GENDER DIFFERENCES IN MATHEMATICS ACHIEVEMENT AS A FUNCTION OF ATTITUDES IN GRADES 8 THROUGH 11 (IN NORTHERN SHOA REGION)

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SELESHI ZELEKE

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SELESHI ZELEKE

Approval of Board of Examiners

Zelalem Fekadu

Chairman, Department Graduate Committee

Darge Wole

Advisor

Examiner

ALMAZ ESHETE

Examiner

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ABSTRACT

The purpose of this study was to examine gender differences in mathematics achievement as a function of attitudes among 8th, 9th, 10th, and 11th graders in Northern Shoa region. A questionnaire, an attitude scale, and mathematics tests were administered to a random sample of 515 boys and 332 girls from 5 randomly selected secondary schools. Analysis of variance, analysis of covariance, and chi-square were employed on the data. The results indicated statistically significant differences (at .01 level) between males and females in both mathematics achievement and attitudes among 9th, 10th, and 11th graders. But at the 8th grade level, a statistically significant gender difference was found in mathematics achievement but not in attitudes. All significant differences were in favor of males. Results of the analysis of covariance similarly indicated substantial gender differences in mathematics achievement at all grade levels. Also, peers, parents, and teachers tend to hold lower expectations for girls than for boys in mathematics. It was concluded that the gender difference in mathematics achievement was due not only to the gender difference in attitudes but due also to other variables which influence the mathematics learning of boys and girls differently. Practical implications of the findings are indicated.

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CHAPTER ONE

INTRODUCTION

1.1 Background to the Problem

Education systems throughout the world place high importance on the teaching and learning of mathematics, and a lot of resource is allowed to maintaining and improving efficiency and effectiveness in these activities (Garden, 1987). Two major reasons for the importance of mathematics are the relationship between mathematics performance and academic or career opportunities and performance (Mills, Ablard, & Stumpf, 1993) and the importance of the study of mathematics to the scientific, industrial, technological, and social progress of a society (Burton, 1979). It has further been suggested that high school mathematics is more basic to a scientific career than high school science courses (Banks, 1964).

Despite the aforementioned importance, it is unfortunate that many students have mistaken impressions about mathematics and dislike mathematical activities; many seem to fear, even hate, mathematics (Neale, 1969). More generally, mathematics appears to be unpopular as a high school subject (Banks, 1964; Ernest, 1976). In particular, more girls than boys in secondary schools seem to have unfavorable attitudes toward mathematics. In some cases, this difference seem to be accompanied by gender differences (that favor males) in mathematics achievement (Aiken, 1976; Sherman, 1980).

In general, the variables that have been forwarded to explain the gender differences in achievement range from inborn to experiential influences (Garron, 1970). It has been suggested, however, that affective (or socio-cultural) more than biological factors were responsible for sex-related differences in mathematics achievement (Fox, Tobin, & Brody, 1979).

Furthermore, the importance of attitudes in mathematics achievement appears to be well recognized. For example, there is some evidence to suggest that students' attitudes are directly related to both actual and aspired marks in mathematics courses (Aiken, 1976). Even more importantly, some investigators (Carey, 1958; Sherman, 1980) have concluded that the sex difference in achievement is due to a corresponding sex difference in attitudes.

Although a similar pattern of gender differences in mathematics achievement were found in different countries (Badger, 1981; Jacobsen, 1985), the exploration of these differences in relation to students' attitudes (or affective factors in general) in developing countries such as Ethiopia has been limited. In the Ethiopian context, the issue has received little or no research attention. The present study, therefore, focuses on an important and unexplored research question which has implications to mathematics education especially at the high school level.

1.2 Statement of the Problem

The purpose of the study was to examine gender differences in mathematics achievement and attitudes and to explore the importance of attitudes in mathematics achievement. Accordingly, the study was designed to answer the following specific questions.

1. Do boys show a statistically significant difference from girls in mathematics achievement?

2. Do students with high-attitude scores* differ, to a statistically significant extent, from those with low-attitude scores in mathematics achievement?

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* Attitude scores were dichotomized as high if greater than the median and low if less than or equal to the median.

3. Is there a statistically significant gender difference in attitude toward mathematics in grades 8 through 11?
4. Does the trend of attitude scores across grade levels differ significantly for males and females?

5. Is the gender difference in achievement entirely due to the gender difference in attitudes?

1.3 Operational Definitions

Following is the definition of selected terms used in the study.

Achievement: Students' mathematics performance as indicated by their scores on a test constructed by the investigator and by some subject teachers on the basis of the contents of the textbook for each grade level.

Attitude: Students' feelings about mathematics particularly their likes and dislikes associated with mathematical activities in and out of school as collected through a Likert - type scale adapted by the investigator.

Parental Expectation: Students' ratings concerning parents' view about the relative performance of boys and girls in mathematics.

Peer Expectation: Self-reported opinions of students regarding the relative performance of girls and boys in mathematics.

Teacher Expectation: Ratings of students concerning teachers' views of the relative performance of boys and girls in mathematics.

1.4 Significance of the Study

As mentioned earlier, little is known about gender differences in mathematics achievement and attitude and the reasons underlying these differences in the Ethiopian context. The present study is expected to have some theoretical contributions in the sense that the results would shed some light on these matters.

In addition, the study is expected to indicate some general problems and needs of high school students related to mathematics achievement. These, in turn, would help those concerned with devising appropriate measures to minimize the problem of teaching and learning mathematics. Furthermore, findings of the study and their implications are expected to provide some useful direction for conducting further research in the area.

1.5 Delimitation of the Study

Some investigators consider students' early experiences as causes of later sex differences in mathematics achievement (Feingold, 1988; Jacobsen 1985). However, due to time constraint, the present study basically examined gender differences in mathematics achievement and attitude and related issues in grades eight through eleven. In order to capture at least some of the early experiences of the students associated with mathematics, some items were included in the questionnaire used in this study.

Furthermore, some investigators (e.g., Fennema & Sherman, 1977) have studied gender difference in mathematics achievement by considering cognitive variables (e.g., verbal ability and spatial visualization) as well as affective variables (e.g., confidence in learning mathematics). The scope of the present study was, however, limited to exploring the role of attitude in mathematics achievement in addition to examining gender differences in achievement and attitude. Finally, the present study focused on grades 8 through 11 with the aim of examining the pattern of gender differences in mathematics achievement and attitude from junior to senior secondary grades.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

After skimming through the research literature on mathematics achievement or ability, one may be tempted to conclude that males are superior to females in mathematics achievement or performance. It may be argued, however, that such a conclusion is not fair since this may not be true for all students at different grade levels. Besides, the conclusion seems to connote biological (rather than environmental) differences which are probably unalterable and may thus have detrimental effects on the achievement of females.

The idea needs, therefore, a careful examination of the literature and this may be done by focusing on the following questions.

(1) Are there significant differences in achievement and attitude toward arithmetic between the sexes when they first begin learning arithmetic in school? Strictly speaking, the present study does not focus on students of grades one through seven. But, since the examination of this question helps to know if in fact attitude influences achievement at the start, a brief review of pertinent findings will be given.

(2) Are there consistent gender differences in mathematics achievement and attitude in grades 8 through 11?

(3) What are the major reasons for gender differences in mathematics achievement and attitude?

(4) Is there any relationship between achievement in and attitude toward mathematics? If so, how important is attitude in mathematics achievement, relative to other factors?

Research findings and reviews indicate the following about the above mentioned questions.

2.1 Gender Differences in Arithmetic Achievement and Attitude Toward the Subject in Elementary Schools.

Some comprehensive reviews of the literature on sex differences in cognitive abilities concluded that boys and girls show equal aptitude and achievement in arithmetic until they are well into the elementary school period (Anastasi, 1958), until about the fourth grade (Fenneman, 1974), or at the elementary school level in general (Maccoby & Jacklin, 1981). It has further been noted that after the fourth grade (Fennema, 1974) or generally among elementary school children (Anastasi, 1958), when differences in achievement appear, they tend to be in boys' favor if higher level cognitive tasks (numerical reasoning and arithmetic problems) are being measured and in girls' favor if lower level cognitive tasks (computation) are being measured.

This latter finding was supported by a more recent study (Marshall, 1984) that involved about 300,000 sixth graders. In contrast, a longitudinal study which included over a thousand subjects disclosed significant differences favoring girls in almost every mathematics area that was evaluated (Marshall & Smith, 1987) in the third grade although the difference decreased at the sixth grade level. It was also revealed that females had fallen behind to a serious extent in word problems and geometry.

Other investigators have found no sex differences at different levels of the elementary school - for nine-year olds (Fennema & Carpenter, 1981), for fifth graders (Hilton & Berglund, 1974), for sixth graders (Fennema & Sherman, 1978), and in the elementary school as a whole (Burton, 1979).

Regarding attitudes, it has been suggested that attitudes are probably unstable in the early grades and that the precision with which students can express their attitudes toward arithmetic varies with their level of maturity (Aiken, 1970). Despite these problems, researchers continued exploring the issue. Stright's study (cited in Aiken, 1970) is a typical example of such investigations. The investigator reported that in the elementary school, compared to boys, girls like arithmetic more.

A different conclusion is provided by Kirschner (1981) after reviewing studies done a long time ago and relatively recent studies. Kirschner wrote: "In studies conducted twenty or more years ago, boys at the elementary school level seemed to prefer mathematics slightly more than did girls; that is, boys' attitudes were more favorable than girls' attitudes. In more recent studies, however, no overall sex differences in preference or attitudes have been observed at the elementary school level" (p.2). The conclusion that there is no sex difference in attitudes toward arithmetic at the elementary school level is supported by some other investigators (Aiken, 1976; Ernest, 1976; Fennema & Sherman, 1978).

In short, studies show that there are no consistent sex differences in both arithmetic achievement and attitude at the elementary school level.

2.2 Gender Differences in Mathematics Achievement in Secondary Schools

To explore gender differences in mathematics achievement in general and the change in these differences across grade levels in particular, longitudinal studies seem to be more useful. One such study (Sherman, 1980) evaluated randomly chosen subjects (N=210) initially in grade eight and later in grade 11. The investigator

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Sherman (1980) employed multivariate statistical analyses and found that although girls and boys were not different in mathematics background or performance in grade eight, significant differences favoring males were found in grade eleven. Furthermore, although boys showed slightly more improvement in spatial skills than did girls, the difference was not statistically significant. Though the investigator has not reported essential characteristics of the instruments employed, they (e.g., DAT) are known to have some reliability and validity in relation to the research problem.

Similarly, in a relatively comprehensive longitudinal study (N = 400,000), Wise, Steel and Mac Donald (cited in Fox, 1981) analyzed test data to determine the extent of sex differences in mathematics achievement with and without controlling for the effect of mathematics course-taking. The investigators found no sex differences in grade nine but by grade twelve, the students differed significantly (males did better). However, when the number of mathematics courses taken in high school was statistically controlled, the observed difference at the grade twelve level disappeared.

In contrast, in a longitudinal study, Hilton and Berglund(1974) found significant differences favoring males in mathematics achievement in grades 7,9, and 11. The observed differences were also reported to increase with age.

In sum, from the above longitudinal studies, one can see that the results favoring males are consistent only at the eleventh grade level. The results are particularly inconsistent at the ninth grade level. Males achieve higher than do females in some studies (e.g., Hilton & Berglund, 1974), while no significant differences are found in other studies (e.g., Fox, 1981).

The above mentioned studies examined mathematics achievement in general. Other cross-sectional studies employed subtests such as geometry, algebra, and measurement. For instance, Fennema and Carpenter (1981) have analyzed data from a representative sample of (over 70,000) 9-, 13-, and 17- year-olds that participated in the second National Assessment of Educational progress (NAEP). The investigators' objectives were to examine sex-related differences and to detect the significance of these differences.

The investigators reported that no clear pattern of differences in achievement was apparent at ages nine or thirteen whereas at age seventeen males' average performance exceeded that of females at every cognitive level (knowledge, skills, understanding, and applications). More specifically, females scored higher on lower level number and numeration skills at ages nine and thirteen whereas males scored higher on multistep word problems in this content area at all ages. There was also a consistent pattern of lower averages for females on geometry and measurement exercises over all cognitive levels and the differences were often substantial particularly in the case of measurement.

The above data on 13- and 17- year olds (from NAEP) were also analyzed using different subtests as a basis -- computations, applications, and algebra. No significant sex differences were found at either age on the algebra subtest whereas males at both ages scored significantly higher on the applications subtest. In contrast, 13-year-old females scored significantly higher on the computation subtest than 13-year-old males although no such differences were found among 17-year olds (Fox, 1981). Armstrong's survey of 13-year olds and 12th graders (cited in Fox, 1981) has revealed identical results for algebra and computation subtests. However, on the problem-solving (or applications) subtest, the results were inconsistent in that Armstrong found sex differences favoring males among 12th graders but not among 13-year olds. In this survey, the composite achievement score for 12th grade boys was significantly higher than for 12th grade girls. In another study (Pattison & Grieve, 1984), a significant female advantage was disclosed on logical and relatively abstract problems as opposed to a significant male advantage on mastery of proportionality, scale, and two-and three-dimensional problems among 10th and 12th graders.

In short, in studies that employed subtests, generally males achieved higher than females on the applications subtest especially at the 12th grade level. In contrast, on the whole eighth-grade females scored better than eighth-grade males on the computation subtest. But, no statistically significant gender difference was observed on the algebra subtest in these grades.

Other cross-sectional studies employed general mathematics achievement tests (rather than subtests). Fennema and Sherman (1977), for instance, examined sex differences in mathematics achievement among a sample of 9th, 10th, 11th, and 12th graders and found significant differences favoring males in every grade. These differences were, however, found in only two schools (out of four) when the number of mathematics courses the students had taken was statistically controlled. Unfortunately, the investigators have not clearly indicated whether or not the subjects are selected randomly. In their later study of middle school students (grades 6,7 & 8, N = 1320), however, Fennema and Sherman (1978) found no significant sex differences in mathematics achievement. Contrary to this latter result, Tsai and Walberg (1983) have disclosed significant difference in favor of females among 13-year olds.

One other study examined gender differences on the mathematics subtest of the Scholastic Aptitude Test (SAT-M) among 11th and 12th graders of a middle - class high school (Byrnes & Takahira, 1993). Although gender differences in favor of males were found, regression analysis showed that whereas prior knowledge and strategies explained nearly fifty percent of the variance in SAT-M scores, gender explained no unique variance. The investigators concluded that it is not one's gender that matters in mathematics but one's prior knowledge and strategies. A similar study (that used a cognitive process approach) examined gender differences in classifying and solving algebraic word problems containing missing, sufficient, or irrelevant information among Australian 10th and 11th graders, respectively (Low & Over, 1993). The investigators found significant differences in favor of males in both grades. The results, as the investigators concluded, point to differences between boys and girls in knowledge of problem structure.

Regarding Ethiopian contexts, in a related study which included senior-secondary students (grades 9-12) in Bahir Dar, the investigators (Ademe & Gebre, 1990) have observed in general terms that boys perform better than girls at all grade levels. The main purpose of the study was not to examine gender differences in mathematics achievement. But, later examination of the data (gathered by Ademe and Gebre) by the present researcher resulted in significant male advantage only for 9th and 12th graders on the objective-test items and consistent and significant male advantage in all grades on the subjective-test items. The absence of sex difference in grades 10 and 11 on the objective test is not consistent with most of the research findings. This result may partly be explained by the limited sample size, particularly in the case of girls (There were only 10 girls in grade 12 as compared to 46 boys, for example).

Generally, at the junior-secondary level, particularly in grade eight, no sex differences in mathematics achievement seem to exist. In studies that employed mathematics subtests, females are often favored on the computation subtest. In the problem-solving subtest, in contrast, males perform higher although no sex differences are found in some rare cases. In studies that employed achievement tests without subtests, either no gender difference or occasional female superiority is found.

In contrast, studies conducted on students of grades 9 to 12 seem to provide a different picture. In most studies, a significant male advantage is found at this level. In some rare cases, either no sex difference or a difference favoring females in some mathematics content areas is found. Those studies which employed subtests found no sex difference on the computation subtest. However, a statistically significant male advantage is often found on the applications subtest. Finally, some investigators (e.g., Fox, 1981) have recognized the importance of differential course taking by the sexes in explaining, at least in part, the sex differences in mathematics achievement.

2.3 Gender Differences in Attitudes Toward Mathematics in Secondary Schools

In a comprehensive survey (Ernest, 1976), the researcher administered a questionnaire to randomly selected students of grades 2 through 12 (N=1324). The investigator's main objective was to examine gender differences in attitudes toward mathematics. Employing chi-square test, he found no relationship between sex and attitudes toward mathematics. This was true for all grade levels involved in the study. However, the popularity of mathematics declined in high school. In this same study, both the boys and the girls at the high school level indicated that girls do better in English and boys in social studies, science, and mathematics.

Using a somewhat similar questionnaire, Hilton and Berglund (1974) examined gender differences longitudinally. They found that more males than females were interested in mathematics and perceived it as useful whereas more females than males observed that mathematics was boring to them. Such a significant difference was, however, evident among students of grades 9 and 11 but not among students of grade seven.

Other studies examined gender differences in attitudes toward mathematics only in grade eight. Tsai and Walberg (1983), for example, analyzed attitude ratings of a representative sample of 13-year olds (N=2368) to investigate the relationship between mathematics achievement and attitudes toward mathematics. The investigators employed regression analysis and found that there were no gender differences in attitudes toward mathematics. However, the attitude scale used by Tsai and Walberg had low internal consistency, though the coefficient was not specifically indicated. Nonetheless, the findings of Tsai and Walberg have been supported by other studies. Callahan (1971), for example, found that eighth-grade girls and boys showed just about the same degree of dislike for mathematics. Furthermore, Sherman (1980) found no gender differences in attitudes toward mathematics among eighth graders (although such a difference was observed when the same students reached the 11th grade).

The above studies suggest that despite differences in the instruments employed for measuring attitude, there is no discrepancy in findings at the eighth grade level.

Some studies have employed subscale measures of attitudes toward mathematics. For example, using eight subscale measures, Fennema and Sherman (1977) examined sex differences among high school students (grades 9-12, N=1233). They found significant differences favoring males on only two subscales (confidence in learning mathematics and stereotyping of mathematics as a male domain) in all grades. In contrast, no significant gender differences were found in any of the grades on the remaining six subscales (attitude toward success, effectance motivation, usefulness of mathematics, the perceived attitude of mother, father, and teacher toward one as a learner of mathematics). Using the same subscales in a later study, Fennema and Sherman (1978) have replicated the above results in lower grades (6,7, & 8). However, the reliability of these instruments used to measure the specific attitudes was not indicated.

The results of the studies discussed above are partly consistent with what Aiken (1976) concluded in his review: "Although some studies have failed to find significant sex differences, differences in both attitudes and achievement in mathematics are frequently found to favor boys over girls at the junior-high level and beyond" (p.296).

Aiken's conclusion does not seem accurate especially for junior-high students. Most studies found no gender differences in attitudes toward mathematics among eighth graders, for example. Nevertheless, the conclusion seems to be somewhat consistent with some findings for the higher grades. Also, in those studies that employed subscale measures consistent gender differences were found in confidence and stereotyping mathematics as a male domain. In conclusion, some investigators (Aiken, 1970; Anttonen, 1969; Ernest, 1976; Neale, 1969) have generally agreed that attitude toward the learning of mathematics becomes increasingly less favorable in the high school for both boys and girls.

2.4 Major Reasons for Gender Differences in Mathematics Attitudes and Achievement

The basic reason for gender differences in mathematics achievement and attitudes seems to be the stereotyped belief that mathematics is a male domain. Many investigators (e.g., Burton, 1979; Fennema, 1974; Fennema & Sherman, 1976; Fox, 1981; Kirschner, 1981) have indicated that historically mathematics has been a masculine discipline. Besides,some investigators (Fennema & Sherman, 1977, 1978) have consistently found, using a subscale for this variable, that boys, more than girls, rated mathematics as a male domain (in grades 6-12). The investigators have further noted, however, that though girls seem to believe that studying mathematics was just as appropriate for women as for men, their behavior in course selection was more stereotyped. Ernest (1976) has also revealed similar results among high school students. There is further evidence to suggest that the stereotyped belief was significantly related to female course taking (Fox, 1981) and to both female achievement and course taking (Fennema & Sherman, 1978); that is, the less the girls stereotyped, the higher their score and the more their course taking.

It may also be noted that stereotyping mathematics as a male domain has some apparent influences on the attitudes of significant other people (parents, teachers, counselors, and peers) toward one as a learner of mathematics.

In connection with teachers' role, Aiken (1970) has offered research evidence that teacher attitude toward and effectiveness in teaching mathematics are important determinants of student attitude and performance in the subject. Inspite of this evidence, it has been suggested, however, that teachers treat boys and girls differently in mathematics classes and that this differential treatment reinforces the sex typing of mathematics as a male domain (Fennema, 1980; Fox, 1981; Jacobsen, 1985). Moreover, the fact that most mathematics teachers (during high school and later) are male is thought to present a powerful message to impressionable teenagers (Fennema & Sherman, 1976).

Considering the issue from another vantage point, the role of counselors is important particularly in the course-taking plans and career goals of young women. However, there is some evidence to indicate that counselors consider advanced mathematics courses unnecessary for girls and that they discourage many talented high school girls from enrolling in advanced science and mathematics courses (Fox, 1981). This counseling approach would have a detrimental effect on girls' attitudes toward mathematics and on their efforts in mathematics.

Another important influence on students' attitude toward mathematics comes from parents. Generally in the United States, support and encouragement from parents were found to be important factors in students' decision to elect or not elect mathematics courses in high school (Fox, 1981). However, here also research findings indicate that parents often think mathematics is more important and appropriate for boys than for girls (Fennema & Sherman, 1977) and it is more difficult for girls than for boys (Fox, 1981). Parents communicate their belief to their children in different ways such as offering more explicit rewards and reinforcement to their sons for learning mathematics than to their daughters (Fennema & Sherman, 1976). Moreover, Fennema and Sherman (1978) have reported that boys perceived both of their parents as more positive towards them as learners of mathematics than did girls. This difference began to show, although not significant, in middle school (grades 6-8) and became significant in high school (grades 9-12).

In a similar fashion, peer attitude and influence were reportedly unfavorable particularly to high school females who chose to pursue advanced mathematics courses. In fact at the 12th grade level, peer influence had a significant correlation with participation in mathematics (Fox, 1981). In short, if boys believe that significant others view mathematics as important (and useful) to them, they are more likely to strive to learn the subject than if they believe otherwise.

Students' perceived usefulness of and confidence in mathematics are other areas that received research attention. Some investigators (Hilton & Berglund, 1974) have concluded that sex-related differences in achievement could be partly accounted for by the growing conviction of girls that the study of mathematics had little real usefulness. Some other investigators (Fox, 1981; Sherman, 1979) have also found that the girls' perceptions were related to course-taking plans and behaviors. Nevertheless, in two cross-sectional studies (Fennema & Sherman, 1977, 1978) that used a subscale for this variable in grades 6 through 12, significant difference in favor of males was disclosed only among 10th graders. The investigators gave no explanation for this result.

Like most of the variables considered so far, confidence in learning mathematics predicted participation in mathematics courses at the high school level (Sherman, 1982). In addition, a strong relationship has been found between this variable and performance in mathematics tests for both boys and girls (Sherman, 1979). More important, however, is the finding that at each grade level (grades 8 through 12), boys were significantly more confident in their mathematical ability than were girls. Moreover, the results have shown that for girls (but not for boys), self-confidence scores were related to perceptions of mathematics as a male domain. Also, girls who perceived mathematics as both male and female domain were more likely to be self-confident than those girls who perceived mathematics as a male domain (Fennema & Sherman, 1977, 1978).

In conclusion, researchers generally agree that there are sex differences in attributions of success and failure in mathematics (Jacobsen, 1985; Jacklin, 1989). Overall, girls tend to believe that success in mathematics is unfeminine. More specifically, whereas boys attribute success in mathematics to their ability and failure in it to bad luck or to insufficient effort, girls feel the reverse - that success is due to extra hard work or to good luck and failure to lack of ability. These patterns of attribution of success and failure appear to be the extension of the stereotyped belief that mathematics is a male domain. In addition, this stereotype seems to contribute (however minimally and indirectly that may be) to each affective factor discussed so far.

2.5 The Importance of Attitudes in Mathematics Achievement

Some researchers believe that students' attitudes toward mathematics affect not only their choice to study mathematics, but also the amount of effort they are willing to exert to learn the subject (Aiken, 1972; Fellows, 1973; Fennema & Sherman, 1976). Besides, past research (Anttonen, 1969; Neale, 1969) has found a relationship between mathematics achievement and attitude among students of grades 8 through 12. Indeed, many authorities in the area seem to recognize the relationship between mathematics achievement and attitude toward mathematics and their reciprocal influence (e.g., Aiken, 1970; Aiken & Dreger, 1961; Johnson, 1984; Tsai & Walberg, 1983).

Some studies at the high school level, although few in number, examined the importance of attitude or interest of students in mathematics achievement. Hilton and Berglund (1974), for example, longitudinally followed a sample of fifth graders (N=1859) and evaluated them in grades 7, 9, and 11. The investigators hypothesized that a difference in achievement would appear beginning with adolescence (and a more pronounced emergence of sex-typed interests). Thereafter the difference would widen in concert with widening differences in interests between the sexes. The investigators found gender differences favoring males in both achievement (in grades 7,9, & 11) and interest in mathematics (in grades 9 & 11). The differences were also found to increase with age. A strong aspect of the study was that the mathematics tests were favorably evaluated (except for face validity) by two reviewers (in Buros, 1978). A limitation of the study was that the questionnaire contained only eight items (out of the original 177 items developed by the Educational Testing Service for the same purpose) and no indication, whatsoever, was given about its adequacy in surveying students' interests.

In a similar longitudinal study, Sherman (1980) has revealed gender differences favoring males in both achievement and attitude in grade eleven. But no such differences were found in grade eight. Since the presence or absence of a sex-related difference covaried with the presence or absence of more favorable attitudes toward mathematics among males, the investigator concluded that the source of the difference could be attributed to sex-related differences in these attitudinal factors. Furthermore, Aiken (1976) has offered research evidence that when attitude scores are used as predictors of achievement in mathematics, a low but significant positive correlation is usually found at the secondary level. It was also found that the correlation between attitude and achievement varies with sex and is generally somewhat higher for girls. Thus, girls' achievement scores seem to be more predictable from their attitudes than are boys' scores (Aiken, 1976). Fennema (1974) endorses this conclusion.

In another study (Sherman, 1979), ninth grade scores (N=305) for three cognitive and eight attitude variables were used to predict mathematics performance one to three years later. The multiple correlation coefficients indicate that girls' mathematics performance was more predictable from the affective variables (such as confidence in learning mathematics and attitude toward success in mathematics) than was boys' performance.

In summary, the relationship and reciprocal influence of mathematics achievement and attitudes seem to be generally recognized (Aiken & Dreger, 1961; Neale, 1969). In addition, attitude variables appear to account for the male-female differences in mathematics achievement more than other variables such as genetic factors, differential course taking, and verbal ability (Sherman, 1980). Furthermore, some investigators (Carey, 1958; Sherman, 1980) have particularly confirmed the hypothesis of sex differences in mathematics performance as a function of sex differences in attitudes. One can, therefore, see that attitude has an important role in mathematics achievement.

Generally, the stereotyped belief that mathematics is a male domain appears to be the basic reason for the gender difference found in attitude toward mathematics (Jacobsen, 1985). Besides, differential treatment and reinforcement by parents, teachers, peers, and counselors together with perceived usefulness of mathematics tend to account for the gender gap in attitude toward mathematics (Fennema & Sherman, 1976, 1977).

In terms of methods of investigation, many investigators have used questionnaires (e.g., Ernest, 1976; Hilton & Berglund, 1974) to measure students' attitudes toward mathematics. However, some of the questionnaires contained only a few items. Some investigators administered subscale measures (Fennema & Sherman, 1977, 1978) or general mathematics attitude scale (Aiken, 1972; Carey, 1958) at the high school and college levels, but the scales were not supplemented by questionnaire items and one may not get sufficient information from them.

Overall the review points to the need for investigation of gender differences in mathematics achievement and attitudes and to exploring the role of attitudes in mathematics achievement at grade levels where research evidence is inconsistent (i.e., grades 8 through 11) using both a general mathematics attitude scale and a questionnaire.

CHAPTER THREE

DESIGN OF THE STUDY

3.1 Subjects

A pilot study, the objectives of which were to test and improve instruments and to create working relationship in the study site, was carried out on 194 students from four grade levels. The subjects were 52 (M=33 & F=19) from grade 8, 44 (M=29 & F=15) from grade 9, 51 (M=41 & F=10) from grade 10, and 47 (M=38 & F=9) from grade 11. They were randomly selected from one junior- and one senior-secondary schools in Debre Birhan. Out of the 194 subjects, seven students failed to provide complete data. Thus, the pilot sample comprised of 187 students.

The main study was conducted on a random sample of 885 students selected from five, out of the 11, senior secondary schools in Northern Shoa region. Once again, for either of two reasons (participating in only the questionnaire or the test administration, or responding to the scale inappropriately), complete data were not available for 38 subjects (M=27 & F = 11). Thus, the main sample comprised of 847 (M=515 & F=332) students. Of these, 217 were 10th graders and 630 were from the other grades (210 from each grade).

To obtain the sample schools, the names of the 11 senior secondary schools were put into an alphabetical list and were assigned consecutive numbers 1 to 11. By the use of a random number table, five schools were selected (See Appendix A). Subjects were also selected in the same way except that males and females were separately listed and random selection was made on the basis of the proportions of boys and girls in each section.

3.2 Instruments

(a) The achievement tests

After a thorough analysis of the mathematics textbooks, objectives were formulated and a table of specifications was prepared for each grade level. Accordingly, items were constructed. In all these activities, the investigator was assisted by four mathematics teachers (one from each grade level).

The tests were then administered to the pilot sample from each grade level and item analysis was carried out. More specifically, indices of item difficulty and discrimination and the relative worth of each distructor were analyzed on the upper (27%) and the lower (27%) scorers (Mehrens & Lehmann, 1984). The pilot tests were moderately reliable (using coefficient alpha, the reliabilities ranged from r=.70 to r=.88).

Based on the item analysis, a total of 20 items were discarded from the four grade levels and these were items with either zero or negative discrimination indices. Eight of these items were, however, substituted by other items so as to keep the number of items in the tests as planned in the tables of specifications. Finally, the tests for the main study contained 50 items each and were sufficiently reliable (Cronbach's alpha reliabilities ranged from r=.82 to r=.90). (See Appendices B through E for details of the mathematics tests administered in grades 8 through 11, respectively).

(b) The attitude Scale

To examine attitudes of students toward mathematics, a Likert-type, five-point scale ranging from strongly disagree to strongly agree was used.

The scale was composed of 40 items (or statements) which were selected from three mathematics attitude scales; i.e., 13 items from Aiken (1972), 17 items from Aiken (1988), and 10 items from Callahan (1971). The main criterion for selection was that the statements should be unambiguous. The statements were then translated (from English) into Amharic in order to make them easily understandable by students of all grade levels.

The scale was administered to the pilot sample and was found to be highly reliable (using coefficient alpha $r \geq .94$ for each grade level). Item analysis was also carried out and mean scores of the upper (27%) and the lower (27%) groups on each item were compared using the t test as suggested by Edwards (1957).

Even though all attitude statements were found to discriminate the two groups to a statistically significant extent ($P<.01$), 16 were discarded on the basis of criteria for editing statements (Edwards, 1957; Likert, 1967). Consequently, the main sample comprised of 24 statements and this was in agreement with Edwards' (1957) suggestion that we can select the 20 to 25 statements with the largest t values for the final scale. the final scale was highly reliable (using Cronbach alpha, $r \geq .91$ for each grade level) although 16 statements were discarded (See Appendix F for statements of the attitude scale).

(c) <u>The questionnaire</u>

In addition to the above two instruments, an open-ended questionnaire (with two structured items included) was administered to students to collect some background information. These included, among others, best-liked school subjects, peer-group expectation, and students' opinions of teachers' and parents' expectations of girls' and boys' mathematics achievement. The questionnaire contained 19 items and was administered to both the pilot and the main samples (See Appendix G).

3.3 Data Collection procedure

In the pilot study, the three instruments (questionnaire, attitude scale, and the test) were administered in one session. The session was conducted in students' free time. On the basis of the pilot data, the instruments were improved.

In the main study, of the three instruments, the questionnaire and the attitude scale were administered consecutively. The achievement tests, on the other hand, were administered five days later after students were informed to prepare themselves for the tests. Both sessions (or administrations) were conducted either in the morning or in the afternoon (depending on the free time of the students). This was done so as to give the students sufficient time to respond to all items.

Each of the four achievement tests were administered by the investigator and the respective subject teacher, and students were supervised so that they worked independently. The scale and the questionnaire were administered by the investigator and a different teacher (not the subject teacher).

3.4 Data Analysis

After assigning scores on the attitude scale, the scores were dichotomized (as high-and low-attitude scores) at the median. The median was used because the scores were not evenly distributed. Similarly, achievement scores were dichotomized at the median to determine high-and low-achievement scores.

Using achievement as a dependent variable, three independent variables were arranged in a 2x2x4 (attitude x sex x grade) factorial analysis of variance (ANOVA). Also, using attitude as a dependent variable, achievement, sex, and grade were arranged in exactly the same design. Besides, a 2x4 (sex x grade) factorial analysis of covariance (ANCOVA) was employed to examine gender differences in achievement using attitude as a covariate. Furthermore, a chi-square test was used to analyze the data gathered through the questionnaire.

Using Bartlett's test of homogeneity of variance (Snedecor & Cochran, 1968), the assumption of homogeneity was found to be tenable and the use of ANOVA was justified. Similarly, cell regression coefficients were homogeneous and the use of ANCOVA was also justified. Finally, all differences were tested for statistical significance at the .05 level.

CHAPTER FOUR

RESULTS

The results of the main study are presented in the following sequence: the achievement of males and females in the mathematics test, the attitudes of males and females toward mathematics, the mathematics achievement of males and females as a function of their attitudes, and students' opinions about different factors related to mathematics learning.

4.1 Mathematics Achievement

The research questions handled in this section are gender and attitude differences in mathematics achievement as related to grade level. The major dependent variable was mathematics achievement and ANOVA was performed using sex, grade, and attitude as independent variables. Table 1 shows the number of observations, means, and standard deviations of mathematics score for each of the various treatment combinations (See Appendix H for the distribution of mathematics and attitude scores).

Table 1
Number of Observations, Means, and Standard Deviations for Mathematics Score by Level of Attitude, Sex, and Grade

		Maths Results by Level of Attitude					
		High-attitude Score			Low-attitude Score		
Grade	Sex	n	mean	Sd.	n	mean	Sd.
8	M	55	62.00*	13.25	55	45.31	13.68
	F	46	46.83	13.22	54	35.19	11.85
9	M	86	58.37	13.30	50	51.60	13.23
	F	38	51.42	12.37	36	42.28	10.98
10	M	81	63.74	14.40	50	43.64	13.95
	F	36	51.94	14.30	50	37.00	12.19
11	M	78	53.56	14.26	60	46.33	14.10
	F	23	46.09	14.20	49	39.59	14.01

* The highest possible score in mathematics was 100.

Table 1 shows that the number of boys with high-attitude scores is larger than the number of boys with low-attitude scores. The reverse is true for girls.

Table 2 presents the results of the analysis of variance. The table shows that the gender difference in mathematics achievement was statistically significant. Closer examination indicates that males (mean = 53.99) performed substantially better on the mathematics test than did females (mean = 42.92). In addition, the attitude main effect was statistically significant. Examination of the means further indicates that subjects with high-attitude scores performed significantly better than did subjects with low-attitude scores (the mean scores were 56.00 and 42.69, respectively).

Table 2

ANOVA Summary Table

Source of variation	SS	df	MS	F
Attitude (A)	37456.55	1	37456.55	158.89**
Sex (S)	16372.75	1	16372.75	69.45**
Grade (G)	2485.73	3	828.58	3.51*
A x S	300.63	1	300.63	1.2800
A x G	4906.24	3	1635.41	6.94**
S x G	853.70	3	284.57	1.2100
A x S x G	524.83	3	174.94	0.7400
Residual	195893.82	831	235.73	
Total	258794.26	846		

** P<.001

* P<.05.

Table 2 indicates that the grade main effect was statistically significant. Employing Tukey's multiple-comparison test (Meyers & Grossen, 1978), ninth graders (mean = 52.74) were found to score significantly higher on the test than did 8th graders (mean=47.41) and 11th graders (mean = 47.42). No other pairwise comparison was significant.

Furthermore, the attitude-by-grade interaction was statistically significant and Figure 1 depicts this interaction.

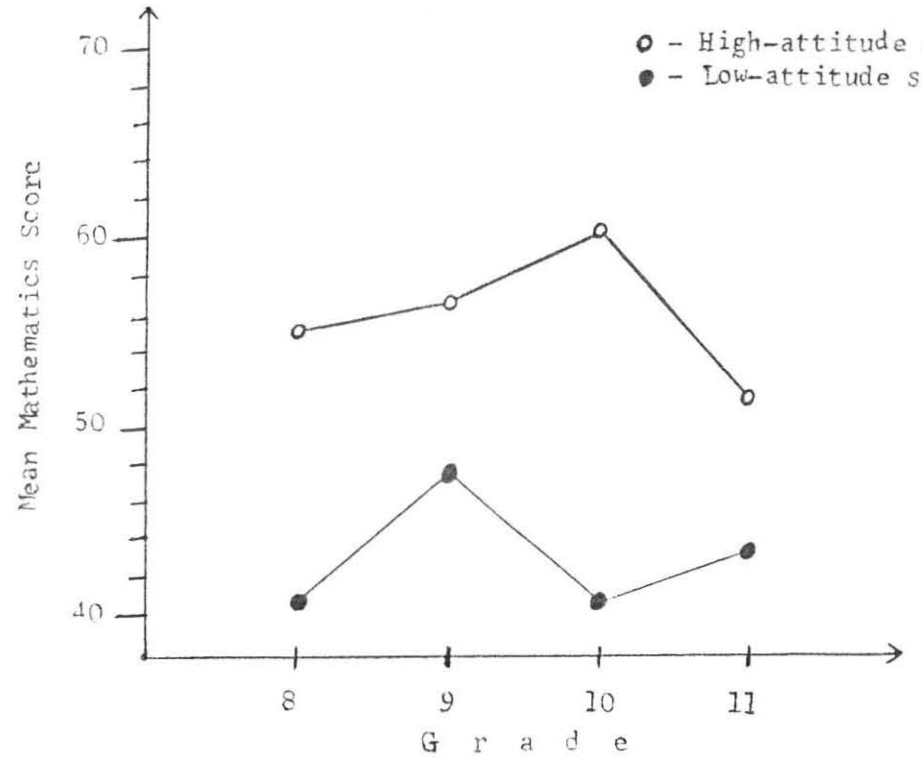

Figure 1. Attitude-by-grade interaction

As can be seen from Figure 1, at each grade level (grades 8 through 11) subjects with high-attitude scores received substantially better scores in mathematics than did subjects with low-attitude scores. Nonetheless, the magnitude of the difference in mathematics achievement varied from one grade level to another. The difference was higher among 8th and 10th graders than it was among 9th and 11th graders.

4.2 Attitudes of Students toward Mathematics

A similar ANOVA was computed on attitude scores and the number of observations, means, and standard deviations for each treatment combination are given in Table 3.

Table 3

Number of Observations, Means, and Standard Deviations for Attitude Score by Level of Mathematics Achievement, Sex, and Grade

Attitude score by Level of Mathematics Achievement							
Grade	Sex	High-achievement score			Low-achievement Score		
		n	mean	Sd.	n	mean	Sd.
8	M F	65 28	100.09* 102.29	12.56 15.69	45 72	81.42 89.39	15.51 15.89
9	M F	98 34	101.42 99.68	12.91 16.70	38 40	93.79 86.93	15.91 16.26
10	M F	81 28	103.83 95.89	13.70 17.20	50 58	87.90 86.10	18.20 16.53
11	M F	72 27	98.75 87.70	15.13 17.57	66 45	92.52 84.73	15.31 15.62

* The highest possible attitude score was 120.

Table 3 indicates that the number of girls with-high-achievement scores are smaller than the number of girls with low-achievement scores. The reverse is true for boys.

The results of the ANOVA are given in Table 4 (below). As in Table 2, the sex main effect in Table 4 was statistically significant and males (mean = 96.50) obtained substantially higher attitude scores than did females (mean = 90.26). In addition, the achievement main effect was statistically significant and high-achieving students received significantly higher attitude scores as compared to low-achieving students (the means were 99.94 and 88.04, respectively).

Furthermore, two of the four interaction effects, namely sex-by-grade and achievement-by-grade interactions were statistically significant.

Table 4

ANOVA Summary Table

Source of variation	SS	df	MS	F
Achievement (A)	29941.98	1	29941.98	122.150***
Sex (S)	1873.34	1	1873.34	7.6400**
Grade (G)	926.75	3	308.92	1.260000
A x S	381.34	1	381.34	1.560000
A x G	2189.28	3	729.76	2.98000*
S x G	5310.76	3	1770.26	7.220***
A x S x G	940.50	3	313.50	1.280000
Residual	203690.51	831	245.11	
Total	245254.47	846		

*** P<.001.

** P<.01.

* P<.05.

The sex-by-grade interaction, as depicted in Figure 2, below, clearly indicates that in grades 9 through 11, males had higher attitude scores than females whereas eighth-grade females had higher attitude scores than eighth-grade males. In fact, the former gender differences were statistically significant while the latter was not. In addition, the magnitude of the male-female difference in attitude scores was found to increase with grade level.

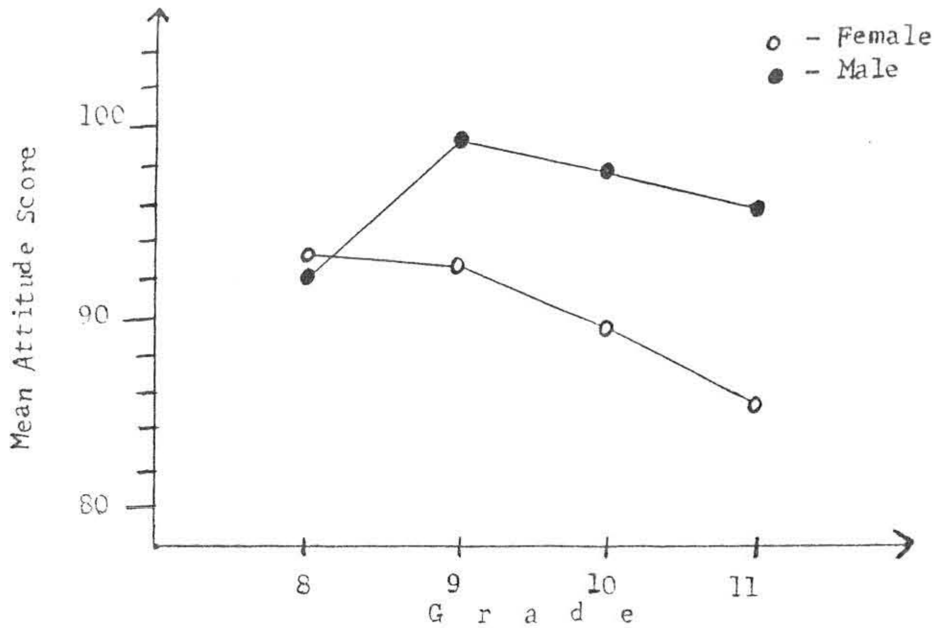

Figure 2. Sex-by-grade interaction

Figure 3 shows the achievement-by-grade interaction and the interaction is ordinal. In other words, at each grade level (grades 8 through 11), high-achieving students had substantially higher mean attitude scores than their low-achieving counterparts. Nevertheless, the magnitude of the difference varied from one grade level to another. To be more specific, the magnitude of the difference was higher for 8th and 10th graders than it was for 9th and 11th graders.

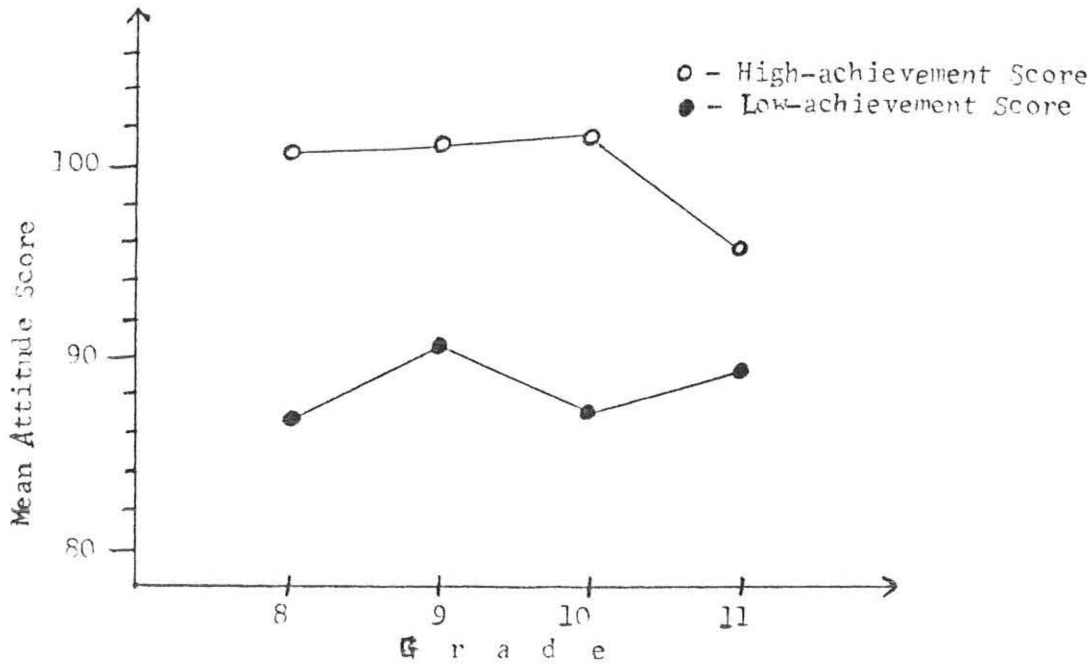

Figure 3. Achievement-by-grade interaction

4.3 Mathematics Achievement as a Function of Attitudes

To examine the extent to which the variation in mathematics achievement was attributable to attitudes toward mathematics, analysis of covariance (controlling for attitude) was employed. The results are presented in Table 5.

As can be seen in Table 5, the gender difference in mathematics achievement was statistically significant. More specifically, males had substantially higher mean mathematics score than females even after male-female differences in attitude scores were statistically controlled (the adjusted means were 52.87 and 44.04, respectively).

Table 5

ANCOVA Summary Table

Source of variation	SS	df	MS	F
Sex (S)	14353.31	1	14353.31	61.05**
Grade (G)	1680.93	3	560.31	2.3800
S x G	1993.85	3	664.62	2.83**
Residual	197018.33	838	235.11	
Total	215046.42	845		

** P<.01.

* P<.05.

In addition to the gender difference in mathematics achievement, the analysis of covariance indicated a statistically significant sex-by-grade interaction, as shown in Figure 4, below.

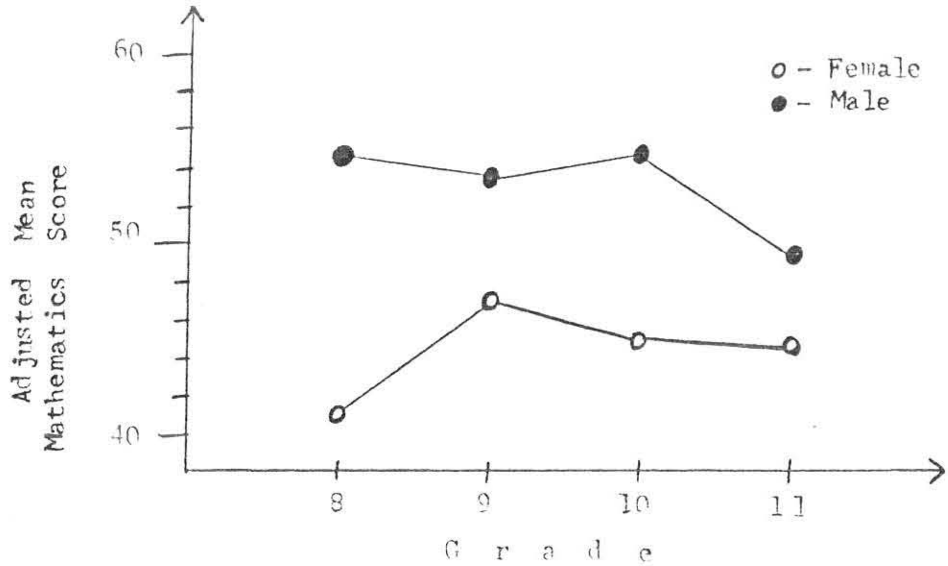

Figure 4. Sex-by-grade interaction

According to Figure 4, males had substantially higher adjusted mean scores than females at each grade level. The magnitude of the male-female difference on the adjusted means was highest among the eighth graders and lowest among 11th graders.

4.4 Students' Opinions about Different Factors Related to Mathematics Learning

As indicated in the design section (Chapter 3), in order to obtain data on additional affective factors that may have a bearing on mathematics achievement (including liking of mathematics relative to other subjects, peer-group expectation, parental expectation, teacher expectation, and perceived utility of mathematics), a brief questionnaire was also administered to the students. Chi-square test of the obtained data produced the following results.

4.4.1 Liking of Mathematics Relative to Other Subjects

The students were asked to indicate the school subject that they liked best. According to the results (Table 6, below), in grades 8, 9, and 11, more males than females liked mathematics best. In contrast, more females than males liked mathematics best in grade 10. However, the only statistically significant difference in the male-female proportions who like mathematics best was observed at the 11th grade level.

Table 6

Students who Liked Mathematics Best(%)

Grade	Male (n=515)	Female (n=332)	X^2
8	45	34	2.02
9	48	36	2.05
10	24	30	0.62
11	28	10	7.89*

*

P<.01.

Closer examination of the overall proportion of students who liked mathematics best suggests that this proportion was substantially higher in grades eight and nine (42%) than it was in grades 10 and 11 (24%). The difference between these two proportions was also statistically significant (X^2 = 4.90,P<.05).

4.4.2 Peer-Group Expectation

The students were asked to name the subjects in which they think (a) boys do better, and(b) girls do better. They also indicated the subject in which they expect no gender difference. The results are presented in Table 7. Among those who felt that boys do better in mathematics, no statistically significant difference was observed in male-female proportions at each grade level. That is, both boys and girls agreed that boys do better in mathematics. It is revealing that only a few (3%) of the students felt that girls do better in mathematics.

Table 7

Peer-Group Expectation about Mathematics Achievement(%)

	Subjects Endorsing the Statement		
Statement	Male (n=515)	Female (n=332)	Males & Female Combined
Boys do better	51	47	49
Girls do better	2	3	3
No gender difference	4	9	6

4.4.3 Teacher and Parental Expectation

The students were given four alternatives ("boys do better", "girls do better", "boys and girls achieve equally", and "do not expect good results from both groups") and they were asked to pinpoint the alternative which they felt would best reflect (a) their mathematics teachers', and (b) their parents' expectations.

Table 8 presents the results. (Two of the options were selected by very few students and they are not included in the Table.) According to the results, in grades 8, 10, and 11 more boys than girls were of the opinion that both mathematics teachers and parents expect boys to do better than girls in mathematics.

Table 8

Students' View of Teacher and Parental Expectations about Performance in Mathematics

Stud. Grade	Referent	Boys do better			Boys & girls do equally		
		M	F	X^2	M	F	X^2
8	Teachers	48	22	14.36**	50	74	11.56**
	Parents	50	27	10.51**	46	68	8.82**
9	Teachers	39	29	1.70	57	64	0.690
	Parents	46	43	0.08	53	54	0.0080
10	Teachers	47	27	6.95**	52	69	5.440*
	Parents	46	25	8.94**	50	70	7.86**
11	Teachers	51	30	7.63**	46	63	4.780*
	Parents	51	22	14.07**	47	75	13.30**

Statements by % of Students Endorsing the Statements

** P<.01.

* P<05.

In direct contrast to this, more girls than boys in these same grades (8,10, & 11) were of the opinion that mathematics teachers and parents expect equal mathematics achievement from boys and girls. Actually, out of the total 847 respondents, only 2 to 3% felt that teachers and parents expect girls to do better than boys in mathematics. No statistically significant gender difference was obtained at grade nine level.

4.4.4 Perceived Utility of Mathematics and the Emphasis Given to it During Studying

The students were asked to identify the subject which they regarded as most useful for future career and education and wanted to study most often. Table 9 presents the results.

As can be seen from Table 9, more boys than girls in grades 8,9, and 11 perceived mathematics as useful for future career and education. However, differences in male-female proportions in these grades were not statistically significant. In contrast, more girls than boys in grade 10 regarded mathematics as useful and the difference in male-female proportions was statistically significant. One can also observe that the proportions of students who perceived mathematics as useful decreased from 34% in the eighth and ninth grades to 21% in the 10th and 11th grades.

Table 9

Perceived Utility of Mathematics and Status of the Subject as Focus for Study (%)

Grade	Maths is useful			Maths should be studied most often		
	M(n=515)	F(n=332)	X^2	M	F	X^2
8	41	33	0.93	54	49	0.2100
9	32	28	0.06	48	50	0.0100
10	15	29	5.94*	38	37	0.0030
11	24	18	0.65	51	26	9.82**

** P<.01.

* P<.05.

Other data show that a substantially higher overall proportion of students liked to study mathematics (45%) and science(36%) most often rather than social studies (10%) and language (9%). There were no statistically significant differences in male-female proportions in grades 8,9, and 10 among those who wanted to study mathematics most often. In grade 11, however, the difference in male-female proportions was statistically significant and more males (51%) than females (26%) liked to study mathematics most often.

CHAPTER FIVE

DISCUSSION

5.1 Gender Differences in Mathematics Achievement

As mentioned in the earlier section (Chapter Four), boys had significantly higher achievement scores in mathematics (mean=53.99) than did girls (mean = 42.92); $F(1,831) = 69.45$, $P<.001$, $R^2=.06$. This result provides an answer to the first question of the study (which asked as to whether or not boys perform significantly higher than girls in mathematics).

Other studies have found a similar general result at the high school level (Byrnes & Takahira, 1993; Fennema & Sherman, 1977; Hilton & Berglund, 1974; Low & Over, 1993). So the present finding is not surprising. However, as reported in this study, there seem to be some inconsistencies if one examines gender differences in achievement at each grade level separately.

The present study indicates that at each grade level (grades 8 through 11), the male-female differences in mathematics achievement were statistically significant. Nonetheless, the differences do not appear to increase with grade level and this was confirmed by the non-significant grade-by-sex interaction. It is true that Hilton and Berglund (1974) disclosed gender differences in mathematics achievement that increased with age and their findings are inconsistent with the present results. However, their conclusion has already been challenged by some other studies (Fennema & Sherman, 1977, 1978) that consistently found results to the contrary.

According to Fennema and Sherman (1977, 1978), the fact that they better controlled the number of mathematics courses males and females took in their studies is one possible explanation why they did not find an increase in gender differences in mathematics achievement with increase in age or grade level. In other words, some investigators (Fox, 1981; Kirschner, 1981) indicate that girls' participation in high school mathematics courses became increasingly lower from grade to grade and that affected their mathematics achievement considerably. Thus, the difference in mathematics achievement in favor of males could increase with increase in (high school) grade level.

In our context, unlike the case in the U.S.A., mathematics courses are not elective, at least, at the high school level and boys and girls often take equal number of mathematics courses. Thus, boys and girls in Fennema and Sherman's (1977, 1978) studies and those in the present one took equal number of mathematics courses, and this could be one possible explanation why gender differences did not increase with grade level in the present study as did in Fennema and Sherman's (1977,1978) studies.

On the other hand, the statistically significant difference in mathematics achievement found between eighth-grade males and females does not agree with some other findings. At the eighth grade level, generally studies found either no significant gender difference (Fennema & Sherman, 1978; Sherman, 1980) or results in favor of females (Tsai & Walberg, 1983).

An explanation for the finding (that revealed significant gender differences in favor of males in mathematics as early as the eighth grade) probably lies in the local cultures which generally discourage the education of girls (Seyoum, 1986). That is, girls' lower performance in mathematics could be related to their life style. Most girls in Northern Shoa do house work such as cooking, taking care of their younger brothers or sisters, or generally helping their overburdened mothers. Training for their future role as wives and mothers at home would also take some of their time. This leaves them very little time for their study. Although the relationship of the time they spend on house work and their mathematics achievement needs further research in our context, one may infer that the little time available for study could partly explain the lower performance of girls in mathematics. This explanation is supported by a cross-national study (Garden, 1987) in which time spent on homework has been found to be an important predictor of mathematics achievement.

In addition to the cultural bias indicated above, differences in attitudes toward mathematics appear to explain at least part of the gender difference in mathematics achievement. But the gender difference in mathematics achievement that was found at the eighth grade level could not be accounted for by the corresponding difference in attitudes. This is because eighth-grade girls tend to have as favorable attitudes toward mathematics as eighth-grade boys.

In contrast, gender differences in both mathematics achievement and attitudes were observed at the 9th, 10th, and 11th grade levels. All results were in favor of males. Thus, the male-female difference in mathematics achievement found at these three grade levels could be attributed to the corresponding difference in attitudes. The present finding that the largest variance in mathematics scores (14%) was accounted for by attitude scores supports this explanation.

The major reasons (besides attitudes of students) forwarded for gender differences in mathematics achievement that were found in other studies include, among others, differential course taking by girls and boys (Fennema & Sherman, 1977), spatial visualization (Sherman, 1980), and parental, teacher, and peer-group expectations (Fennema & Sherman, 1976; Fox, 1981). First, there is no differential course taking in the present context, as indicated earlier. Hence, the gender difference in mathematics achievement found in the present study cannot be attributed to this factor.

Second, the present study did not examine whether or not spatial abilities contribute to the gender difference in mathematics achievement. Nevertheless, since spatial activities are supposed to be logically related to mathematics in general and to geometry in particular (Fennema & Sherman, 1976), one can examine as to whether the male-female difference is wider on geometry-type questions. But, such an examination indicated that this was not the case. More specifically, the magnitude of the male-female difference in achievement on geometry-type questions was quite similar to the corresponding difference on algebra-type questions. This does not necessarily imply, however, the absence of gender differences in spatial abilities. Nor does it rule out the possibility that differences in spatial abilities between the sexes explain, at least in part, male-female differences in mathematics achievement. On the whole, therefore, whether or not spatial abilities have a bearing on the gender difference in mathematics achievement is not clear.

Third, from the present data it seems that teacher, peer-group, and parental expectations favor boys over girls as learners of mathematics. In other words, teachers, peers, and parents seem to hold lower expectations for girls than for boys in mathematics achievement. But, there is evidence (Fennema & Sherman, 1976; Fox, 1981) to indicate that these interpersonal expectations have effects on mathematics achievement. Especially, girls' perception of the expectations could very well affect their achievement negatively. The present gender difference in mathematics achievement at each grade level may, therefore, be attributable (at least partly) to the differential expectation parents, peers, and teachers hold for girls and boys in mathematics achievement.

The finding indicating a statistically significant grade main effect is generally consistent with that of other studies (e.g., Fennema & Sherman, 1977). However, whereas the mean scores in other studies increased with grade level because of students' maturity and increased knowledge (Fennema & Sherman, 1977, 1978) such a pattern was not observed in the present study. Ninth graders did perform significantly better on the mathematics test than the 8th and 11th graders. Other pairwise comparisons of mean scores were not statistically significant.

One possible explanation for the inconsistency of the present results with that of previous studies could be the difference in the tests employed. That is, the mathematics tests employed in other studies although designed for each grade level were vertically equated (the same test in series) and the results were treated as if the same test was administered at all levels. The tests used in the present study, on the other hand, may be viewed as somewhat grade-specific rather than similar to each other. In other words, the tests were developed on the basis of the contents taught at each grade level and no attempt was made to develop similar items. Thus, mean scores were not expected to increase with grade level in the present study as opposed to the result in other studies.

But, it is more difficult to explain why the performance of ninth graders was substantially better than that of 8th and 11th graders on the mathematics test. In search of a possible explanation for this result, the number of students with more favorable attitudes toward mathematics was examined by grade level. This examination suggested that there were more students (59%) who had favorable attitudes in grade nine than there were in grades 8 and 11 (in each case 48%). In addition, examination of mean attitude scores disclosed differences in attitude scores similar to those found in mathematics scores (though not statistically significant in the case of attitude scores). As a whole, therefore, the advantage of ninth graders on the achievement test could be due to the fact that there was a greater proportion of students with favorable attitudes in grade nine relative to those in grades 8 and 11.

The finding that subjects with high-attitude scores performed significantly better on the mathematics test than those with low-attitude scores supports the above explanation. In connection with this, the results showed that 14% of the variance in mathematics scores was accounted for by the variation in attitude scores. Also, this was the largest contribution relative to the variance accounted for by the other factors and their interaction. This shows the importance of attitudes in mathematics achievement.

The importance of other affective factors in mathematics achievement was also reported in various studies (Aiken, 1970; Fennema & Sherman, 1976,1977; Fox, 1981; Neale, 1969; Tsai & Walberg, 1983). Generally, findings of these studies indicated that gender differences in mathematics achievement were attributable to male-female differences in affective factors (including students' attitudes, confidence in learning mathematics, perceived usefulness of mathematics, teacher, peer-group, and parental expectations). Thus, the present finding is consistent with the research literature.

Further examination of the statistically significant attitude-by-grade interaction clarified the importance of attitudes in that it confirmed the significant difference in mathematics achievement found between those with high- and low-attitude scores at each grade level (grades 8 through 11). Closer examination also indicated particularly for those with high-attitude scores that mean achievement scores slightly increased from 55.09 for 8th graders to 56.24 for 9th graders and to 60.11 for 10th graders. To the contrary, the mean score dropped to 51.86 for 11th graders and the reduction was statistically significant.

Although not statistically significant, the slight increase in mean score of mathematics up to grade 10 may be expected because those with favorable attitudes are supposed to exert all their effort in learning the subject as they progress to higher grades. One possible explanation for the remarkable reduction in mean score of 11th graders with high-attitude scores, however, is probably the way the subject matter is presented at this level. More specifically, at the 11th grade level, mathematics contents are generally presented at a relatively advanced level (similar to first year college mathematics) and this seems peculiar compared to the presentation in other grades of the high school. For instance, the textbook presents problems (to be solved by students) which tend to be so difficult that only few students could solve them. Furthermore, students do not appear to be introduced to such kind of presentation at the lower grade levels (grades 8,9, & 10). Thus, the requirement on the part of students does not seem comparable to the corresponding requirement in lower grades.

Examination of the Grade 11 mathematics textbook showed that the presentation of contents at that level is by far difficult as compared to the presentation at the lower grade levels. Personal communication with some mathematics teachers also supported the above argument. The teachers emphasized that the mathematics contents and their presentation at the 11th grade level are by far difficult (and different) from those in grades 9 and 10. The teachers further indicated that especially the way contents are presented is similar to the way introductory mathematics is presented at the first year college and/or university level. Hence, the advanced presentation of contents (mathematical) may partly explain why the mean score (in mathematics achievement) of students with favorable attitudes remarkably decreased at the 11th grade level. It may also explain why 11th graders obtained substantially lower mean scores in mathematics than did ninth graders.

5.2 Gender Differences in Attitudes toward Mathematics

Similar to the ANOVA of achievement scores, a separate ANOVA of attitude scores was computed and it revealed that males received significantly higher mean score (96.50 out of 120) than did females (90.26). A similar finding was reported by some other investigators (Aiken, 1976; Hilton & Berghand, 1974).

More important in the analysis of attitude scores, however, was the trend of gender differences in attitudes across grade levels and this was enhanced by the significant sex-by-grade interaction.

The absence of a statistically significant gender difference in attitudes at the eighth grade level is consistent with results of other studies (Callahan, 1971; Sherman, 1980; Tsai & Walberg, 1983). Furthermore, some investigators have found similar significant gender differences in grade 9 (Hilton & Berglund, 1974) and grade 11 (Hilton & Berglund, 1974; Sherman, 1980) as found in the present study.

The absence of a statistically significant gender difference in attitudes at the eighth grade level where there was such a significant difference in mathematics achievement seems to suggest that although a favorable attitude is necessary for better achievement, it is not sufficient. In other words, a favorable attitude alone may not result in good achievement. Thus, attitudes should be seen along with students' efforts and mathematical abilities.

But why do we see a notable difference between the attitudes of boys and girls at the ninth grade level but not at the eighth grade level? Although difficult to ascertain from the present data, one possible explanation could be the sex-role hypothesis (Hilton & Berglund, 1974). That is, with the emergence of sex-typed interests during adolescence, boys and girls would give priority to the development of appropriate sex-role standards. Unfortunately, mathematics is perceived as male discipline in various countries (Jocobsen, 1985) and the study of mathematics is conceived to be inconsistent with feminine sex role. Thus, girls' mathematics performance could not be comparable to the performance of boys. The present data fairly fit the sex-role hypothesis in that most of the subjects in grades eight (mean age = 14) and nine (mean age = 15 1/2) are in their early adolescence (Hurlock, 1990).

There is also an indication that peers and teachers perceive mathematics as a male discipline. Furthermore, the age gap between eighth and ninth graders seems to be consistent with some researchers' (Fennema & Sherman, 1976; Hilton & Berglund, 1974) hypothesis that the gap between boys' and girls' attitudes or interests would widen beginning from adolescence. Admittedly there is probably no direct evidence to indicate that the sex-role hypothesis is an important explanation for the gender difference in attitudes toward mathematics among ninth graders but not among eighth graders. Yet the possibility could not be ruled out.

Simply saying that girls have less favorable attitude toward mathematics than do boys may be an oversimplification. For instance, among those who reported that they like mathematics best, no statistically significant difference was observed in male-female proportions in grades 8,9, and 10. Of course, the difference in male-female proportions was statistically significant among 11th graders and more males (28%) than females (10%) liked mathematics best; $x^2 = 7.89$, df=1, n=210, p<.01.

Using a similar item, Ernest (1976) found no statistically significant gender difference in male-female proportions among students of grades 2 through 12. Thus, the result of the present study for 8th, 9th, and 10th graders is consistent with that of Ernest whereas the gender difference found among 11th graders is not. One possible explanation for the latter inconsistent result may be that the advanced-level presentation of mathematics at the 11th grade level entails a higher-level requirement on the part of students' work. But, once again since girls have little time for study at home, it seems unlikely that they meet this requirement. As indicated earlier, there is evidence to suggest that the amount of time spent in studying and doing homework is an important factor in determining the level of achievement students will attain (Garden, 1987). That is, all other things being equal, the more time one has for study, the better his (or her) achievement would be.

There is also evidence to indicate that attitude toward mathematics is influenced by home conditions and achievement (Tsai & Walberg, 1983). In other words, to the extent that home environment and parents encourage perseverance, achievement is likely to rise proportionately and attitudes toward mathematics would thus become more favorable. One can see, therefore, that home environment influences one's liking for (or one's attitude toward) mathematics either directly or indirectly. Thus, the statistically significant gender difference in favor of males found among 11th-grade students' liking for mathematics may be attributable to the higher-level requirement on students' work and to the amount of available study time on the part of girls.

Whereas no statistically significant gender difference was found in the liking for mathematics among 9th and 10th graders, there was such a significant difference in attitudes toward mathematics. One possible explanation for these apparently contradictory results could be that there are many reasons why students like certain subjects and dislike others. Some of these reasons may not reflect students' mathematics achievement or their attitudes toward the subject exactly.

In Seirra Leone, for instance, Ferron (1973) identified some reasons for liking a subject among secondary school students. These included: (a) the proficiency motive (students like subjects in which they score high marks and dislike others in which they show little or no proficiency.), (b) the utility motive (students tend to like a subject which is perceived useful for future career more than a subject which is perceived otherwise.), (c) the prestige motive (certain school subjects are perceived as having a higher academic status (prestige) among the student population and some students tend to like these subjects.), (d) the interest motive (some school subjects are liked because students find them interesting regardless of their proficiency in the subjects.), and (e) liking the teacher (whether or not students like a subject very often depends upon the impact of the teacher).

The present subjects have also given similar reasons for liking mathematics. But, the more frequent ones were the proficiency motive, liking the teacher (for his ability, teaching approach, and enthusiasm), and the utility motive, in that order. A few students have also expressed prestige and the interest types of motives as reasons for liking mathematics.

One cannot deny that liking for and attitude toward mathematics are closely related. Students who like mathematics because they are proficient in the subject can have favorable attitude toward the subject. But, a considerable number of students have also reported something related to their teacher as a reason for liking mathematics. And liking the teacher does not necessarily mean liking the subject. This implies that students who like their mathematics teacher may not necessarily have positive attitudes toward the subject. This may explain the discrepancy of students' attitudes toward and their liking for mathematics among 9th and 10th graders.

Likewise, no statistically significant gender difference was observed in the perceived usefulness of mathematics in grades 8,9, and 11. Moreover, even though a statistically significant difference was found in male-female proportions among 10th graders, more girls (29%) than boys (15%) perceived mathematics as useful; $X^2 = 5.94$, df=1, n=217, $p<.05$.

Generally, the above results were unexpected because in some studies (Fennema & Sherman, 1977; Hilton & Berglund, 1974) mathematics was perceived as more useful by boys than by girls. The latter investigators have even gone further to conclude that sex-related difference in achievement could be partly accounted for by the growing conviction among girls that the study of mathematics had little real usefulness.

The perceived usefulness of mathematics is important in mathematics achievement. As Fennema and Sherman (1976) put it, "Certainly usefulness is a reality factor. Mathematics is not particularly easy to learn for most people. Why learn it if it has no use" (p.14).

Closer examination of Fennema and Sherman's (1977) study invites greater discussion regarding the relationship between perceived usefulness of mathematics and attitudes and achievement in mathematics. Fennema and Sherman found no gender difference in two of the four schools they studied as opposed to the statistically significant gender difference found in the remaining two schools. But when they later examined the overall data (for the schools as a whole), they found a statistically significant gender difference among 10th graders but not among 8th, 9th, and 11th graders (Fennema & Sherman, 1978). Hence, the existence (among 10th graders) and the absence (among 8th, 9th, and 11th graders) of a statistically significant gender difference in perceived usefulness of mathematics in the present study is generally consistent with what Fennema and Sherman (1978) found. Nevertheless, the statistically significant gender difference found among 10th graders was in favor of females in the former study whereas it was in favor of males in the latter.

The present result favoring females at the 10th grade level is inconsistent with the research literature. Of course,in many fields of training, even in those stereotyped as female's (e.g., nursing), a candidate is often required to have a good grade in mathematics. In addition, in order to join colleges or universities, students should receive a good grade in mathematics because mathematics is one of the two compulsory subjects in Ethiopia. Given all this, females as well as males may perceive mathematics as useful. Females may also perceive mathematics, at least, as useful as any other subject. But, why substantially more girls than boys (in grade 10) perceived it as useful is difficult to explain. The finding also seems inconsistent with the result that boys had substantially better mathematics achievement scores than did girls. That is to say while perceiving mathematics as useful is supposed to help students exert all their effort and achieve better, this was not the case for 10th-grade females. Finally, it may be that girls' perceived usefulness of mathematics was somewhat exaggerated.

The absence of a statistically significant difference in male-female proportions among 9th and 10th graders who, according to their reports, wanted to study mathematics most often appears incompatible with girls' less favorable attitudes toward mathematics. In other words, someone who has less favorable attitudes toward mathematics is unlikely to study the subject most frequently in general, or as compared to those with more favorable attitudes in particular. Overall, the consistent findings in grades 9 and 10 (that girls liked mathematics, that they perceived mathematics as useful, and that they wanted to study mathematics most often to the extent that was comparable to boys) suggest that had all things been equal girls could have shown as favorable attitudes toward mathematics as boys. This seems to imply the existence of external influences. In simple terms, the above results seem to suggest the existence of other variables which could influence the attitudes of girls and boys differently.

Among those factors that affect boys' and girls' attitudes toward mathematics differently, the present study has examined parental, teacher, and peer-group expectations. These interpersonal expectations tend to favor boys over girls as learners of mathematics. That these interpersonal expectations influence girls' attitude toward mathematics negatively is well-documented (Aiken, 1972; Fennema, 1974; Fennema & Sherman, 1976; Fox, 1981; Kirschner, 1981). Hence, girls less favorable attitudes toward mathematics could be attributed to the lower expectations parents, peers, and teachers hold for girls in relation to mathematics achievement.

In connection with liking for and attitude toward mathematics, some trends are evident across grade levels. For instance, the proportion of respondents who reported that they liked mathematics best substantially decreased from 42% in grades eight and nine to 24% in grades 10 and 11. Also, although not statistically significant, mean attitude scores were found to decrease from 97 for 9th graders to 94.40 for 10th graders and to 92.37 for 11th graders. On the whole,there is some reason to believe that attitudes toward mathematics became less favorable as students progress to higher grades. This finding is consistent with results of other studies (Aiken, 1970; Anttonen, 1969; Neale, 1969) and it may also explain the reduction in mean mathematics scores from grade 9 to grades 10 and 11.

Why would attitudes toward mathematics become less favorable as students progress to higher grades? According to many investigators, girls tend to avoid the study of mathematics as they progress to upper grades for they think mathematics is a male domain. Their attitude toward mathematics is also tied up with attitude of teachers, parents, peers, and counselors toward them as learners of mathematics which is generally discouraging (Fennema & Sherman, 1977; Fox, 1981; Kirschner, 1981). Likewise, teachers and peers in our context appear to hold the same attitude toward girls' mathematics learning. It also seems that girls would feel these interpersonal expectations more as they mature and progress to higher grades than they were in lower grades. Their attitudes would also be more and more negative. In addition, attitudes of many students including boys could also become increasingly less favorable because of the increasing difficulty of mathematics from lower to higher grades. This tends to be true especially at the 11th grade level.

From the statistically significant achievement-by-grade interaction, one can also observe that the differences in attitude scores between high and low achievers were substantial among 8th, 9th, and 10th graders but not among 11th graders. This can be seen from the figure showing the interaction (Figure 3, Chapter Four). The figure clearly shows that the attitude of high achievers at the 11th grade level has become remarkably less favorable as compared to high achievers at the 8th, 9th, and 10th grade levels. This was also the main reason for the relatively smaller difference in attitude scores between high achievers and low achievers at the 11th grade level. Thus, at the 11th grade level, even the attitudes of high achievers become less favorable. As indicated earlier, this remarkable reduction in attitude scores could be due to the difficulty of mathematics at the 11th grade level.

In the same figure, the attitude scores of high-achieving students showed an increase, although not substantial, up to the 10th grade level. This finding is generally consistent with the research literature (e.g., Aiken, 1970, 1976). Students who are more proficient in a subject are supposed to have more favorable attitude toward the subject than those who are less proficient. The present finding is, therefore, what one expects.

Finally, according to the results of the two ANOVAs, the variance in mathematics scores that was accounted for by attitude scores (14%), and vice versa (12%), was much larger than the variance accounted for by the two factors (sex and grade) combined (7% and 3%, respectively). In addition, there are some similar results in the two ANOVAs. For example, besides the gender difference found in the first ANOVA, the attitude main effect and the attitude-by-grade interaction effect were statistically significant. Similarly, in the second ANOVA, gender and achievement main effects and the achievement-by-grade interaction effect were statistically significant.

These consistently similar results in achievement and attitude among different treatment groups should not be underestimated. The results suggest that attitude and achievement are important interrelated variables in the learning of mathematics. In particular, the significant attitude main effect in the ANOVA of achievement, and vice versa, together with the statistically significant variance in one variable accounted for by the other variable seem to confirm the reciprocal influence of achievement in and attitude toward mathematics as suggested by different authorities in the area (Aiken, 1970; Aiken & Dreger, 1961; Johnson, 1984; Tsai & Walberg, 1983).

5.3 Gender Differences in Mathematics Achievement as a Function of Attitude

The present results generally suggest that gender differences in both mathematics achievement and attitude are substantial and in favor of males. In addition, mathematics achievement and attitude appear to be interrelated ($r=.41$, $p<.01$). From these results, it may be logical to ask the questions: Could gender differences in achievement be fully explained by male-female differences in attitudes? Or would there still be some other factors to which gender differences in achievement are attributable?

The first question was a central objective of the present study and it required analysis of covariance. The results of this analysis revealed that gender differences in mathematics achievement cannot be reduced considerably by statistically equating gender differences in attitudes. Even though the mean scores (on the attitude scale) of males and females were equated statistically, gender differences in mathematics were still substantial. This does not mean, however, that gender differences in mathematics achievement have nothing to do with gender differences in attitudes. On the contrary, attitude differences have their own contributions to the male-female differences in mathematics achievement. An examination of the results of the one-way ANCOVAs (See Appendix I) and the significant sex-by-grade interaction in the two-way ANCOVA clarifies the contributions of attitudes.

Overall, the gender difference in mathematics was reduced by about 20% in the analysis of covariance as compared to the difference in the analysis of variance. In other words, the covariate (attitude) accounted for about 20% of the gender difference in mathematics achievement (see Appendix J).

Examination of the reduction of the magnitude of the gender difference due to the covariate at each grade level is informative. At the eighth grade level, the gender difference was not reduced. It rather showed a slight increase (roughly 2%). The results show that eighth-grade females received a slightly higher mean score on the attitude scale than did eighth-grade males. But statistically controlling this little advantage of females in attitude scores raised the gender difference in mathematics achievement slightly. In contrast, the gender difference in mathematics found among 9th, 10th, and 11th graders was substantially reduced as a result of the statistical control of attitude scores. The reduction was 27%, 24%, and 42%, respectively. In these grades (9,10, & 11), males received substantially higher mean scores on both the test and the attitude scale, and the reduction is what one would generally expect from a simple comparison of the mean scores.

The above results clearly show that the magnitude of the gender difference in mathematics scores was highly reduced (42%) among 11th graders. Although attitude scores accounted for about 42% of the gender difference in mathematics scores, once again this was not high enough to reduce the gender difference among 11th graders to a minimum.

On the other hand, the magnitude of the gender difference was not uniform across grade levels in the ANCOVA as opposed to the case in the ANOVA. This is disclosed by the statistically significant sex-by-grade interaction in the two-way ANCOVA. The magnitude of the difference was highest among eighth graders while it was lowest among 11th graders. This was so because there was no gender difference in attitudes among eighth graders and the magnitude of the corresponding difference in mathematics would not show much change. In contrast, there was a substantial gender difference in attitudes among 11th graders and controlling (statistically) this difference would reduce the magnitude of the gender difference in mathematics considerably. Broadly speaking, the magnitude appears to decrease as one moves to higher grades.

In direct contrast to this, the magnitude of male-female differences in attitudes increased with grade level. The magnitude of the corresponding differences in achievement was somewhat uniform across grade levels as revealed by the non-significant sex-by-grade interaction (in the first ANOVA). A logical question may follow from all this: Why did the magnitude of gender differences in achievement generally decrease (in the ANCOVA) as one moves to higher grades as opposed to the corresponding magnitude (in the ANOVA) which was somewhat uniform?

An explanation for the discrepancy in the above results is that gender differences in attitude were controlled in the former analysis but not in the latter. In other words,the discrepancy is attributable to the statistically controlled attitude difference between the sexes in the ANCOVA. But, the result of the analysis of variance and the analysis of covariance taken together imply that the effect of attitudes on mathematics achievement was higher in higher grades (especially at the 11th grade level) than it was in lower grades. A somewhat similar result was reported by Sherman (1980) who found a statistically significant gender difference in both mathematics achievement and attitudes among 11th graders but not among eighth graders.

Why did attitude influence mathematics achievement of students in the four grade levels differently? The present results along with results of previous studies (e.g., Neale, 1969) suggest that mathematics achievement and attitude toward mathematics influence each other positively. On the other hand, many investigators (e.g., Fennema & Sherman, 1976) seem to agree that mathematics is not easy to learn for most people. It is also true that mathematics becomes increasingly difficult from lower to higher grades. As a result of this and perhaps others, students' attitudes toward mathematics become increasingly less favorable as they progress to higher grades. This implies that students would exert increasingly less effort in learning or studying the subject as a result of which their mathematics achievement would become lower and lower. Thus, the influence of attitude on mathematics achievement may be expected to increase from lower to higher grades.

Generally, the results of the analysis of covariance suggest the existence of other concomitant variables, besides students' attitudes, which influence boys' and girls' mathematics achievement differently. Accordingly, other affective variables such as teacher, peer-group, and parental expectations which were found to affect particularly girls' attitudes toward mathematics and thus their mathematics achievement (Fennema, 1980; Fennema & Sherman, 1978; Fox, 1981) were separately examined. With regard to peer-group expectations, for example, females as well as males (in grades 8 through 11) thought males will do better in mathematics. Only 22 respondents (3%) thought that females will do better in mathematics. The findings are consistent with what Ernest (1976) found for peer-group expectations among a high school sample.

As Fox (1981) suggested, the dynamics by which peers influence mathematics achievement is not well-documented. Nonetheless, Fox has offered some research and anecdotal accounts that illustrate how peer attitude and expectation operate in general and how they negatively affect even gifted girls' mathematics achievement and participation in particular. Elaborating her idea, Fox has offered the evidence that although many gifted boys skip grades or take college courses early with little or no problem, mathematically gifted girls are very reluctant to skip a grade or take college courses early because of fear of peer rejection. She has added an account about one mathematically gifted girl who dropped out of an accelerated mathematics program only because her best friend did so. Some other investigators (Ide, Parkerson, Haertel, & Walberg, 1981) have also shown that peer influence is a strong, consistent determinant of a wide range of educational outcomes (including scores on standardized achievement tests, course grades, and both educational and occupational aspirations) for elementary and high school students.

According to the present study, peer-group expectation favors males over females in relation to mathematics achievement. The main reason for this, as suggested by various authorities in the area (e.g., Fennema & Sherman, 1976; Fox, 1981), is the stereotype that mathematics is a male discipline. That is, boys and girls especially in high school conceive mathematics as a male discipline. As a result, in achievement areas identified as male and in which females would be competing with males (e.g., medicine, law, business, mathematics), some females with the capacity to perform at high levels may not do so because if they are successful, they fear a variety of sanctions from males (Fennema & Sherman, 1976). According to Horner (1972), this "fear of success" or the motive to avoid success is regarded to be an internal psychological representation of the dominant societal stereotype which views competence, competition, and intellectual achievement as qualities basically inconsistent with femininity. As Horner indicated, the expectancy that success in achievement related situations will be followed by negative consequences arouses fear of success in otherwise achievement-motivated women and inhibits their performance and levels of aspiration.

With reference to mathematics, some investigators have found results that support the idea of fear of success (Sherman, 1982) while others have confirmed it in some schools but not in others (Fennema & Sherman, 1978). Fennema and Sherman (1977) have also found that the degree to which girls stereotyped mathematics as a male domain was significantly related to their mathematics achievement while this was not the case for boys.

When it comes to the present context, one cannot certainly tell why peer-group expectations favor males over females with regard to mathematics achievement. Nevertheless, from girls' as well as boys' opinions (that males often outshine females in mathematics rather than in other subjects), it may be inferred that students had a tendency of stereotyping mathematics as a male domain. What makes this possibility even more likely is the common view of both boys and girls that the former often outshine the latter in mathematics.

From the present data, it is difficult to ascertain from where the peers get the idea of male superiority in mathematics. Studies conducted in the U.S.A., however, indicate that mathematics is thought to be more appropriate and important for boys than for girls by parents, teachers, counselors, and the society at large (Fox, 1981). Furthermore, these people tend to reinforce the mathematics learning of boys and girls differently. Peers, as observers of these activities, may thus begin to perceive mathematics as a male domain and also begin to accept that males are superior in mathematics. From the present results, it is more likely that teachers communicate this belief to the peers through differential treatment and differential reinforcement as would be seen later.

Relatively speaking, students' opinion of parental expectations were not as clear-cut as their opinion about peer-group expectations. For instance, in grades 8,10, and 11, more males than females thought that parents expect boys to do better. But in these same grades, more females than males thought that parents expect boys and girls to perform equally. Such a significant difference was not observed among ninth graders. It may also be important to note that only 3% of the respondents were of the opinion that parents expect better mathematics results from girls than from boys.

This latter result suggests that parents do not expect girls to do better than boys in mathematics. The former results, on the other hand, seem to imply that while girls are at best, expected to achieve as well as boys, boys are generally expected to achieve better than girls in mathematics. From these results it appears that parents have lower expectations for their daughters than for their sons in relation to mathematics achievement. It is important to note, however, that parents were not asked to give their opinions. In stead, students were asked to report their view of parental expectations as well as their own expectations. This could be one possible explanation for the discrepancy between peer expectations and parental expectations.

As compared to the results of the present study, studies conducted in the United States (e.g., Fennema & Sherman, 1977; Fox, 1981) have clearly reported, particularly in relation to mathematics achievement, that parents have lower expectations for their daughters than for their sons and that they communicate this belief to their children in many ways. Different findings indicate that parents buy more mathematics-related games for their sons than for their daughters and that they offer more explicit rewards and reinforcement to their sons for learning mathematics than to their daughters (Fennema & Sherman, 1976). Kirschner (1981) has also offered evidence that parental expectations influence the mathematics achievement of girls and boys either negatively or positively.

One should not expect the same result in the present study as that found in the U.S.A. because the concerned community in the present study is more or less agrarian with little or no exposure to modern education. As a result, parents (at least most of them) may not specifically distinguish the school subjects let alone differentially expect the results of their sons and daughters in each of these school subjects. But since the general attitude of the community tends to favor the education of boys more than the education of girls, parents seem to expect better achievement in most school subjects including mathematics from their sons than from their daughters.

Finally, even though the results of the present study and of those conducted in the U.S.A. may be similar, the conditions under which these results were found seem to be generally different. Firstly, whereas most of the American parents have gone to modern schools, most parents in Northern Shoa do not have that experience. Secondly, while most studies were conducted in urban areas of the U.S.A., the present one was conducted in a rural area. Thirdly and perhaps most importantly, while most studies found that parents in America stereotype mathematics as a male discipline (and hence believe that mathematics is more appropriate for their sons than for their daughters), parents in Northern Shoa do not generally seem to perceive mathematics as a totally male domain. Many investigators have concluded that parents' lower expectations for their daughters (in the U.S.A.) seem to be due almost to their perception that mathematics is a male domain. But, this does not seem to be the case in the present context. It rather seems due to the general attitude of the community which tends to favor the education of males over the education of females.

Students' opinions of teachers' expectations were quite identical with what they reported about parents' expectations. Here also, the results imply that whereas girls are, at best, expected to achieve as well as boys, boys are expected to achieve better than girls. Once again, according to students' opinions, teachers do not expect girls to do better than boys in mathematics.

Students' reports taken together tend to indicate the existence of differential expectations on the part of teachers. More specifically, mathematics teachers seem to have lower expectations for girls than for boys. Personal communications with some mathematics teachers in the study area have also confirmed this conclusion. The teachers agreed that most mathematics teachers expect better results in mathematics from boys than from girls. This finding is consistent with that of Ernest's (1976) study. Nevertheless, unlike the present study, in Ernest's study teachers themselves reported what they would expect from boys and girls.

What part do teachers' differential expectations play in the mathematics achievement of girls and boys? How do students know these expectations? Firstly, students tend to be influenced by what they believe the teacher thinks of them and their ability in mathematics (Fennema & Sherman, 1976). Secondly, many researchers agree that differential expectations result in differential treatment and this is evidenced in many ways. Kirschner (1981), for example, offered evidence that reported differntial treatment of boys and girls by teachers in terms of such factors as offered responses, cognitive level of questions, praise and criticism, individual help, and even conversation and joking. Kirschner concluded that the interaction patterns generally reinforced the sex-typing of mathematics as a male domain.

Since the first study by Rosenthal and Jacobson in 1968 (cited in Lindgren & Sutter, 1985), many studies have examined interpersonal expectancy effects in general or teacher expectany effects in particular. A synthesis of findings from 18 experiments clearly showed that interpersonal expectancy effects are evident across a wide variety of outcomes including teacher-pupil interaction and achievement (Raudenbush, 1984). More specifically, the performance of students for whom teachers have high expectations was enhanced whereas the performance of students for whom teacher have low expectations was depressed.

With regard to mathematics achievement in particular, many researchers (e.g., Fennema, 1980; Fennema & Sherman, 1976) seem to agree that teachers' expectations tend to be self-fulfilling (through their differential treatment and students responses which tend to be generally consistent with teachers' expectations). Thus, teachers' differential expectation may have negative influence especially on girls' mathematics achievement.

In summary, from the results of the analysis of covariance, it seems that the gender difference in achievement was not due only to the gender difference in attitudes toward mathematics but due also to other variables which influence the mathematics learning of boys and girls differently. Interpersonal expectations appear to be among these latter variables. An examination of these affective variables tends
to indicate that teachers, peers, and parents hold lower expectations for girls than for boys in relation to mathematics achievement. Thus, these interpersonal expectancy effects may partly explain the gender difference in mathematics achievement.

One area of particular interest was the proportion of variance in mathematics scores that was accounted for by the indpendent variables included in the design (i.e., sex, attitude, and grade) and their interactions. In the present study the proportion was only 24%. This is apparently small relative to the variance accounted for in other studies. In one study (Tsai & Walberg, 1983), for example, the proportion of variance in mathematics achievement that was explained by the experimental variables (sex, ethnicity, father's education, mother's education, home environment, experience, and attitude) was 32%. In light of the importance of the variables in mathematics achievement that were considered in the latter study but not in the former, the difference in the proportions of the explained variance of the above two studies is very small (only 8%). That is, there is evidence to indicate that father's education, mother's education (Ernest, 1976) and experience (Byrnes & Takahira, 1993) play important roles in the mathematics achievement of students. Thus, the difference in the proportions of the explained variance may be attributed to these latter factors to some extent.

On the other hand, since the main objective of the present study was examining the role of attitudes in mathematics achievement, cognitive variables were not considered at all. But, it is evident that cognitive variables highly influence mathematics achievement. According to Byrnes and Takahira (1993), for instance, some cognitive variables (prior knowledge and strategies) explained nearly 50% of the variance in mathematics scores. In addition, according to Sherman (1980), some other cognitive variables (vocabulary, spatial visualization, mathematics concepts) explained about 60% of the variance in mathematics scores.

On the whole, therefore, the smaller proportion of variance that was explained in the present study is attributable to its objective, i.e, the role of attitude in mathematics achievement (but not the role of cognitive variables).

One other pertinent issue in such types of research has been: Is it the attitude or the achievement that comes first? What is equally important is the question: Is it the gender difference in attitude or the gender difference in achievement that comes first? Authorities in the area (e.g., Aiken, 1972; Fennema & Sherman, 1976) generally agree in the reciprocal influence of mathematics achievement and attitude toward mathematics. However, they do not seem to specify as to which one comes first.

But, closer examination of the present results seems to suggest a possible answer for the second question. The findings indicate that gender differences in mathematics achievement were observed at each grade level (grades 8 through 11). But gender differences in attitude toward mathematics were observed beginning from grade nine (grades

9 through 11). This indicates that gender differences in mathematics achievement appeared prior to gender differences in attitude. Hilton and Berglund (1974) have found similar results. In their longitudinal study, gender differences in mathematics achievement were first observed at the seventh grade level. But the corresponding differences in attitude toward mathematics first appeared two years later, i.e., at the ninth grade level. The findings of the above two studies suggest that the gender difference in mathematics achievement occurs earlier than the gender difference in attitude toward mathematics.

In contrast, other investigators (Fennema & Sherman, 1978) revealed a statistically significant gender difference in a specific attitude (e.g., confidence in learning mathematics) toward mathematics prior (in grade eight) to the corresponding difference in mathematics achievement (in grade nine). On the whole, it is difficult to conclude as to whether the gender difference in mathematics achievement or the gender difference in attitude toward mathematics comes first.

Generally, most of the present findings are not new. What is relatively new is the gender difference in mathematics achievement that was observed among eighth graders. Such a difference in favor of males as early as the eighth grade is not common in the literature. As indicated earlier, eighth grade girls' lower performance in mathematics is not attributable to their attitudes toward the subject. This is so because girls tend to have as favorable attitude toward mathematics as do boys at the eighth grade level. On the contrary, girls' lower performance in mathematics could be due to the local cultures which encourage the education of boys generally more than the education of girls.

The present findings have practical implications to mathematics education and further research. First, teachers of mathematics should not only focus on the cognitive aspects (e.g., acquisition of skills) of the subject, but should equally be concerned with the affective domain (e.g., development of positive attitude toward mathematics). Various techniques have been used to improve students' attitudes toward mathematics in the U.S.A. (Aiken, 1972). Only some of them may be applicable in the present context. These include demonstrating the usefulness of mathematics both in careers and in everyday life, provision for success experiences through group activities, and counseling. Teachers and guidance officers may use the second and the third techniques, respectivley, to develop (or improve) self-confidence of students in learning mathematics.

Second, it appears that there is a need to change the 11th grade mathematics textbook. At least, there is a need to change the way of presentation at that level. Actually, such a change needs relatively longer time. Until then, however, additional effort on the part of the subject teachers seems necessary. One way of minimizing students' problems in such a condition is to provide them with more teacher assistance. This can be done by arranging supplementary mathematics classes.

Third, the relatively new finding of the present study which reveals gender difference in mathematics achievement among eighth graders seems to provide a new research direction. That is, gender differences may appear even before students reach the eighth grade level. Thus, the examination of the existence of such a gender difference is recommended for further research.

The present study has some weaknesses. One potential problem is that the study is partly based on self-reported data. This is particularly true of the data gathered through the questionnaire and the attitude scale. Especially the questionnaire items are susceptible to response set such as social desirability. That is, students could respond to the questionnaire items not on the basis of what they really feel but on the basis of what they think are socially acceptable or desirable answers. Also since teacher and parental expectations were reported by the students they could have some limitations in that the reports may not exactly reflect what parents and teachers expect.

However, the attitude scale was a sound instrument and this may be inferred from its reliability coefficients for each grade level ($r \geq .91$). Moreover, some internal evidence of the validity of the attitude scale was suggested by the finding that all attitude statements have discriminated those with the higher (27%) and the lower (27%) attitude scores significantly. Each of the statements favored the upper group. This seems to suggest that the scale actually measured attitude toward mathematics.

Likewise, effort has been made to establish the reliability of each of the four mathematics tests ($r \geq .82$). Further effort has been made to establish the content validity of each test through the use of a table of specifications. Moreover, since students were supervised to work independently, the possiblity of cheating during test sessions was, at least, highly minimized. Mathematics teachers from all grade levels were also involved in the preparation of the tables of specifications, the tests, and administration of the tests.

CHAPTER SIX

SUMMARY AND CONCLUSIONS

The objective of the present study was to examine gender differences in mathematics achievement as a function of attitudes in grades 8 through 11 in Northern Shoa region. Accordingly, the following specific questions were formulated for investigation:

1. Do boys show a statistically significant difference from girls in mathematics achievement?

2. Do students with high-attitude scores differ to a statistically significant extent from those with low-attitude scores in mathematics achievement?

3. Is there a statistically significant gender difference in attitudes toward mathematics in grades 8 through 11?

4. Does the trend of attitude scores across grade levels differ significantly for males and females?

5. Is the gender difference in achievement entirely due to the gender difference in attitudes?

There were 11 secondary schools in Northern Shoa. Of these, five were selected at random. From these sample schools, 847 subjects (Males = 515 & Females = 332) were randomly selected from four grade levels (8,9,10, & 11).

Three instruments (namely, achievement tests, an attitude scale, and a questionnaire) were used to collect data. While a mathematics test was constructed for each grade level, the attitude scale and the questionnaire were common for all levels. Initially, these instruments were administered on a pilot sample. Based on this, item analysis was carried out and the instruments were improved.

Analysis of variance, analysis of covariance, and chi-square were employed to analyze the data. The analyses disclosed that there were statistically significant gender differences in both mathematics achievement and attitudes toward mathematics. All results were in favor of males. In addition, students with high-attitude scores performed substantially better than those with low-attitude scores on the mathematics tests. Furthermore, the trend of attitude scores showed a statistically significant difference for males and females across grade levels. In specific terms, except in grade eight where females received a slightly higher mean attitude score than did males, males in other grades (9,10, & 11) received substantially higher mean attitude score than did their female counterparts. Also, the magnitude of the gender difference in attitude scores was found to increase with grade level.

The use of attitude scores as a covariate similarly revealed a statistically significant gender difference (in favor of males) in mathematics achievement. It was further disclosed that the magnitude of the gender difference in mathematics achievement varied across grade levels and while it was highest among eighth graders it was lowest among 11th graders.

Moreover, analysis of the responses to items of the questionnaire revealed that teacher, peer-group, and parental expectations tend to favor males over females as learners of mathematics. That is, parents, teachers, and peers tend to expect boys to do better than girls in mathematics.

From the above findings, one may arrive at the following conclusions.

1. Mathematics achievement and attitude are closely related variables that play important roles in learning the subject. Also, a favorable attitude is a necessary condition for better mathematics

achievement and vice versa. However, differences in achievement may not necessarily imply differences in attitude and vice versa.

2. Compared to the variance accounted for by the attitude scores, the variance in mathematics scores that was accounted for by the sex of the student was much lower. It appears that the attitude of the student is more important in mathematics achievement than is his or her sex.

3. Although positive attitude toward mathematics slightly declined among all students with increase in grade level, the decline appears to be more remarkable in the case of girls. Also, the effect of attitude on mathematics achievement tends to be higher at the 11th grade level than it is at the lower grade levels.

4. Gender differences in mathematics achievement are due not only to differences in attitude but also due to other variables including interpersonal expectancy effects (parental, teacher, and peer-group) that favor males over females as learners of mathematics.

5. Peers and teachers seem to expect boys to do better than girls in mathematics rather than in any other subject. This is perhaps attributable to the perception of peers and teachers that mathematics is a male discipline.

Finally, the present findings seem to have practical implications to mathematics education and further research. These implications are discussed in detail in the preceding chapter (Chapter Five). In brief, these include the need to (a) improve students' attitude toward mathematics, (b) provide the students with more teacher assistance, and (c) conduct further research to examine the existence of gender differences in mathematics achievement at the lower grade levels.

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Appendix A

A LIST OF SECONDARY SCHOOLS IN THE AREA OF THE STUDY (NORTHERN SHOA REGION)

1. Arbegnoch Secondary School
2. Arerti Secondary School
3. Ataye Secondary School
4. Debre Sina Secondary School
5. Enwari Secondary School
6. Gishe Rabel Secondary School
7. Haile Mariam Mammo Comprehensive Secondary School
8. Mehal Meda Secondary School
9. Mida Secondary School
10. Molale Secondary School
11. Robi Secondary School

N.B. Schools numbered 3,4,7,8,and 11 were the sample schools.

Appendix B

MATHEMATICS TEST ADMINISTERED TO GRADE EIGHT STUDENTS

NAME ____________________ SECTION ________ ROLL No. __________

SEX ____________________ STREAM

DIRECTION: THIS TEST BOOKLET CONTAINS 50 MULTIPLE-CHOICE ITEMS. EACH ITEM IS FOLLOWED BY FOUR POSSIBLE ANSWERS. THERE IS ONLY ONE BEST ANSWER FOR EACH QUESTION. CHOOSE THE ONE THAT BEST ANSWERS THE QUESTION AND BLACKEN THE CIRCLE CORRESPONDING YOUR CHOICE ON THE ANSWER SHEET.

1. In the decimal numeral 80123, Zero represents
   (a) thousands (b) hundreds (c) tens (d) ones
2. Simplify $\frac{6ab-4ac}{2a}$ (where $a \neq 0$)
   (a) 3b-2c (b) 2b-3c (c) 3a-2b (d) 2c-3a
3. The expanded form $4(10^5)+1(10^2)+9$ gives the numeral
   (a) 4,000,109 (b) 400,109 (c) 40,109 (d) 4,109
4. The sum of two numbers is 40 and their difference is 10. What are the numbers?
   (a) 25 and 15 (b) 27 and 13 (c) -25 and -15 (d) 35 and 5
5. In order for the ordered pairs (0,3) and (b,4) to represent a function, the value of b must not be
   (a) 4 (b) 3 (c) 2 (d) 0
6. Simplifying $[12(mx)^2]/(6mx)$ (where $m, x \neq 0$) gives
   (a) 2x (b) 2mx (c) $2x^2$ (d) $2mx^2$
7. Which one of the following fractions represents a repeating decimal?
   (a) 1/3 (b) 2/5 (c) 4/5 (d) 1/2
8. If A={0,1,2,3,...,9}, then n(A) equals
   (a) 12 (b) 10 (c) 9 (d) 8

9. If the universal set U={1,2,3,....,9} and sets A,B,C are defined as A={1,3,5,8,9}, B={2,7}, and C = {1,2,3}, then which one of the following sets is equal to $(A \cap B) \cap C'$?

(a) U (b) {1,3,5,8} (c) {3} (d) $\emptyset$

10. Simplify $6x^6/2x^2$ (where $x \neq 0$).

(a) $3x^2$ (b) $3x^3$ (c) $3x^4$ (d) $3x^5$

11. For the values of x and y in the table select the rule that holds true for all pairs.

x	0	1	2	3	7
y	-1	0	3	8	48

(a) $y = x^3-1$ (b) $y=x^2-1$ (c) $y=x^2-3$ (d) $y = x^2$

12. Find the truth set of the equation $(4x+12)/4 = x+5$, if the domain is the set of rational numbers.

(a) {-2} (b) {0} (c) {1} {d} $\emptyset$

13. Which one of the following is equal to $(1.3)^2$?

(a) 16.9 (b) 1.69 (c) 0.169 (d) 0.0169

14. Which one of the following is <u>NOT</u> a proposition?

(a) 5-4=1 (b) 5+3=4 (c) x>9 (d) 5<6

15. Find the truth set of the system of simultaneous equations

$$x + y = 16$$
$$3x - y = 20$$

(a) {(10,6)} (b) {(8,8)} (c) {(9,7)} (d) {(11,5)}

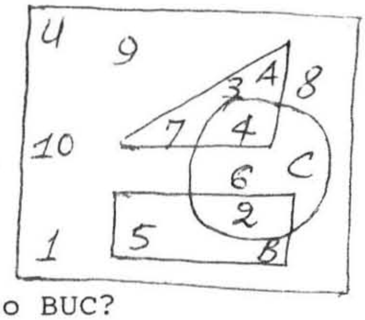
16. What is the degree measure of the supplementary angle of an angle whose degree measure is 72?

(a) 288 (b) 108 (c) 38 (d) 18

17. One of the following is <u>NOT</u> a terminating decimal.

(a) 1/2 (b) 2/3 (c) 3/4 (d) 4/5

<u>QUESTIONS 18 AND 19 REFER TO THE VENN DIAGRAM BELOW</u>



18. Which one of the following is true about the Venn diagram?
    (a) $A \cap B = \{2,4\}$ (b) $B \cap C = \{2,6\}$
    (c) $A' = \{1,2,5,6,8,9,10\}$
    (d) $B' = \{2,5\}$
19. Which one of the following is equal to BUC?
    (a) {2,4,5,6} (b) {2,5,6}
    (c) {2,5} (d) {5,6}
20. A Polygon with 5 sides is called
    (a) Pentagon (b) Hexagon (c) Heptagon (d) Octagon
21. Wtiting 3.254 correct to one decimal place gives
    (a) 3.2 (b) 3.25 (c) 3.26 (d) 3.3
22. If either of two propositions, p or q, is false, then the truth value of their conjunction ($p \wedge q$) is
    (a) false (b) true (c) sometimes true and sometimes false (d) cannot be determined
23. Let A = {1,2,3,4} and B={2,4,5,7,8}. Which one of the following is <u>TRUE</u> about the two sets.
    (a) n(A)=n(B) (b) $A \cap B=\{2,4,7\}$
    (c) AUB = {1,2,3,4,5,7,8} (d) A and B are disjoint sets.
24. The sum of the degree measures of the interior angles of a polygon of 9 sides is equal to
    (a) 1260 (b) 1440 (c) 1620 (d) 3240
25. Which one of the following is <u>NOT TRUE</u> for all real numbers a?
    (a) a+0=a (b) 1xa=a (c) a-a=0 (d) a÷a = 1
26. If 1/3 of a number is 1/12, then 4/3 of the number is
    (a) 1/9 (b) 1/6 (c) 3/16 (d) 1/3
27. If 0.5x0.2=0.10, then 0.5x0.02 is equal to
    (a) 1 (b) 0.1 (c) 0.01 (d) 0.001
28. Simplifying ab+2ba+4+2ab gives
    (a) 9ab (b) 3ab+2ba (c) 5ab+4 (d) 3ab+2ba+4

29. If x=0.666..., then 9x equals

(a) 6.66 (b) 6 (c) 5.99994 (d) 5.999

30. Which one of the following is exactly equal to 137÷7?

(a) 19+ 2/7 (b) 19+ 3/7 (c) 19+ 4/7 (d) 20

31. One of the following represents a simple path.

(a) line segment (b) triangle (c) square (d) circle

32. Simplifying 3(2b+1)+5(3b+1)+10 gives

(a) 20b+15 (b) 21b+13 (c) 20b+18 (d) 21b+18

33. Which one of the following is a regular quadrilateral?

(a) rhombus (b) rectangle (c) square (d) trapezium

34. Which one of the following numbers has a different value?

(a) 0.8 (b) (2/5)x2 (c) (4/5)x2 (d) 0.2x4

35. Writing 3.456 correct to the nearest whole number yields

(a) 3 (b) 3.4 (c) 3.46 (d) 3.5

36. The sum of the vectors (-3,-3) and (3,-3) is the vector

(a) (-6,-6) (b) (0,-6) (c) (6,0) (d) (0,6)

37. The truth set of the system of simultaneous equations

$$7x-2y = 4$$
$$2y = 4$$ is

(a) {(2,7/8)} (b) {(8/7,2)} (c) {(-7/8,2)} (d) {(2,8/7)}

38. Which one of the following sets is <u>NOT</u> finite?

(a) set of days in 1000 years.

(b) set of natural numbers less than 100.

(c) set of negative integers greater than -10.

(d) set of rational numbers beween 10 and 15.

39. If 0.207y = 207, then the value of y is

(a) 1000 (b) 100 (c) 50 (d) 1

40. Expressing 1.75 as a fraction in lowest term gives

(a) 75/100 (b) 3/4 (c) 4/3 (d) 7/4

41. The sum of two consecutive odd integers is 48. Find the numbers.

(a) 21 and 27 (b) 22 and 26

(c) 23 and 25 (d) 19 and 29

42. If a translation of the plane moves (4,3) to (-3,5), then it also moves (2,6) to

    (a) (-5,8) (b) (0,3) (c) (-8,-5) (d) (3,0)

43. Identify the pair having equivalent equations

(a)	(b)	(c)	(d)
y=3x+3	2y=x-8	3y=9x-3	2y=6x-4
y=x+1	y=x-4	y=6x-1	y=3x-2

44. One of the following is a regular triangle.

    (a) Isosceles triangle (b) Equilateral triangle
    (c) Right triangle (d) Scalen triangle

45. Which one of the following numbers is greater than -3/2?

    (a) -5/2 (b) -4/3 (c) -7/4 (d) -5/3

46. For any real numbers a and b, a+b=b+a. This property is

    (a) commutative property (b) associative property
    (c) distributive property (d) identity property

47. Which one of the following is <u>NOT TRUE</u> about the angles formed when two parallel lines are crossed by a transversal?

    (a) Alternate interior angles are congruent.
    (b) Alternate exterior angles are congruent.
    (c) Vertically opposite angles are congruent.
    (d) The sum of a pair of alternate interior angles is 360°

48. The length of a rectangle is twice its width. If the perimeter is 48 units, find the length and the width, respectively.

    (a) 12 and 6 (b) 15 and 7.5 (c) 16 and 8 (d) 17 and 8.5

49. Find the truth set of the inequality 3(x-1)/2<x-1, if the domain is the set of integers.

    (a) {...,-3,-2,-1,0,1,2} (b) {...,-3,-2,-1,0}
    (c) {...,-4,-3,-2} (d) {...,-2,-1,0,1,2}

50. One of the following triplets of angles belongs to an acute triangle.

    (a) 30°-60°-90° (b) 30°-40°-110°
    (c) 45°-45°-90° (d) 50°-60°-70°

Appendix C

MATHEMATICS TEST ADMINISTERED TO GRADE NINE STUDENTS

NAME ______________________ SECTION ____________ ROLL NO. _______

SEX _______________________ STREAM _____________________

DIRECTION: THIS TEST BOOKLET CONTAINS 50 MULTIPLE-CHOICE ITEMS, EACH ITEM IS FOLLOWED BY FOUR POSSIBLE ANSWERS. THERE IS ONLY ONE BEST ANSWER FOR EACH QUESTION. CHOOSE THE ONE THAT BEST ANSWERS THE QUESTION AND BLACKEN THE CIRCLE CORRESPONDING YOUR CHOICE ON THE ANSWER SHEET.

1. If the equation of a line is y=2x+3, then the slope and the y-intercept of this line are, respectively
   (a) 2 and 3 (b) 3 and 2 (c) 0 and 3 (d) 3 and 0
2. If the base of a parallelgram is 8 meters and the height from this side is 12 meters, find the area.
   (a) 86 sq.m. (b) 94 sq.m. (c) 96 sq.m. (d) 192 sq.m.
3. The product of (2a-3b) (2a+3b) is
   (a) $4a^2+9b$ (b) $(2a)^2-9b$ (c) $4a^2-9b^2$ (d) $2a^2-(3b)^2$
4. Identify the decimal numeral which is NOT IRRATIONAl.
   (a) 0.141441444... (b) 0.121121112...
   (c) 1.12345.... (d) 3.23333....
5. One of the following is NOT a perfect square. Identify it.
   (a) $x^2+12x+36$ (b) $x^2+4x+16$ (c) x^2+2x+1 (d) x^2-6x+9
6. Which one of the following is NOT an irrational number?
   (a) $\sqrt{8}$ (b) $\sqrt{5}$ (c) $\sqrt{4}$ (d) $\sqrt{3}$
7. Of the following, identify the pair of irrational numbers whose sum is IRRATIONAL and whose product is RATIONAL.
   (a) $\sqrt{2};\sqrt{3}$ (b) $\sqrt{3};\sqrt{5}$ (c) $2\sqrt{2};\sqrt{2}$ (d) $\sqrt{3};\sqrt{7}$
8. Find two numbers whose sum is 15 and whose product is 36.

(a) 6;9 (b) 6;6 (c) 3;12 (d) 4;11

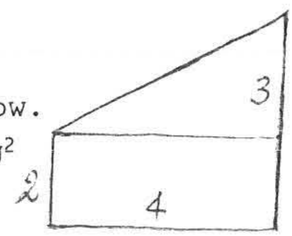
9. Factoring $16x^2-9$ will give one of the following.
(a) (4x-3) (4x-3) (b) (2x+3) (2x+3)
(c) (2x-3) (2x+3) (d) (4x-3) (4x+3)

10. If A = {1,3,5,7,...} and B = {2,4,6,8,...}, then which one of the following statements is NOT CORRECT?
(a) A/B = A (b) B/A=B (c) A/B = B/A (d) $A \cap B = \emptyset$

11. One of the following real numbers has No multiplicative inverse.
(a) -1 (b) 0 (c) 1 (d) 3/2

12. The y-intercept of the graph whose equation is $y=(x-3)^2$ is
(a) -3 (b) 0 (c) 6 (d) 9

13. Find the total area of the figure below.
(a) $6U^2$ (b) $8U^2$ (c) $12U^2$ (d) $14U^2$



14. The perimeter of the figure is
(a) 15U (b) 16U
(c) 19U (d) 24U

15. If a set has 4 elements, how many subsets does it have?
(a) 32 (b) 16 (c) 8 (d) 4

16. Select the equation of a line whose slope is zero and whose y-intercept is -3.
(a) y=x+3 (b) y=x-3 (c) y=3x (d) y=-3

17. If a and b ae any real numbers such that a<b, then which one of the following is true about their opposites?
(a) $-a<-b$ (b) $-a>-b$ (c) $-a=-b$ (d) $-a\leq-b$

18. The base and height of a triangle are 5 and 6 units, respectively. The area is
(a) $30U^2$ (b) $24U^2$ (c) $18U^2$ (d) $15U^2$

19. A right-angled triangle has an area of 38 sq.cm. One of the perpendicular sides has length 9.5 cm. What is the length of the other prependicular side?
(a) 8 cm. (b) 10 cm. (c) 11 cm. (d) 14 cm.

20. The sides of a triangle are 6m., 8m., and 9m. long. What is the perimeter of the triangle?
(a) 36m. (b) $28m.^2$ (c) $23m.^2$ (d) 23m.

21. A four-sided polygon whose sides and angles are all congruent is

(a) square (b) rhombus (c) rectangle (d) trapezium

22. If a+c = 0, then which one of the following is <u>NOT TRUE</u> about the relationship of a and c?

(a) a is the opposite of c.

(b) If a=0, then c=0.

(c) If a is positive, then c is negative.

(d) a is the reciprocal of c.

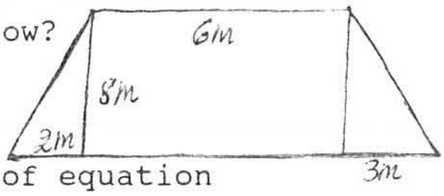
23. Select the truth set of /x-6/ = 2.

(a) {-8,4} (b) {-4,8} (c) {-8,-6} (d) {4,8}

24. What is the area of the figure below?

(a) $44m^2$ (b) $48m^2$

(c) $60m^2$ (d) $68m^2$



25. Find the truth set for the system of equation

$$y = 3x + 5$$
$$y = 6x + 6$$

(a) {(-1/3,4)} (b) {(4,-1/2)}

(c) {(0,4)} (d) {(1/3,4)}

26. Let A = {1,2,3,5}, B={2,3,5,7,8}, and C= {1,3,6,7,9}. Then, AU (B∩C) equals one of the following. Identify it.

(a) {1,2,3,5,7} (b) {1,3,5,7} (c) {1,2,3} (d) {3}

27. What is the slope of the line with an equation 3x+5y=3?

(a) -5/3 (b) -3/5 (c) 1 (d) 3/5

28. Identify the number whose value is different from the others.

(a) $2\sqrt{2}$ (b) $\sqrt{8}$ (c) $\sqrt{3+5}$ (d) $\sqrt{3}+\sqrt{5}$

29. Changing 0.73333... to a fractional form and simplifying gives

(a) 11/14 (b) 11/15 (c) 22/29 (d) 73/100

30. If $x^2-9 = 0$, then the solution set of this equation is

(a) {-3} (b) {0,3} (c) {-3,3} (d) {-3,0,3}

31. An angle whose degree measure is greater than 90 and less than 180 is

(a) acute angle (b) obtuse angle

(c) right angle (d) straight angle

32. If a,b, and c are any real numbers, then which one of the following is <u>NOT</u> NECESSARILY TRUE?

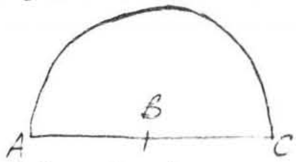
(a) If $a<b$, then $a+c<b+c$. (b) If $a>b$ and $b>c$, then $a>c$.

(c) If $a<b$, then $a-c>b-c$. (d) If $a<b$ and $b<c$, then $a<c$.

33. If the length of $\overline{AC}$ is 10 cm. (in the figure below), find the perimeter of the figure to the nearest. Whole number?

(a) 25 cm. (b) 26 cm.

(c) 27 cm. (d) 30 cm.



34. Suppose that y is proportional to x and their relationship is given by the equation $7x-7y=0$. What is the constant of proportionality?

(a) -2 (b) 1/7 (c) 1 (d) 2

35. Let A be the set of natural numbers greater than 4 and B be the set of integers less than 10. Then, which one of the following is <u>TRUE?</u>

(a) $A \cap B = \{5,6,7,8\}$ (b) $A \cup B = Z$

(c) $A/B = \{11,12,13,14\}$ (d) $B/A = \{4,3,2,1\}$

36. The set of points in a plane having equal distance from a fixed point in the same plane is

(a) rhombus (b) circle (c) rectangle (d) square

37. If a circle has radius 7 cm., then its circumference, to the nearest whole number, is

(a) 44 cm. (b) 44 $cm.^2$ (c) 43 $cm.^2$ (d) 42 cm.

38. If a number is multiplied by itself and twice the number substracted, the result is 15. What is the solution set?

(a) $\emptyset$ (b) $\{-5,5\}$ (c) $\{-3,-5\}$ (d) $\{-3,5\}$

39. The sum of a rational number and an irrational number is necessarily

(a) irrational (b) rational

(c) zero (d) cannot be determined

40. Which one of the following sets is finite?
    (a) The set of whole numbers greater than 3.
    (b) The set of negative numbers greater than -5.
    (c) The set of natural numbers greater than 2.
    (d) The set of rational numbers less than 2.

41. Which one of the following numbers makes (x-4)(x+4) negative?
    (a) -5 (b) 1 (c) 4 (d) 6

42. Select the one in which the numbers are arranged in an increasing order (starting from the smallest to the largest).
    (a) -1.2, -1.3 -1.5, -2.2 (b) -1.5, -1.3, -1.2, -2.2
    (c) -1.3, -1.2, -1.5,-2.2 (d) -2.2, -1.5, -1.3, -1.2

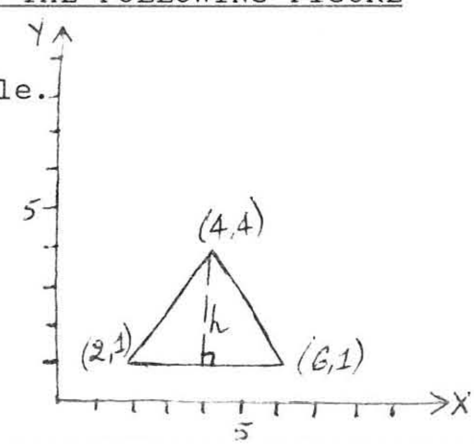
43. The length of a rectangle is 3 times its width. Its area is 12 sq. units. The width and length, respectively, are
    (a) 3u;4u (b) 3u;9u (c) 2u;6u (d) 4u;12u

44. Which one of the following numbers is the multiplicative identity?
    (a) -1 (b) 0 (c) 1 (d) 2

45. Which one of the following statements is <u>NOT</u> TRUE?
    (a) Terminating and repeating decimals are rational numbers.
    (a) {rational numbers} $\cap$ {Irrational numbers} = $\emptyset$
    (c) Every decimal corresponds to a rational number.
    (d) Every real number locates a definite point on the number line.

QUESTIONS 46 AND 47 REFER TO THE FOLLOWING FIGURE

46. Find the area of the triangle.
    (a) 10 U^2 (b) 7 U^2
    (c) 6 U^2 (d) 5 U^2



47. What is the height of the triangle?

(a) 7U (b) 6U

(c) 5U (d) 3U

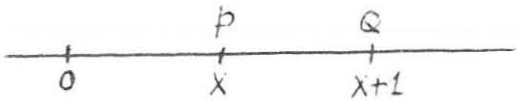
48. The area of a circle of radius 10 cm. is the same as the area of a triangle whose base is 40 cm. What is the approximate height of the triangle?

(a) 14.7cm. (b) 15.7cm. (c) 16.5cm. (d) 17 cm.

49. Suppose that $f(x) = x^2-5x+6$. Which one of the following is a factor of f(x)?

(a) x-4 (b) x+1 (c) x-2 (d) x+3

50 On the number line below, which one of the following is the coordinate of the midpoint of segment PQ?



(a) (x+1)/2 (b) x+1/4 (c)x+1/2 (d) 2x+1/2

Appendix D

MATHEMATICS TEST ADMINISTERED TO GRADE TEN STUDENTS

NAME ______________________ SECTION __________ ROLL NO. ______

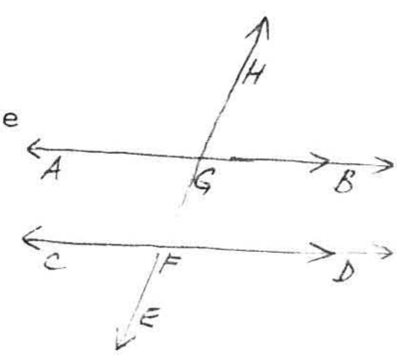
SEX ______________________ STREAM _______________

DIRECTION: THIS TEST BOOKLET CONTAINS 50 MULTIPLE-CHOICE ITEMS. EACH ITEM IS FOLLOWED BY FOUR POSSIBLE ANSWERS. THERE IS ONLY ONE BEST ANSWER FOR EACH QUESTION. CHOOSE THE ONE THAT BEST ANSWER THE QUESTION AND BLACKEN THE CIRCLE CORRESPONDING YOUR CHOICE ON THE ANSWER SHEET.

1. If $2^x = 16$, then x equals
   (a) 1 (b) 2 (c) 3 (d) 4
2. Identify the number that is NOT equal to the others.
   (a) $5x2^3$ (b) $(5x2)^3$ (c) 40 (d) $10x2^2$
3. The sum of the degree measure of the angles of any triangle is
   (a) 360 (b) 180 (c) 120 (d) 90
4. The expanded form $(8x10^4)+(2x10^2)+3$ represents
   (a) 823 (b) 8203 (c) 8230 (d) 80203

QUESTIONS 5 AND 6 REFER TO THE FIGURE BELOW

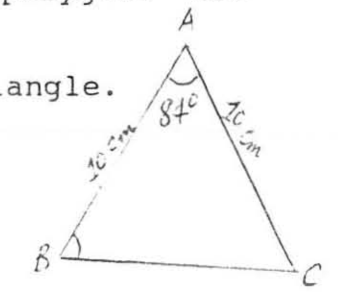
5. If $m(\hat{AGF}) = 65°$ and $m(\hat{BGF}) = 115°$, then $m(\hat{AGH})$ equals
   (a) 65° (b) 70° (c) 110° (d) 115°
6. All of the following pairs of angles are corresponding angles EXCEPT one. Identify it.
   (a) $\hat{AGF}$ and $\hat{DFG}$ (b) $\hat{BGH}$ and $\hat{DFG}$
   (c) $\hat{AGH}$ and $\hat{GFC}$ (d) $\hat{BGF}$ and $\hat{DFE}$



7. Identify the quadrilateral whose angles are all congruent but <u>NOT</u> all of its sides are congruent.
(a) Trapezium (b) Square (c) Rhombus (d) Rectangle

8. $8^{1/3}$ is equal to one of the following.
(a) 1/8 (b) 1/2 (c) 2 (d) 4

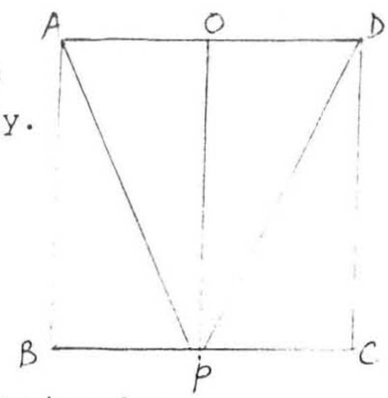
9. Which one of the following is NECESSARILY TRUE?
(a) The degree measure of each interior angle of a regular traiangle is 90.
(b) A square is a regular quadrilateral.
(c) Corresponding sides of similar polygons are congruent.
(d) Isosceles triangle is a regular triangle.



10. Triangle ABC has AB = AC = 10 cm.
and m $(B\hat{A}C)$ = 84. Then, m$(A\hat{B}C)$ equals
(a) 46 (b) 48 (c) 49 (d) 84

11. If $2^x = 13$, then x is between
(a) 5 and 6 (b) 4 and 5 (c) 3 and 4 (d) 2 and 3

12. In $(2/3)^4$, the exponent is
(a) 4 (b) 3 (c) 2 (d) 2/3



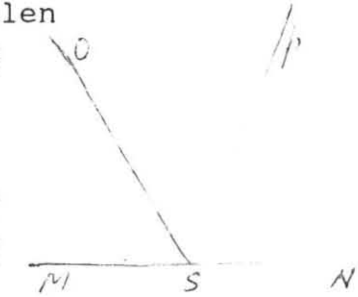
13. In the square ABCD, P and O are the midpoints of BC and AD, respectively. Which one of the following is <u>NOT</u> NECESSARILY TRUE?
(a) $\overline{PA} \equiv \overline{PD}$ (b) $\triangle POD \equiv \triangle DCP$
(c) $\triangle POA \equiv \triangle ABP$
(d) area ($\triangle PAD$) = 3 area ($\triangle PDC$).

14. If the measures of the angles of a triangle are (1/2)x, x, and x+10 in degrees, then x is
(a) 64° (b) 68° (c) 136° (d) 138°

15. If the lengths of the hypotenuse and one leg of a right triangle are 10 cm. and 8 cm. respectively, then the length of the other leg is
(a) 8 cm. (b) 7 cm. (c) 6 cm. (d) 5 cm.

16. Given $\triangle ABC$, if $\triangle ABC \equiv \triangle ACB$, then the triangle is
(a) equilateral (b) isosceles
(c) right triangle (d) Scalen

17. One of the following gives a pair of adjacent supplementary angles (in the figure).



(a) $M\hat{S}P$ and $N\hat{S}O$ (b) $M\hat{S}O$ and $N\hat{S}P$
(c) $M\hat{S}O$ and $O\hat{S}P$ (d) $M\hat{S}O$ and $O\hat{S}N$

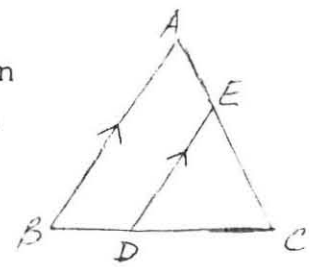
18. Simplifying $(4x^3)(8x^2)$ gives
(a) 2^6x^5 (b) $32x^6$ (c) $32x^5$ (d) $32x^4$

19. If $2^x = 4^x$, then the value of x is
(a) 0 (b) 1/5 (c) 1/3 (d) 1

20. Which one of the following sets of numbers could be the lengths of the sides of a rlight-angled triangle?
(a) 1,2,3 (b) 4,5,7 (c) 5,12,13 (d) 4,4,6

21. Consider the following numbers:
I. $0.5x10^4$, II.$5.4\ x10^2$, III.$5.41x10^2$, (iv) $3.5x10^3$
Arranging the numbers in order of increasing size gives one of the following.
(a) IV, I, II,III (b) I,II,III,IV
(c) II,III,IV,I (d) II,III,I,IV

22. If a,b,x and y are integers such that a and b are even while x and y are odd, then which of the following statements is false?
(a) a+b is even (b) x.y is even
(c) x^2-y^2 is even (d) a.y is even

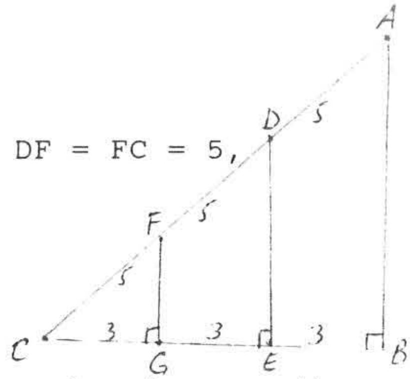


23. In the figure $\overline{AB}//\overline{DE}$. IF AE = 3, CE = 4, and CD = 6, find BD
(a) 4 (b) 4.5 (c) 5 (d) 6

24. Simplifying $(2xy)^3/2xy^2 \div 2x^2/x$, where $x,y \neq 0$, gives
(a) 2x (b) 2xy (c) 2y (d) 4xy

25. If $\triangle ABC \sim \triangle DEF$, and AB = 10, DE=8, BC=12, EF=9.6 and AC = 8, DF equals
(a) 6.4 (b) 6.8 (c) 7 (d) 7.2

26. In the figure, $\overline{AB}//\overline{DE}//\overline{FG}$ and AD = DF = FC = 5, BE = EG =GC = 3 and FG = 4. Then, ED and AB are respectively,



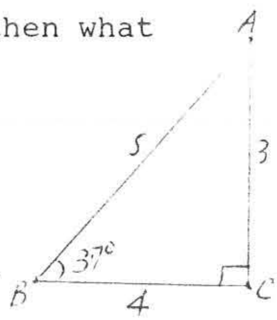
(a) 8 and 12 (b) 8 and 13
(c) 9 and 12 (d) 9 and 13

27. The midpoints of the sides of a rectangle are the vertices of a quadrilateral. Identify the quadrilateral.

(a) Trapezium (b) Square (c) Rectangle (d) Rhombus

28. If the sum of the interior angles minus the sum of the exterior angles of a convex polygon is zero then what is the number of sides of the polygon?

(a) n=3 (b) n=4 (c) n=5 (d) n=6

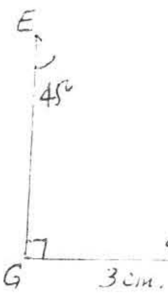


29. Find tan $\hat{B}$ from the figure.

(a) 0.6 (b) 0.75 (c) 0.8 (d) 1

30. Find sin $\hat{B}$ from the figure where m($A\hat{B}C$) = 37.

(a) 1 (b) 0.8 (c) 0.75 (d)0.6



31. Find EG from the figure, if FG = 3 cm.

(a) 2.5 cm. (b) 3 cm. (d) 3.5 cm. (d) 5 cm.

32. Once again, if FG = 3 cm., find EF.

(a) $\sqrt{18}$ cm. (b) 4.5 cm. (c) 5 cm. (d) 6 cm.

33. If P>0 and $P^{3/2}$ = 8, then the value of P is

(a) 8 (b) 6 (c) 4 (d) 2

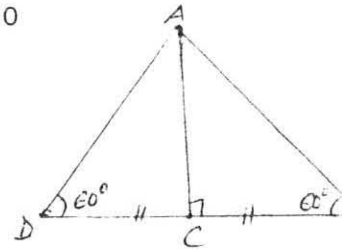
34. Identify the one which is NOT equal to the other three.

(a) $3^{1/6}$ (b) $\sqrt[3]{\sqrt{3}}$ (c) $\sqrt[6]{3}$ (d) $(\sqrt{3})^4$

35. Identify the decimal numberal which equals $(2001)_{\text{three}}$

(a) 55 (b) 53 (c) 51 (d) 50

36. In $\triangle$ABD, AB = 6 units. Find BC.



(a) 2 units (b) 3 units
(c) 3.5 units (d) 4 units

37. One of the following is necessarily true.

(a) Any two right triangles are similar.
(b) Any two isosceles triangles ae similar.
(c) Any two scalen triangles are similar.
(d) Any two equilateral triangles are similar.

38. If $2^{(x-2)}$ = 1/2, then the value of x is

(a) 0 (b) 1/2 (c) 1 (d) 2

39. If $(30.12)_{four} = (x)_{ten}$, then the value of x is

(a) 10 (b) 11.357 (c) 12.357 (d) 12.375

40. If $x = 4^{-1/2}$, then the value of x is

(a) -2 (b) -1/2 (3) 1/2 (d) 2

41. Simplifying $\sqrt[3]{8^4}$ yields

(a) 16 (b) 12 (c) 4 (d) 2

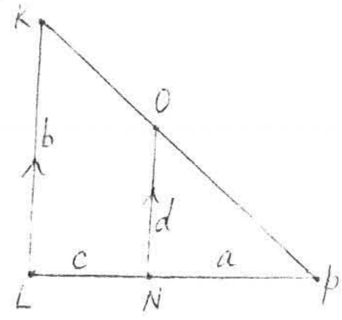
42. Simplifying $4^{5/2}$ gives

(a) 64 (b) 32 (c) 16 (d) 4

43. If $32^x = 2$, find the value of x.

(a) 5 (b) 4 (c) 1/4 (d) 1/5

44. In the figure, $\overline{KL}//\overline{NO}$. Express a in terms of b,c, and d.



(a) a=bd /(d-c) (b) a=bc /(c-d)

(c) a=cd /(b-d) (d) a=bc /(b-d)

45. Simlifying $(32)^{1/4}/(2)^{1/4}$ gives

(a) 2 (b) 2.5 (c) 4 (d) $2\sqrt{2}$

46. 2^{-4} is equal to one of the following

(a) -16 (b) 1/16 (c) 4^2 (d) 16

47. If $x = (1/4)^{-2}$, then the value of x is

(a) 16 (b) 8 (c) 4 (d) 1/8

48. $8^{3/5} \times 4^{3/5}$ is equal to

(a) 8 (b) 16 (c) 24 (d) 32

49. Which one of the following is true?

(a) $2^{-3}>2^{-2}$ (b) $2^3<2^2$ (c) $2^{\circ}=1^{-3}$ (d) $(1/2)^2<(1/2)^3$

50. If $16^x = 8$, then the value of x is

(a) 0 (b) 0.25 (c) 0.75 (d) 1

Appendix E

MATHEMATICS TEST ADMINISTERED TO GRADE ELEVEN STUDENTS

NAME ________________ SECTION ___________ ROLL NO.________

SEX __________________ STREAM ____________________

DIRECTION: THE TEST BOOKLET CONTAINS 50 MULTIPLE-CHOICE ITEMS. EACH ITEM IS FOLLOWED BY FOUR POSSIBLE ANSWERS. THERE IS ONLY ONE BEST ANSWER FOR EACH ITEM. CHOOSE THE BEST ANSWER AND BLACKEN THE CIRCLE CORRESPONDING YOUR CHOICE ON THE ANSWER SHEET.

1. Of the following, identify the angle with the smallest degree measure.
   (a) acute angle (b) obtuse angle
   (c) right angle (d) straight angle
2. If the circumference of a circle is 25π cm., find its radius.
   (a) 50 cm. (b) 15 cm. (c) 12.5 cm. (d) 5 cm
3. One leg of a right-angled traingle is 6 units long. The hypotenuse is 10 units long. Find the area of the traiangle.
   (a) 6 sq.u. (b) 12 sq.u (c) 24 sq.u (d) 36 sq.u
4. Identify the pair that represents a regular traingle and a regular quadrilateral.
   (a) Isosceles traingle; square
   (b) Isosceles triangle, rectangle
   (c) Equilateral triangle; rectangle
   (d) Equilateral triangle; square
5. Identify the different one among the four figures.
   (a) Trapezium (b) square (c) Rhombus (d) Rectangle

6. If the measure of the angles of a quadrilateral are (1/2)x, (1/2)x+10, x, and x + 20 in degree, then x is

(a) 90° (b) 100° (c) 110° (d) 120°

7. A parallelogram and a triangle have equal bases. The heights corresponding to these bases are equal. What is the ratio of the area of the parallogram to the area of the triangle?

(a) 1 (b) 2 (c) 4 (d) 5

8. The base of a parallelogram is 12 cm. The corresponding height is 9cm. A traiangle has the same base and area. Find its height.

(a) 18 cm. (b) 14 cm. (c) 12 cm. (d) 10 cm.

9. If $\triangle$ABC is an isosceles right traingle inscribed in a circle of unit radius, then the area of the traiangle is

(a) 1 sq.u. (b) $\sqrt{2}$ sq.u (c) 1.5 sq.u (d) 2 sq.u.

10. The length of the hypotenuse of the triangle (of question 9) is

(a) 4 units (b) 3 units (c) 2 units (d) 1 unit

11. If f and g are polynomials defined as f(x) = 2 and g(x) = x, then which one of the following is NOT a polynomial?

(a) f/g (b) g/f (c) fxg (d) f-g

12. Which of the following is a factor of f(x) = x^3-1?

(a) x-1 (b) x+1 (c) x+2 (d) x-2

13. Which one of the following is NECESSARILY TRUE?

(a) If x>0, then $2^x>3^x$ (b) If x<0, then $2^x>3^x$

(c) If 0<x<1, then $2x>3^x$ (d) If x>1, then $2^x>3^x$

14. The area of $\triangle$ABC is 40 sq.cm and AB=16cm. Find AC if the degree measure of the angle at A is 30 (sin 30°=0.5).

(a) 5 cm (b) 10 cm. (c) 15 cm. (d) 18 cm.

15. Identify the pair that gives measure of the same angle.

(a) 90°; (2/3)π (b) (1/3)π ;80°

(c) (1/4)π; 45° (d) (4/3)π;210°

16. Consider the following two statements and determine their respective truth values.

I. Congruent circles have the same radius

II. Two circles with the same radius are congruent

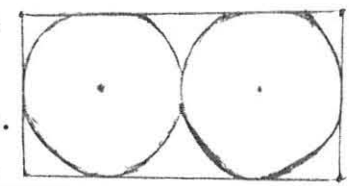
(a) True;False (b) True;True

(c) False;True (d) False;False

17. If R is expressed as the set of all ordered pairs of (y,x) where y=x-3, which one of the following ordered pairs belongs to R?

(a) (0,-3) (b) (1,-2) (c) (2,5) (d) (3,0)

18. The rectangle to the right contains two circles tangent to each other and each tangent to three sides of the rectangle. Which of the following pairs of numbers CANNOT be the length and width, respectively of the rectangle?



(a) 12,6 (b) 2,1 (c) 16,10 (d) 22,11

19. If $f(x,y) = (2x^2+5xy-3y^2)/[y^2+(9/2)xy-(5/2)x^2]$, find $f(1,-1)$.

(a) 1 (b) 2 (d) 6 (d) -6

20. A polygon is said to be circumscribed about a circle if

(a) the vertices are on the circle

(b) the polygon is in the circle

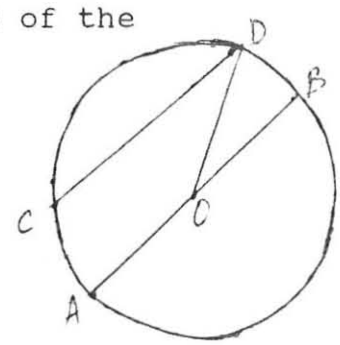
(c) the sides are tangent to the circle

(d) the polygon is regular

21. For $x \neq -6,0$ if $3x/(3x+18) \times (x^2-36)/x$ is simplified, we get

(a) 6-x (b) 1 (c) x-6 (d) x-36

22. In the circle with center 0, segments AB and CD are parallel and $m(\hat{AOD}) = 120°$. Which one of the following is NOT NECESSARILY TRUE?



(a) Quadrilateral ACDB is a trapezium

(b) AC=BD

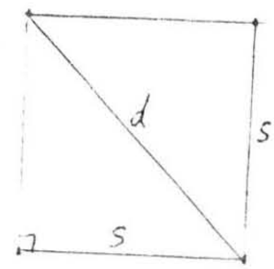
(c) Area of ACDB is three times the area of $\triangle$ODB.

(d) Quadrilateral ACDO is square

23. Find the circumference of a circle whose area is 25π sq.cm.

(a) 12.5π cm. (b) 10π cm. (c) 7.5π cm. (d) 5π cm.

24. The following figure is a square with sides s units long.



The diagonal of the square is d.
Write the area of the square in terms of d.

(a) $a=4d^2$ (b) $a=2d^2$

(c) $a=(1/2)d^2$ (d) $a = d^2$

25. The perimeter of the isosceles right traingle (in the figure of the square above) when written in terms of s is (a) $p=(2+\sqrt{2})$ S (b) p=3s (c) p=2.5s (d) p=2s

26. Find the area of a circle whose circumference is 6π cm.

(a) 9π sq.cm. (b) 18π sq.cm. (c) 24π sq.cm. (d) 36π sq.cm.

27. If f is a function expressed in terms of h and g, where $h(x) = 4x^2$, and $g(x) = 3-2x^2$, then

(a) $f = g+h = 2x^2-3$ (b) $f = g-h = 2x^2+3$

(c) $f = g/h = 3/(4x^2)$ (where $x\neq0$) (d) $f=h/g=4x^2/(3-2x^2)$, $2x^2\neq3$

28. The area of the figure whose vertices have coordinates (3,2), (8.5), (8,11), and (3,14) is

(a) 45 sq.u. (b) 50 sq.u (c) 60 sq.u. (d) 90 sq.u

29. If s is the length of side of a regular polygon and r is radius and d is diameter of a circle, which one of the following pairs of formulas gives circumference of a circle and perimeter of a regural polygon with n sides, respectively?

(a) 2ns; $2\pi r$ (b) πd;ns (c) πd;2ns (d) $2\pi d$;ns

30. What will be the remainder if $3x^3+2x^2+x+1$ is divided by x-2?

(a) 35 (b) 33 (c) -34 (d) -36

31. Which one of the following is <u>NOT TRUE</u> in Euclidean geometry?

(a) Any two distinct points determine one and only one line.

(b) Through a point not on a line, there are more than one line parallel to the given line.

(c) The line segment joining any two points is shorter than any other path joining the two points.

(d) There cannot be two right angles in a traingle.

32. Let $h(x)=4x^2$ and $g(x) = 3-2x^2$. If f = gxh, find f for $x=1/2$.

(a) 5/2 (b) 7/3 (c) 3/2 (d) 1

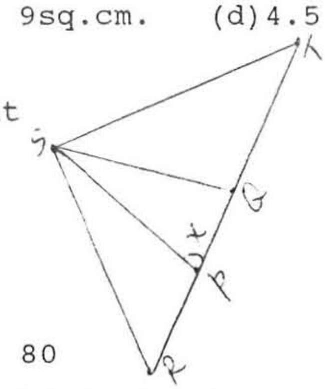
33. The simplified form of $\frac{1/x-1/y}{1/x+1/y}$ is

(a) $\frac{y^2-x^2}{(xy)^2}$ (b) $\frac{y-x}{y+x}$ (c) 1 (d) $\frac{y+x}{y-x}$

34. The hypotenuse of an isosceles right-angled triangle is 6 cm. long. Find its area.

(a) 18sq.cm. (b) 13.5sq.cm. (c) 9sq.cm. (d)4.5 sq.cm.

35. In the figure triangle RST is a right angled triangle. RS=ST and right angle RST has been divided into 3 equal angles. What is the value of x?



(a) 65 (b) 70 (c) 75 (d) 80

36. Which one of the following represents a one-to-one function?

(a) $f = \{(x,y) : y=x^2, x\leq 0\}$

(b) $f = \{(x,y) : y=x^2+x+5\}$

(c) $f = \{(x,y) : y=x^2, xER\}$

(d) $f = \{(x,y) : y=x^2-1\}$

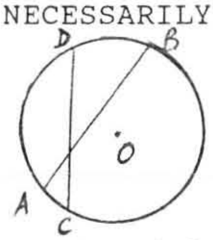
37. The area of a square with each side S units long and the area of an equilateral triangle with the same length of side as the square are, respectively given by the formulas

(a) $s^2, (1/2)s^2$ (b) $s^2, (\sqrt{3}/4)s^2$

(c) $2s^2, (\sqrt{3}/4)s^2$ (d) $s^2, \sqrt{3}\ S^2$

QUESTIONS 38,39, & 40 REFER TO THE FIGURE BELOW

38. Which one of the following is NOT NECESSARILY TRUE?



(a) (AP) (PB) = (CP) (PD)

(b) DB/AC = BP/AP

(c) $P\hat{D}B \equiv P\hat{A}C$

(d) $A\hat{C}P \equiv D\hat{B}P$

39. In the circle, let DB be an arc of 70° and let AC be an arc of 34°. What is the degree measure of $A\hat{P}C$?

(a) 60° (b) 55° (c) 52° (d) 45°

40. In the above circle, DB is an arc of 45° and AC is an arc of 33°. What is the degree measure of $A\hat{P}D$?

(a) 145° (b) 141° (c) 102° (d) 39°

41. Suppose that two angles of one triangle are congruent to two corresponding angles of another traingle. Which one of the following is NOT NECESSARILY TRUE about the triangles?

(a) The remaining corresponding angles are also congruent.

(b) The two triangles are similar.

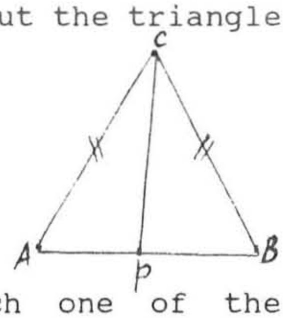
(c) Corresponding sides of the two triangles are proportional.

(d) The two traingles are congruent.

42. Find the truth set of the equation 3/(3x+27)+2/(2x+18)=4/(36+4x)

(a) {9} (b) {1} (c) {-9} (d) ∅

43. Which of the following is <u>NOT TRUE</u> about the triangle below?



(a) If $m(A\hat{C}P) = m(A\hat{P}C)$, then AP = BC.

(b) If $m(A\hat{C}P) = m(B\hat{C}P)$, then AP<PB.

(c) If AP = BP, then $\overline{CP} \perp \overline{AB}$.

(d) If AP<PB, then $m(A\hat{P}C) > m(M\hat{P}C)$.

44. If R={(x,y): y<-x and y>x+2}, which one of the following ordered pairs belongs to R?

(a) (-1,1) (b) (0,-3) (c) (1,3) (d) (-5,0)

45. If $P\hat{O}Q$ is a central angle of 60° in a circle with center O, the measure of the major arc QP is ________.

(a) 60° (b) 120° (c) 250° (d) 300°

46. R={(x,y)/y =(1/2)x+2}. Which one of the following is <u>NOT</u> the inverse of R?

(a) R^{-1} = {(x,y)/y=2x-4} (b) R^{-1}={(x,y)/x=(1/2)y+2}

(c) R^{-1}= {(y,x)/y = (1/2)x+2} (d) R^{-1} = {(x,y)/x = 2y-4}

47. Which one of the following is <u>NOT</u> a function?

(a) R = {(x,y)/y=x} (b) R={(x,y)/y=$\sqrt{x}$;x>0}

(c) R = {(x,y)/y=x^2} (d) R={(x,y)/x=3}

48. If R is the set of ordered pairs (x,y) where x=y^2, what is the domain of R?

(a) The set of all real numers

(b) The set of negative integers

(c) The set of nonnegative real numbers

(d) The set of positive integers

49. What is the truth set of (x-2)/x<4?

(a) {x/x<-2/3 or x>0} (b) {x/x<-2/3 and x<0}

(c) {x/x>2/3 or x<0} (d) {x/x>-2/3 or x<0}

50. If triangles ABC and DEF are similar and if areas of the triangles are 27 and 36 square units, respectively, then the ratio of the perimeter of triangle ABC to that of triangle DEF is

(a) 1/4 (b) 1/2 (c) 3/4 (d)$\sqrt{3}/2$

Appendix F

SCALE USED TO MEASURE ATTITUDE TOWARD MATHEMATICS

ADDIS ABABA UNIVERSITY
DEPARTMENT OF EDUCATIONAL PSYCHOLOGY
GRADUATE PROGRAM

Attitude Scale (to be rated by students)

The objective of this scale is to examine attitudes of students toward mathematics in grades 8 through 11. Since the success of the study highly depends on your honesty in rating the scale, you are kindly requested to respond accordingly.

Thank you.

NAME ____________________ GRADE _________ NO. ___________
AGE _______________ SEX ___________ STREAM _______________

INSTRUCTION: Each of the statements in this scale expresses a feeling or attitude toward mathematics. You are to indicate, on a five-point scale, the extent of agreement between the attitude expressed in each statement and your own personal feeling. The five points are: Strongly disagree (SD), disagree (D), undecided (U), agree (A), and strongly agree (SA). Mark (✓) the point which best indicates how closely you agree or disagree with the attitude expressed in each statement as it concerns you.

No.	Attitude	SD	D	U	A	SA
1	I am always under a terrible strain in a mathematics class.					
2	I do not like mathematics; and it scares me to have to take it.					
3	I am not motivated to work very hard on mathematics problems.					
4	I detest mathematics and avoid using it at all times.					
5	I don't get upset when trying to work mathematics problems.					
6	Sometimes I enjoy the challenge presented by a math problem.					
7	Mathematics is fascinating and fun.					
8	Mathematics makes me feel secure, and at the same time					
	it is stimulating.					
9	My mind goes blank and I am unable to think clearly when					
	working mathematics.					
10	I avoid mathematics because I am not very good with figure.					
11	I am very calm and unafraid when studying mathematics.					
12	I feel a sense of insecurity when attempting mathematics.					
13	Mathematics makes me feel as though I am lost in a jungle of					
	numbers and can't find my way out.					
14	I have seldom liked studying mathematics.					
15	I like mathematics because it is practical.					
16	I approach mathematics with a feeling of hesitation,					
	resulting from a fear of not being able to do mathematics.					
17	I never get tired of working with numbers.					
18	Mathematics is a course in school that I have always enjoyed studying					
19	It makes me nervous to even think about having to do					
	a mathematics problem.					
20	I think about mathematics problems outside school and					
	like to work them out.					
21	I like trying to solve new problems in mathematics.					
22	I feel at ease in mathematics, and I like it very much.					
23	Trying to understand mathematics doesn't make me anxious.					
24	Mathematics is dull and boring.					

Appendix G

QUESTIONNAIRE FOR COLLECTING BACKGROUND INFORMATION

ADDIS ABABA UNIVERSITY
DEPARTMENT OF EDUCATIONAL PSYCHOLOGY
GRADUATE PROGRAM

Questionnaire (to be completed by students)

The objective of this questionnaire is to collect some background information on attitudes of students in grades 8 through 11. Since the success of the study highly depends on your honesty, you are kindly requested to respond in as much honest way as possible.

Thank you.

NAME ____________________ GRADE _________ NO. _____________
AGE _________________ SEX _______________ STREAM __________

INSTRUCTION: For each of questions 1-17, write brief and clear answers on the space provided. For questions 18 and 19, choose one of the four alternatives which you think is right and encircle the letter of your choice.

1. From the school subjects you are learning (or studying) now, write the one you like best.

   ____

2. Why did you like the subject?

   1. _________________________ 2. _________________________
   3. _________________________ 4. _________________________

3. When did you begin to like the subject? Write a specific grade.

____

4. What is the school subject you dislike most?

____

5. Why did you dislike the subject?

1. ____________________ 2. ____________________

3. ____________________ 4. ____________________

6. When did you begin to dislike the subject? Write a specific grade.

____

7. Write the subject which you think is most useful for future career.

____

8. Write the subject in which you think boys do better than girls.

____

9. Write the subject in which you think girls do better than boys.

____

10. Write the subject in which you think boys and girls often do equally.

____

11. Write the subject the following people advise you to study hard on the space provided (for each).

(a) Father __________ (b) Mother __________

(c) Teacher __________ (d) Peers __________

12. Write the subject which you think is most boring.

____

13. Write the subject which you want to study most often.

____

14. Write briefly your first painful experience, if any, with mathematics.

____

15. Specify the grade in which you had this painful experience.

____

16. Write briefly your first delightful experience, if any, with mathematics.

____

17. Specify the grade in which you had this delightful expericence.

____

18. Mathematics teachers expect good mathematics results
    (a) from boys (b) from girls
    (c) from both equally (d) from neither of them
19. Parents expect good mathematics results
    (a) from daughters (b) from sons
    (c) from both equally (d) from neither of them

Appendix H

DISTRIBUTION OF MATHEMATICS SCORES AND ATTITUDE SCORES BY GRADE AND SEX

GRADE EIGHT

FEMALE								MALE							
Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X
36	104	38	110	46	109	60	83	72	114	58	105	58	99	58	90
42	103	38	109	36	109	30	75	38	107	66	103	70	99	46	89
56	101	64	109	58	109	32	74	62	104	74	102	36	99	68	86
32	100	56	109	56	109	34	68	32	101	42	100	40	99	52	85
24	100	32	105	66	108	28	67	68	97	54	100	50	98	24	83
38	99	30	103	36	100	28	56	40	93	46	100	48	98	64	81
28	91	48	102	40	99	52	109	52	88	66	99	68	97	34	80
32	90	44	100	54	97	40	109	32	85	64	98	76	96	76	76
22	89	40	97	24	97	42	103	22	84	70	97	34	93	32	75
22	88	26	96	36	94	42	98	46	84	76	96	40	86	40	75
28	86	26	95	52	91			36	83	62	92	80	82	34	74
34	83	34	94	22	91			54	82	44	92	32	75	42	69
30	74	30	90	76	90			36	79	40	90	36	68	34	69
34	73	34	90	40	89			44	79	28	89	44	57	70	66
26	70	30	90	54	85			46	73	46	87	28	49	60	66
20	69	30	89	28	82			48	71	46	86	78	120	38	59
32	66	46	88	32	76			38	70	62	86	66	116	62	112
24	64	28	86	38	76			24	63	62	81	70	116	76	111
52	60	42	83	66	72			32	61	40	79	66	112	56	101
32	57	26	82	40	71			32	52	28	67	32	111	64	86
20	57	40	81	66	113			38	51	82	114	74	109		
24	56	28	80	68	109			76	118	62	114	62	107		
44	120	36	71	38	107			64	116	74	114	54	106		
50	120	24	69	46	100			56	114	74	111	60	105		
48	120	56	120	36	94			54	113	74	110	78	101		
52	120	50	120	32	92			64	109	74	109	52	100		
38	117	90	116	58	90			36	109	92	106	62	97		
30	112	46	115	50	88			70	109	60	104	38	96		
44	111	64	113	40	88			62	107	68	103	56	94		
40	110	74	113	48	88			82	107	56	101	38	94		

N.B.: Y is achievement score and x is attitude score. The maximum possible scores are 100 and 120, respectively.

GRADE NINE

FEMALE						MALE									
Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X
62	118	58	111	44	85	92	120	50	113	58	95	38			
48	115	86	110	60	83	78	114	68	111	84	95	44	110	44	105
40	112	56	108	48	117	60	112	70	98	62	94	58	109	60	105
50	112	56	106	42	108	84	111	34	98	34	92	50	109	58	103
48	112	60	104	48	104	62	111	60	95	68	92	36	108	66	101
64	109	42	103	36	99	56	110	52	95	60	92	64	106	54	100
54	105	50	101	52	95	76	110	40	80	48	92	60	105	54	99
56	102	46	94	30	92	52	110	46	66	76	90	50	104	50	97
42	86	50	85	58	90	56	109	34	62	62	89	56	103	52	97
40	85	26	85	48	86	52	109	58	37	58	89	62	102	66	96
38	82	34	84	46	86	72	103	92	120	64	87	50	101	58	96
26	82	66	80	42	78	64	99	90	120	38	86	36	100	60	89
32	79	26	79	32	75	58	99	34	117	44	82	34	100	64	87
42	77	52	72	54	61	52	97	76	115	36	82	46	97	54	86
68	73	40	69			56	93	42	113	46	74	46	96	48	86
46	72	42	65			40	91	22	112	42	120	64	95	58	86
38	70	26	62			22	89	64	110	52	120	42	92	54	83
40	70	52	52			62	85	56	109	52	118	70	92		
30	68	46	115			70	83	62	109	68	118	58	92		
28	46	64	113			44	83	72	108	54	118	60	74		
62	120	50	112			60	81	66	106	58	117	50	113		
52	114	42	104			30	81	98	104	64	116	44	113		
40	110	48	102			52	79	68	104	76	116	62	112		
34	98	66	101			36	78	56	104	30	115	62	111		
46	97	40	101			28	75	60	103	78	112	66	110		
46	93	34	10			26	72	78	102	76	111	58	109		
34	89	36	100			42	71	64	101	40	111	62	107		
46	60	48	99			30	71	72	100	40	111	56	107		
92	120	44	98			66	65	42	100	48	110	74	106		
46	118	60	97			58	114	80	98	46	110				

GRADE TEN

FEMALE						MALE									
Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X
40	119	24	69	28	89	58	120	68	111	62	105	34	111	24	92
40	116	78	112	44	89	62	120	44	110	94	104	44	111	62	89
58	110	36	108	28	83	50	118	44	107	48	102	64	109	22	88
44	107	62	107	32	80	56	116	36	102	90	100	64	109	44	86
40	102	70	106	32	69	66	115	86	102	72	100	30	107	42	79
60	98	70	105	78	113	66	114	76	99	80	98	60	105	24	73
34	93	82	105	72	111	86	112	54	94	80	98	40	103	52	68
38	92	88	104	44	106	58	109	44	94	72	97	42	100	36	67
34	92	58	104	48	105	74	108	62	84	70	97	56	98	34	67
62	85	84	98	74	98	38	105	52	77	30	97	74	97	40	57
50	82	80	93	36	96	80	105	58	119	38	96	62	95	30	56
26	81	24	92	36	96	46	101	62	116	68	95	30	94		
30	76	30	87	32	89	32	99	76	116	50	94	38	93		
32	72	54	75	46	89	70	97	40	115	74	93	30	87		
22	71	40	117	34	86	46	96	78	115	46	86	28	86		
32	69	66	110	30	82	70	96	70	114	78	85	32	82		
44	68	32	109	34	81	58	94	56	114	62	84	44	73		
20	57	52	109	54	75	34	88	94	114	26	66	22	69		
38	55	52	108	52	74	46	83	96	113	18	64	66	120		
34	52	24	108	22	69	40	81	84	113	48	56	42	116		
66	111	14	105	62	69	30	77	96	112	52	120	86	115		
32	103	20	105	28	66	36	72	99	112	82	120	70	115		
22	81	58	105	44	63	58	71	60	111	72	118	56	113		
34	79	40	104	54	62	32	69	82	110	52	116	76	112		
34	76	30	99	44	61	36	64	58	110	44	114	72	111		
44	74	40	98	48	51	38	63	70	110	78	113	88	110		
44	71	36	98			32	61	52	109	40	113	92	99		
38	71	42	97			56	53	66	108	32	112	58	98		
22	71	36	96			30	52	62	105	52	112	56	94		
26	70	22	90			74	112	78	105	40	111	68	93		

GRADE ELEVEN

FEMALE						MALE									
Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X
48	104	66	99	26	71	52	116	74	52	44	97	34	96	48	102
68	104	72	95	22	70	64	116	40	120	34	97	30	93	58	100
26	101	58	91	44	114	82	116	74	118	86	95	28	93	64	100
50	98	30	89	70	113	40	115	26	116	62	91	26	86	28	99
66	95	26	85	62	109	74	112	70	112	50	89	24	85	46	99
38	94	36	81	20	93	60	112	98	109	44	88	24	81	56	97
60	93	26	81	34	91	60	111	74	108	58	87	36	80	42	96
40	92	42	76	42	83	40	109	22	104	62	85	28	78	86	94
64	90	24	72	54	72	56	108	66	102	16	83	36	78	30	94
60	90	42	69	48	69	68	106	74	94	68	81	26	76	40	90
30	88	26	67	52	50	74	104	26	92	18	74	24	75	52	89
70	81	44	65	62	37	70	103	78	85	46	72	30	74	44	87
56	73	32	50			42	103	34	79	38	66	28	73	70	86
68	54	26	49			60	103	62	77	36	64	20	72	50	84
58	54	44	111			26	101	44	76	22	120	30	60	34	81
28	52	34	107			62	101	62	75	66	116	66	114	70	74
50	50	52	105			44	97	72	119	28	114	28	114	34	61
60	118	34	101			54	96	36	119	74	110	68	112	68	43
50	115	34	97			74	90	42	118	34	109	48	112		
10	103	40	90			52	90	60	118	68	107	62	110		
68	103	38	88			74	88	70	116	46	106	64	109		
26	94	28	87			46	88	90	114	24	104	98	109		
22	84	22	83			36	87	68	109	28	103	46	106		
28	77	38	82			40	86	74	107	36	103	54	105		
28	113	30	80			44	85	44	107	54	103	64	105		
36	107	26	78			60	79	56	105	28	100	46	104		
66	105	36	77			60	79	36	103	74	99	58	103		
50	101	18	76			52	78	28	103	24	99	74	103		
32	101	20	73			38	72	66	99	52	98	48	103		
28	99	36	72			68	66	46	99	28	97	58	102		

Appendix I

RESULTS OF THE ONE-WAY ANCOVAS AND THE CORRESPONDING ANOVAS

ANCOVA Summary Table

Grade	Source	SS	df	MS	F
8	Sex	9362.22	1	9362.22	56.05**
	Error	34577.92	207	167.04	
9	Sex	2240.09	1	2240.09	12.56**
	Error	36906.44	207	178.29	
10	Sex	3730.93	1	3730.93	13.55**
	Error	58916.84	214	275.31	
11	Sex	1977.33	1	1977.33	6.47*
	Error	63214.31	207	305.38	

ANOVA Summary Table

Grade	Source	SS	df	MS	F
8	Sex	9009.07	1	9009.07	38.97**
	Error	48085.71	208	231.18	
9	Sex	3804.05	1	3804.05	19.12**
	Error	41384.06	208	198.96	
10	Sex	8523.23	1	8523.23	24.69**
	Error	74228.75	215	345.25	
11	Sex	3625.50	1	3625.50	11.49**
	Error	65635.62	208	315.56	

** P<.001

* P<.05

Appendix J

REDUCTION IN THE MAGNITUDE OF GENDER DIFFERENCE DUE TO THE COVARIATE

Grade	Mathematics Mean Scores (Unadjusted)			Mathematics Mean Scores Adjusted for Attitude Scores			Reduction in the gender difference (%)
	Male	Fem.	Dif.	Male	Fem.	Dif.	
8	53.65	40.54	13.11	54.27	40.95	13.32	-1.6
9	55.88	46.97	8.91	53.97	47.47	6.50	27.0
10	56.07	43.26	12.81	54.73	45.05	9.68	24.4
11	50.42	41.67	8.75	49.81	44.73	5.08	41.9
Overall	53.99	42.92	11.07	52.87	44.04	8.83	20.2

D E C L A R A T I O N

I hereby declare that this thesis is my original work done under the guidance of Dr. Darge Wole. All relevant sources used for the thesis are duly acknowledged.

Seleshi Zeleke