 |
| | | Within Groups | 16996.5 | 131 | 129.744 | | |
| | | Total | 17204.4 | 132 | | | |
| | Final Result | Between Groups | 12.439 | 1 | 12.439 | .090 | .765 |
| | | Within Groups | 18262.4 | 132 | 138.352 | | |
| | | Total | 18274.8 | 133 | | | |
| Agr.& Bio. | Pre-Test | Between Groups | 1800.66 | 1 | 1800.66 | 5.910 | .017 |
| | | Within Groups | 26812.5 | 88 | 304.687 | | |
| | | Total | 28613.1 | 89 | | | |
| | Test.1 | Between Groups | 2051.08 | 1 | 2051.08 | 6.545 | .012 |
| | | Within Groups | 27264.3 | 87 | 313.383 | | |
| | | Total | 29315.4 | 88 | | | |
| | Test.2 | Between Groups | 1532.28 | 1 | 1532.28 | 8.005 | .006 |
| | | Within Groups | 16462.1 | 86 | 191.419 | | |
| | | Total | 17994.3 | 87 | | | |
| | MINITEST | Between Groups | 401.495 | 1 | 401.495 | 1.723 | .193 |
| | | Within Groups | 20267.9 | 87 | 232.965 | | |
| | | Total | 20669.4 | 88 | | | |
| | Final Result | Between Groups | 1225.05 | 1 | 1225.05 | 6.909 | .010 |
| | | Within Groups | 15426.1 | 87 | 177.311 | | |
| | | Total | 16651.1 | 88 | | | |

Tables of One-way ANOVA of the cognitive levels by Gender

**ANOVA[a,b]**

| | | | Unique Method | | | | |
|---|---|---|---|---|---|---|---|
| | | | Sum of Squares | df | Mean Square | F | Sig. |
| RECALL | Main Effects | GENDER | 7750.276 | 1 | 7750.276 | 10.503 | .001 |
| | Model | | 7750.276 | 1 | 7750.276 | 10.503 | .001 |
| | Residual | | 165284 | 224 | 737.876 | | |
| | Total | | 173035 | 225 | 769.042 | | |

a. RECALL by GENDER

b. All effects entered simultaneously

**ANOVA[a,b]**

| | | | Unique Method | | | | |
|---|---|---|---|---|---|---|---|
| | | | Sum of Squares | df | Mean Square | F | Sig. |
| UNDERST | Main Effects | GENDER | 885.585 | 1 | 885.585 | .929 | .336 |
| | Model | | 885.585 | 1 | 885.585 | .929 | .336 |
| | Residual | | 213453 | 224 | 952.914 | | |
| | Total | | 214338 | 225 | 952.615 | | |

a. UNDERST by GENDER

b. All effects entered simultaneously

**ANOVA[a,b]**

| | | | Unique Method | | | | |
|---|---|---|---|---|---|---|---|
| | | | Sum of Squares | df | Mean Square | F | Sig. |
| APLICAT | Main Effects | GENDER | 141.469 | 1 | 141.469 | .182 | .670 |
| | Model | | 141.469 | 1 | 141.469 | .182 | .670 |
| | Residual | | 173997 | 224 | 776.772 | | |
| | Total | | 174138 | 225 | 773.948 | | |

a. APLICAT by GENDER

b. All effects entered simultaneously

Tables of Two-way ANOVA for the cognitive levels by Section and Gender

**ANOVA[a,b]**

| | | | Unique Method | | | | |
|---|---|---|---|---|---|---|---|
| | | | Sum of Squares | df | Mean Square | F | Sig. |
| RECALL | Main Effects | (Combined) | 7761.899 | 2 | 3880.950 | 5.214 | .006 |
| | | SECTION | 11.103 | 1 | 11.103 | .015 | .903 |
| | | GENDER | 6475.313 | 1 | 6475.313 | 8.700 | .004 |
| | 2-Way Interactions | SECTION * GENDER | 9.569 | 1 | 9.569 | .013 | .910 |
| | Model | | 7796.045 | 3 | 2598.682 | 3.491 | .017 |
| | Residual | | 165238 | 222 | 744.317 | | |
| | Total | | 173035 | 225 | 769.042 | | |

a. RECALL by SECTION, GENDER

b. All effects entered simultaneously

**ANOVA[a,b]**

| | | | Unique Method | | | | |
|---|---|---|---|---|---|---|---|
| | | | Sum of Squares | df | Mean Square | F | Sig. |
| UNDERST | Main Effects | (Combined) | 1470.796 | 2 | 735.398 | .773 | .463 |
| | | SECTION | 586.480 | 1 | 586.480 | .617 | .433 |
| | | GENDER | 345.355 | 1 | 345.355 | .363 | .547 |
| | 2-Way Interactions | SECTION * GENDER | 2363.312 | 1 | 2363.312 | 2.486 | .116 |
| | Model | | 3257.646 | 3 | 1085.882 | 1.142 | .333 |
| | Residual | | 211081 | 222 | 950.814 | | |
| | Total | | 214338 | 225 | 952.615 | | |

a. UNDERST by SECTION, GENDER

b. All effects entered simultaneously

**ANOVA[a,b]**

| | | | Unique Method | | | | |
|---|---|---|---|---|---|---|---|
| | | | Sum of Squares | df | Mean Square | F | Sig. |
| APLICAT | Main Effects | (Combined) | 965.232 | 2 | 482.616 | .619 | .540 |
| | | SECTION | 823.746 | 1 | 823.746 | 1.056 | .305 |
| | | GENDER | .126 | 1 | .126 | .000 | .990 |
| | 2-Way Interactions | SECTION * GENDER | 212.043 | 1 | 212.043 | .272 | .603 |
| | Model | | 967.261 | 3 | 322.420 | .413 | .744 |
| | Residual | | 173171 | 222 | 780.050 | | |
| | Total | | 174138 | 225 | 773.948 | | |

a. APLICAT by SECTION, GENDER

b. All effects entered simultaneously

## Tables of ANCOVAS for Final Result by Section and Gender with cognitive levels as covariate variables

**ANOVA[a,b]**

| | | | Unique Method | | | | |
|---|---|---|---|---|---|---|---|
| | | | Sum of Squares | df | Mean Square | F | Sig. |
| Final Result | Covariates | RECALL | 2595.810 | 1 | 2595.810 | 18.200 | .000 |
| | Main Effects | (Combined) | 3595.499 | 2 | 1797.750 | 12.605 | .000 |
| | | SECTION | 2407.814 | 1 | 2407.814 | 16.882 | .000 |
| | | GENDER | 205.010 | 1 | 205.010 | 1.437 | .232 |
| | 2-Way Interactions | SECTION * GENDER | 398.529 | 1 | 398.529 | 2.794 | .096 |
| | Model | | 7329.259 | 4 | 1832.315 | 12.847 | .000 |
| | Residual | | 31092.7 | 218 | 142.627 | | |
| | Total | | 38421.9 | 222 | 173.072 | | |

a. Final Result by SECTION, GENDER with RECALL

b. All effects entered simultaneously

**ANOVA[a,b]**

| | | | Unique Method | | | | |
|---|---|---|---|---|---|---|---|
| | | | Sum of Squares | df | Mean Square | F | Sig. |
| Final Result | Covariates | UNDERST | 116.388 | 1 | 116.388 | .756 | .386 |
| | Main Effects | (Combined) | 4494.030 | 2 | 2247.015 | 14.591 | .000 |
| | | SECTION | 2401.076 | 1 | 2401.076 | 15.591 | .000 |
| | | GENDER | 595.945 | 1 | 595.945 | 3.870 | .050 |
| | 2-Way Interactions | SECTION * GENDER | 330.102 | 1 | 330.102 | 2.144 | .145 |
| | Model | | 4849.837 | 4 | 1212.459 | 7.873 | .000 |
| | Residual | | 33572.1 | 218 | 154.000 | | |
| | Total | | 38421.9 | 222 | 173.072 | | |

a. Final Result by SECTION, GENDER with UNDERST

b. All effects entered simultaneously

**ANOVA[a,b]**

| | | | Unique Method | | | | |
|---|---|---|---|---|---|---|---|
| | | | Sum of Squares | df | Mean Square | F | Sig. |
| Final Result | Covariates | APLICAT | 2228.989 | 1 | 2228.989 | 15.446 | .000 |
| | Main Effects | (Combined) | 4182.013 | 2 | 2091.007 | 14.490 | .000 |
| | | SECTION | 2136.248 | 1 | 2136.248 | 14.803 | .000 |
| | | GENDER | 616.220 | 1 | 616.220 | 4.270 | .040 |
| | 2-Way Interactions | SECTION * GENDER | 317.330 | 1 | 317.330 | 2.199 | .140 |
| | Model | | 6962.438 | 4 | 1740.609 | 12.062 | .000 |
| | Residual | | 31459.5 | 218 | 144.310 | | |
| | Total | | 38421.9 | 222 | 173.072 | | |

a. Final Result by SECTION, GENDER with APLICAT

b. All effects entered simultaneously

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**Name of thesis: Gender performance and attitudes toward mathematics in buscep students at universidade Eduardo Mondlane**

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