GENDER DIFFERENCE IN MATHEMATICS ACHIEVEMENT AS A FUNCTION OF MATH SELF-EFFICACY AND SPATIAL VISUALISATION AMONG GUJI ZONE NINTH GRADE STUDENTS

BY

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Abstract

The major purposes of this study were to examine gender difference in mathematics achievement as a function of math self-efficacy and spatial visualization and the effects of the latter two (predictor) variables on math performance.

A math achievement test, a math self-efficacy scale, and a spatial visualization test were administered to a random sample of 196 female and 198 male ninth grade students from four high schools of Gujji Administrative Zone. Then the data were analyzed using t-test, correlation analysis, and Analysis of Covariance (ANCOVA).

Analysis of the mean differences disclosed statistically significant gender differences (at .01 level) in favor of males in all the variables (math self-efficacy, spatial ability, and math achievement). The results of the correlation analysis unraveled that math self-efficacy had significantly stronger relationship to math achievement than that of spatial visualization. According to the stepwise multiple regression, as depicted by coefficients of multiple determination (R squared), the predictor variables had significant joint effect on the criterion variable. Of this total effect, much of the variance in performance was accounted for by gender followed by math self-efficacy. On the other hand, the results of the analysis of covariance showed that after statistically controlling the effects of math self-efficacy and spatial visualization, gender difference in math achievement was still significant. However the overall effect of gender, prior to controlling the two covariates, was significantly reduced.

It was concluded that these differential math achievements between boys and girls were not only due to differences in their self-efficacy and spatial abilities but also due to other potential factors accounting for differences in mathematics learning of male and female students.

Paying attention to gender difference in math achievement and to the factors (cognitive and non-cognitive), that could potentially affect students' mathematics learning, in the teaching learning process; understanding students' self-confidence in mathematical capability and taking remedial measures for extremely high or low self-efficacy beliefs; and improving the students spatial visualizations through educational interventions are among the practical implications of the present study.

CHAPTER ONE

INTRODUCTION

1.1. BACKGROUND OF THE STUDY

Students' academic achievement is not merely a matter of what happens in school. Even though schools can and do make significant differences, research has identified a number of factors which affect student success in schools. Among those factors, gender difference is the most important one.

Interests in studying the fundamental gender differences in intellectual ability and personality began as early as 1960. However, gender difference in mathematics achievement has been widely investigated in psychological research since the mid 1960s (Jacklin, 1989). The field of mathematics, particularly, has been the focus of research since it is an area in which a sizable amount of literature and controversy exist concerning gender related differences in mathematics performances.

Mathematics learning is important in many professional fields such as engineering and technology-oriented areas, especially, in this technologically advancing and dynamic world. Emphasizing the importance of mathematics education, for present and future careers, Burton and Mills, Ablard, and Stumpf, (cited in Seleshi, 1995), raised two major reasons for the importance of mathematics – its strong relationship to academic or career opportunities and to the scientific, industrial, technological, as well as social progress of a society.

In spite of the aforementioned importance, mathematics has been a difficult subject area for most people. Both sexes, mainly females, do not seem to have much interest and high level of proficiency in mathematics. Since most girls do not like to take science and science-oriented courses, either at high school or college, their number in technical and science classes is marginal (Atsede, 1991). Very few women join professional fields that demand science and science-related courses. In most cases it is very unlikely for young girls to have the opportunity or encouragement to pursue their studies in the fields of science and technology (Atsede, 1991)

Such a few enrollment and participation of female students in the more advanced level of mathematics classes, particularly in colleges, could be considered as a good indicator of gender difference in mathematics performance. On top of that, gender difference in mathematics ability also influences the male-female wage differences through gender related differences in occupations (Penner, 2003). Since advanced mathematics is often viewed as a "gateway" to high-paying careers, females' lower achievement in this subject can lock them out of careers in science, engineering, medicine, and data processing.

These days people who are highly trained and capable of performing in the highly technical workplaces are very much required. Although males in science-related careers far outnumber the females, there is still a real shortage of both males and females in the sciences today. For this reason, mathematics learning and achievement has been the focus of research over the last several decades. A large body of research has been carried out on investigating gender differences in science achievement and several potential factors that are considered to be causal variables in elementary, junior, and tertiary levels.

In Ethiopia female students as compared to male students show lower school performances in general (Genet, 1991) and score lower on Mathematics (Eshete, 2001) and Physics tests (Yalew, 1997) in particular. They also performed less satisfactorily than boys in the Ethiopian School Leaving Certificate Examinations (ESLCE) (Genet, 1991).

Several research findings identified a variety of cognitive and non-cognitive factors as potential causes for such differences in mathematics achievement between boys and girls. In the present study math self-efficacy and spatial visualization of male and female students were treated as major factors for differential math performances.

Naturally, people have differing level of capabilities in different activities. As can be observed in schools, even average students are sometimes found to perform poorly in specific subject areas while performing up to the standard in others. This phenomenon is often reflected in the domain of mathematics. According to the study by Schunk (1989) when capable learners do not perform up to their potentials in spite of positive environmental conditions, it might be very important to pay more attention to the self-regulatory processes within individuals that promote or inhibit performance. Among the self-regulatory processes self-efficacy holds significant power for predicting and explaining academic performances in various domains (Zimmerman, Bandura, & Martinez-Pons, 1992).

From the cognitive factors, spatial visualization has been considered as potential sex-linked cognitive factor that may have substantial influence on mathematics performance. It has also been argued that girls' marked decline in mathematics achievement at adolescence is usually linked to deficiencies in spatial visualization. For instance, female students were found to perform relatively poorer than male students in geometry and measurement because females perform at lower levels than males on items that measure spatial visualization skills (Badger, 1981). This seems to clearly demonstrate the relationship between spatial visualization and mathematics achievement.

Several studies have been carried out on sex-related difference in spatial visualization and its impact on mathematics achievement. However, some found no significant gender difference in spatial skills and no clear relationship between such skills and mathematics performance. While others revealed that mathematical ability and spatial visualization are highly correlated for girls than for boys, especially for samples of high ability students (Friedman, 1995; Sherman, 1979; and Sherman, 1980).

Therefore, studying gender differences in mathematics achievement as a function of male-female differences in math self-efficacy and spatial visualization and their effects on mathematics achievement especially at the high school level may help to improve female students' participation in many male-dominated subjects and masculine-oriented careers and occupations.

1.2 RELATED RESEARCH EVIDENCES TO THE PROBLEM

1.2.1 Gender Difference in Mathematics Achievement

Gender difference in cognitive ability in general and mathematics ability in particular has been a subject of research for years. However, despite all the works that have been done, researchers have reached consensus on only very few issues.

The better performance of boys, on average, than girls on tests of mathematical ability is a widely accepted issue (Halpern, 1992; Halpern, 1996; Hyde, Fennema and Lammon, 1990; Maccoby and Jacklin, 1974; Stumt, 1995;as all cited in Nowell and Hedges, 1998). According to the results of several studies, in lower levels of learning (i.e. in primary schools) girls and boys do not have a significant difference in mathematics performance except some differences in the strategies male and female students use to solve mathematical problems (Carr and Jessup, 1997; Doolittle and Cleary, 1987; Marshall and Smith, 1987). However, dramatic differences between the two sexes were reported by the time they became teenagers. Around the age of adolescence, girls are likely to decline in their mathematical competence (Badger, 1981). Some studies (e.g. Fennema et al, 1980), as cited in Badger (1981), further confirmed that girls during early teens perform relatively better than boys in computations, whereas boys in application of numbers.

At elementary school levels, male and female students seem to earn equivalent scores, especially at the lower grades. For instance, the analyses of the test scores of 286,767 boys and girls who were tested on two types of mathematical problems (computations and story problems) revealed that boys were more successful than girls in solving story problems whereas girls outperform boys in solving computations (Marshall, 1984). Similarly, Marshall and Smith (1987) conducted a longitudinal study that contrasted boys' and girls' performances on mathematics tests given to third and sixth grades and arrived at similar conclusions. The strongest finding of their study, however, is that the better performances of girls relative to boys at third grade surprisingly declined by the time they were evaluated at sixth grade. Their performance on geometry had also fallen behind to a serious extent. These results clearly demonstrate the emergence of differential mathematics achievements with age. The finding was further supported by the study of Armstrong (1980) cited in Badger (1981) which states that as the age increases, boys tend to surpass girls in most mathematical competencies like probability, geometry, measurement, as well as statistics and surprisingly perform as equally as girls in computations.

In another global study by Beller and Gafni (1996), which was conducted on nine and thirteen year olds from 20 countries of the world, the gender effect sizes were found to be small especially among nine year olds. Likewise, another cross-sectional study analyzed scores of male and female students on mathematical subtests and arrived at a conclusion that revealed little difference between males and females in overall mathematical achievement at age nine and thirteen (Fennema and Carpenter, 1981).

Contrary to the ongoing results, a similar investigation by Mills et al (1993) on tests of mathematical reasoning ability in grades two to six reported a somehow different result. Their finding disclosed that boys out performed girls overall indicating the appearance of gender difference in mathematical ability as early as second grade level. Another similar study conducted in Ethiopia (Habtamu, 1996), which examined gender difference in mathematics achievement and the influence of language on mathematical performance, also revealed a result that seems to support the findings of

Mills et al (1993). More boys than girls earned significantly higher scores in mathematics, particularly, in lower grades.

The aforementioned local study has used all the necessary research techniques and procedures. However, the results seem to be entirely inconsistent with most findings (e.g. Marshall, 1984; Marshall and Smith, 1987).

Unlike a few of the aforementioned findings, the extant literature established so far is the fact that girls and boys have similar mathematical achievements in the lower grades whereas they differ in their achievements in high school (Hyde, Fennema and Lamon, 1990). Boys tend to improve their scores relative to girls as they move to upper grades (Benbow, 1988; Maccoby and Jacklin, 1974; Willingham and Cole, 1997; cited in Nowell and Hedges, 1998).

In line with the above point, a comparative study conducted by Sherman (1980) examined the performances of girls and boys in grades 8 – 11. The result of the study showed that males and females displayed similar cognitive skills and attitudes in mathematics in grade eight. However, by grade eleven, boys performed significantly better than girls in mathematics.

Similarly, as investigated by Fennema and Carpenter (1981), at age seventeen females were found to achieve less well than males in mathematics. Moreover, even with equal enrollment of girls and boys in the same mathematics courses, males outperform females and such differences become more exaggerated with more complex tasks. The findings of Fennema and Carpenter further suggested that securing equal performances of girls with boys in mathematics is much more than ensuring that females enroll in mathematics courses as much as males do. That is to say, although encouraging girls to enroll in advanced courses of mathematics is an important first step; it is not a means to an end by itself.

Other investigations of gender differences in mathematics ability across grade levels also supported the above-mentioned finding. For instance, a longitudinal study conducted by Hilton and Bergland (1974) on 1,859 male and female students from grades 5,7, 9,and 11 revealed no significant difference in mathematics achievement at grade five whereas it reported a significant gender difference in favor of males at the subsequent grade levels (7,9,and 11).

On the other hand, in a study which included 11^{th} and 12^{th} grade students with mean age of 16.5 and used a cognitive process approach to explain gender difference on the SAT-Math subtest (Byrnes and Takahira, 1993), a more interesting finding was discovered. Although, male students performed better than female students on the SAT- items, the regression analyses revealed that 50% of the variance was explained by prior knowledge and strategies whereas no unique variance was explained by gender. Thus, their findings indicated that one's gender is not as important as one's prior knowledge and strategies.

Another source of male-female difference in their mathematics performance seems to be the use of different problem solving strategies and thought processes. Research has shown that girls and boys differ significantly in their problem solving strategies and thought processes as early as elementary school years. In this regard, Carr and Jessup (1997) found that girls in elementary schools preferred learning in a rote fashion and were better at manipulating and categorizing numbers. The boys, on the other hand, were better at problem solving which is characterized by the use of retrieval strategy with autonomous learning style that helped them use more complex strategies.

Similarly, Fennema et al (1998) found that males often used abstract strategies that displayed conceptual understanding and were more flexible in their strategies. In addition, boys were found to employ derived facts or invented algorithms. However, their study further revealed that the girls were more likely to engage in concrete methods like modeling or back up strategies of counting on counters and fingers to solve mathematical problems. According to Fennema et al, this was so because the girls who used algorithms may not have the same conceptual understanding and do not succeed in extension problems. Consequently, this lack of conceptual understanding, will hinder their understanding of later mathematics classes,

Regarding eventual changes and trends of gender differences in academic achievement including mathematical ability, Nowell and Hedges (1998) conducted trend and gender analyses on the academic achievement of in-school 12th grade students from 1960 to 1994. Their findings of gender analysis indicated that the mean gender differences were generally small though males' scores were higher than females' scores on tests of mathematics. The trend analysis, on the other hand, showed that gender difference in means had not changed significantly overtime.

In further support of the above findings, recent studies by Hyde, Fennema, & Lammon (1990) revealed that academic gender gaps in general and mathematics performance differences in particular have declined over time. In addition, citing the ideas of De Lisi & McGilliuddy-De Lisi (2002), and Willingham & Cole (1997), Gallagher et al (2002) confirmed that though performance variations seem to decrease eventually, the differences are not totally gone and boys continue to out score girls in advanced math classes, in the areas of mechanical reasoning, as well as on high-stake tests that are designed to measure mathematical reasoning and problem solving, such as the SAT I: Reasoning Test (Byrnes & Takahira, 1993) and the Graduate Record Examinations (GRE).

The above-mentioned findings of Hedges and Nowell may in turn indicate a decline in the effect of some of the factors that could contribute to the gender variation in math achievement. In line with this, some researchers like Godstein and Chance, (1965); Connor and Serfin, (1980) as cited in Badger (1981), argued that in situations where girls were given exposure to space related activities, they were found to improve their math performances to a greater degree and the gap of Performance between the sexes was also found to successfully diminish.

In the Ethiopian context, similar investigations, which have been undertaken at different times, revealed somehow consistent findings with those elsewhere. For instance a study, which examined differences in mathematics ability across grade levels in some selected schools revealed statistically significant differences (at .01 level) in mathematics achievements at eighth, ninth, tenth, and eleventh grades, in favor of males (Seleshi, 1995). Similarly other studies also disclosed males' excellence in mathematics (Eshete, 2001) and Physics (Yalew, 1997) achievements.

In general, the issue of male's superiority over girls in mathematics performance has been challenged due to the inconsistency of the results of the reviewed studies that showed males' excellence at one time and insignificant differences at another time. Nowadays, various scholars are showing greater concern in investigating even the real existence of gender difference in mathematics achievement as well as the possible factors that account for the differences.

1.2.2 The Role of Self-Efficacy in Mathematics Achievement

From the social-cognitive point of view, self-efficacy is an important factor that resides within the learner and mediates between cognition and affect, and results in changes in academic performance (Zimmerman, Bandura, & Martinez-Pons, 1992). Recent studies show that self-efficacy holds significant power in predicting and explaining academic performances in mathematics education (Hackett & Betz, 1989; Norwich, 1987; Randhawa, Beamer, & Lundberg, 1993). Individuals who have strong sense of academic self-efficacy are more likely to spend greater time and effort to accomplish certain tasks (Salmon, 1984; Schunk, 1983), persist somewhat longer (Schunk, 1982), and experience little anxiety under difficult circumstances (Meece, Winfield, and Eccles, 1990). Such students are better self-regulated (Zimmerman & Martinez Pons, 1990) and are more likely to employ effective learning styles and strategies (Pintrich & De Groot, 1990).

In the same token, Chemers, Hu, and Garcia (2001) cite that Bandura (1997) argued that efficacy beliefs significantly affect the specific courses of action a person chooses to pursue, the amount of effort that one expends, one's tolerance of challenges and failures, as well as one's ability to cop with every demand that may be associated with the chosen activity. This means, as Mone, Baker, & Jeffries (1995) asserted, higher capability and confidence levels lead to higher personal goals, task persistence, and task performance.

In one study, Pajares and Miller (1994) examined the hypothesized mediational role and predictive power of self-efficacy in mathematics problem solving. Using previously validated measures; the researchers ran several mathematics-related independent variables in relation to mathematical problem solving. Results showed that self-efficacy held greater predictive power for problem solving than did other variables such as mathematics self-concept, background in mathematics, perceived usefulness of mathematics, and gender. However, the effects of background and gender were significantly related to self-efficacy, which supports Bandura's assertion of the mediational role of self-efficacy on performance. Positive self-efficacy, in this regard, is related to a relatively high level of performance and individuals with positive perceived self-efficacy are less likely to give up tasks easily and rather look for every possible solution in order to persevere through challenging task assignments (Vrugt, 1994).

Other scholars examined self-efficacy in relation to similarity of tasks. Bong (1997), for instance, asserts that the generality of academic self-efficacy partly depends on the degree of perceived similarity among tasks. In her study when high school students were asked to rate their confidence toward eight pairs of isomorphic algebra and physics problems, they reported more comparable strength of self-efficacy, as they perceived greater similarity between the problems.

In further support of the above view points, other studies (e.g. Ames & Archer, 1988; Dweck & Elliott, 1983; Ecceles, 1983; Meece, Blumenfeld, & Hoyle, 1988; Nolen, 1988; Paris & Oka, 1986; as all cited in Pintrich & De Groot, 1990) asserted that students with a motivational orientation involving goals of mastery, challenge, and beliefs that the task is interesting and important will engage in more meta-cognitive activity, more cognitive strategy use, and more effective effort management. In explicit terms, students with high expectancies for success are more likely to achieve better on tasks. For instance, expectations about doing well in mathematics (confidence) relates closely to one's beliefs about personal capabilities for successfully performing domain-specific tasks (self-efficacy). However, although a high level of self-efficacy is closely related to a positive self-confidence (a belief in personal worth and likelihood of succeeding), a person can maintain high mathematics self-confidence in general, but low mathematics self-efficacy with regard to specific tasks of mathematics (Bandura, 1977).

To sum up, as could be inferred from the literature reviewed so far, mathematics self-efficacy may raise or reduce one's expectations for overall success in the domain, but it may not determine precisely one's capability for accurately solving particular mathematics problems. In addition, the interacting perceptual influences of confidence and gender stereotyping are influential sources of self-efficacy information, but not determinants of beliefs about capabilities with regard to specific tasks. Therefore, it is reasonable to critically examine the effect of self-efficacy on mathematics performance as well as gender difference in math self-efficacy with regard to task-specific performance objectives.

1.2.3 Gender Difference in Math Self-Efficacy

As far as non-cognitive factors are concerned, scholars argue that such factors have potential influences that facilitate or hinder cognitive developments (Mekonnen, 1987). In this regard, Sherman (1980) asserted that among the non-cognitive factors, self-efficacy perceptions are highly associated with students' academic motivation and achievement. Sherman further noted that self-confidence in learning mathematics is important not only because of its relationship to mathematical performances but, perhaps, even because of its role in deciding whether or not to take further mathematics courses.

Self-efficacy is presumed to be pervasively influential in affecting academic achievement of girls and boys. Torberg (1977), for instance, points to the assertion made by Maccoby & Jacklin (1974) that self-efficacy as compared to other variables is a prominent factor that could possibly bring about differences between female and male students in their academic performances over time.

Initially, elementary school male and female children usually have greater confidence in their academic capabilities, and this confidence extends equally across gender to both verbal and mathematical domains of learning. In later years, however, gender differences regarding mathematics begin to emerge. Fennema and Sherman (1978), examining 1,300 middle school children, found no significant differences with gender and mathematics learning, or with gender and motivation for learning. However, significant effects on mathematics confidence and on perceptions of mathematics as a male domain were found later on, with boys repeatedly averaging higher on both variables. When these results are compared to their previous research (Fennema and Sherman, 1977), using the same design but with high school students, the overall results indicate that the gender gap on mathematics confidence and perceptions begins to widen in middle school and increasingly widens in high school. Although these studies did not measure self-efficacy, by itself, the significant variables of confidence and gender stereotyping of a domain are contributing sources of self-efficacy information.

Accounting for the decline of girls' self confidence in doing science courses over time, Hackett & Betz (1989) stated that women are less likely than men to receive self-efficacy information about their skills in engineering, physical sciences, and mathematics and thus have lower self-efficacy beliefs in these fields.

A study conducted in our country (Eshete, 2001), has also supported the widely established fact that female students have lower math self-efficacy as compared to male students. In line with this, Vermeer, Boekarts, and Seegers (2002), cited in Hyde, Fennema, & Lamon (1990), asserted that girls have lower perception of competence in mathematics than boys. Moreover, they also have less confidence than males in mathematics ability, and many of them who had no previous success in mathematics feel to have lower math capability due to lack of ability and feeling of unsuccessfulness.

In addition to having low self-efficacy in mathematics female students are more likely to stereotype math as a male domain and are less likely to admit that they have mathematical capacity and they are not as likely as boys to attribute success to their own ability (Hackett, 1985). This is due to, as Brabender and Boardman (1977) argued, teacher's bias in providing equal amount of self-efficacy information to boys and girls through verbal persuasion and feedback. In relation to the above idea, Tiedman (2000) as cited in Eshete (2001), argues that male students have higher belief in their mathematical ability than female students even though they earn equivalent grades.

To sum up, as can be inferred from the aforementioned research findings, it may be quite reasonable to think that the gap in mathematics performances is not merely due to lack of ability to learn, but also due to lack of experience and confidence. For instance, as pointed out by Linn & Hyde, (1989), when female students are effectively encouraged to pursue their mathematical-based education and experience, the confidence gap was found to decrease to a greater extent.

1.2.4 The Role of Spatial Visualization in Mathematics Achievement

Spatial visualization encompasses such skills as being able to create mental image of an object and then manipulate it mentally, like, for instance, the ability to imagine how an odd shaped, flat piece of paper could be folded into a box. Such ability is believed to have significant and practical applications in the fields of mathematics, physics, architecture, engineering, and design (McGee, 1979).

Several studies have been conducted on the effect of spatial skill on mathematics performance. The majority of the studies on this particular issue concluded that spatial ability and visualization skill appear to be directly related to geometry and may also exert an indirect influence on another mathematical area like problem solving (Badger, 1981). This is due to, as Fennema (1977) and Wood (1976) explained in Pattison (1984), the logical connection between mathematics and spatial visualization since much of the contents of mathematics are spatial in nature.

Voyer (1996) pointing to the research review by Friedman (1995), Linn & Petersen (1986), and Tartre (1990), stated that the correlation observed in several studies between spatial and mathematical performance has led a number of researchers to hypothesize a link between gender difference in spatial and mathematical skills. However Robinson et al (1996) cited that Kerns & Berenbaum (1991), Maccoby & Jacklin (1974), Stillman (1982), and Waber (1976), observed gender differences in spatial visualization as well as mathematical performance at different age levels. The age at which such differences begin to appear between the two sexes is not certain; and this makes the question of early gender difference in both skills still unresolved.

A study by Sherman (1979) compared some predicting factors for mathematics performance using ninth grade scores of females and males on three cognitive tests (Test of Academic Progress, quick Word Test, and Space Relation Test of DAT) and other mathematical attitude scales. His findings revealed that spatial visualization significantly predicted girls' geometry grades but not boys' grades. He also found the same variable to have a significant weight in predicting mathematical problem solving for girls.

Replicating the previous data sets (Sherman, 1980); further asserts that spatial visualization contributed more uniquely than other factors (Mathematical attitude scales) to the prediction of mathematics performance for females than for males. Thus spatial visualization is more likely to be problematic for girls than for boys and would differentiate more among female students in relation to predicting performances in mathematics.

Pattison and Grieve (1984) conducted a research on 10^{th} and 12^{th} grade male and female students to examine sex differences as a function of problem contents and of the relationship between these sex differences and specific spatial skills. Their result on the pattern of sex differences, which showed boys' excellence in mathematical problems related to measurement, proportion, and spatial visualization whereas girls' excellence on more abstract deduction problems, is likely to be consistent with patterns indicated in other studies (e.g. Fennema & Carpenter, 1981; Fennema & Sherman, 1977; Sherman, 1979). Their results concerning sex differences in a number of spatial skills, particularly, in the visualizations of rotations in two or three dimensions, do not clearly demonstrate the relationship between spatial visualization and sex difference in mathematics ability. In other words, gender variation in spatial skills did not significantly result in gender variation in any type of mathematics, nor did it relate itself to more spatial kinds of mathematics. Moreover, measures of Surface Development Test, which show strongest relationships to mathematics performance, could not exhibit any sex difference; and this made it difficult to draw any conclusion that more boys than girls adapt a spatial approach to mathematics (Pattison & Greive, 1984).

Another study by Voyer (1996) examined how past mathematics courses and students performances on them are related to gender and spatial ability. The results showed that there was a non-significant positive correlation between the number of mathematics courses taken and spatial ability scores as well as a non-significant negative correlation between mean past mathematics scores and spatial ability scores. However, Voyer (1996) in his conclusion further suggested that performances in mathematics courses either as measured by the number of courses taken earlier or by previous mean high school mathematics grades suppress some of the unexplained variance in gender difference in spatial skills. He further explained that in such uncommon situation where the spatial correlation is larger than its associated zero-order correlation, the presence of suppression effect must be considered no matter what the actual size of the difference between the partial and zero- order correlation is.

On the other hand, Gallagher et al (2002) assert that gender difference in performance in some GRE quantitative items may be influenced by item context and spatially based shortcuts. Their results generally seem to be consistent with works of Casey et al (1997), which highlight the importance of spatial skills for performance on standardized tests of mathematics.

The importance of spatial visualization ability for advanced mathematical reasoning has been questionable and more research has been done repeatedly resulting in various conclusions. Some scholars like Mc Guinnes (1995), as cited in Robinson et al (1996), reported that males tend to use more spatial strategies even for solving verbal word problems. But others like Friedman (1995) argued that within samples of high ability students, mathematical and spatial abilities are highly correlated for girls than for boys.

In summary, the role of spatial visualization in mathematic performance probably depends upon the type of the problem and measure used (Badger, 1981). That means some kinds of spatial ability, especially visual imagery, may account for some of the sex related variations in mathematics performance. The possession of such skills is not only relevant to solutions of visual problems but also likely to permit greater latitude in dealing with the range of problems. Therefore, it seems that an excessive dependence of females on verbal strategies may hinder their flexibility in their mathematical work.

1.2.5 Gender Difference in Spatial Visualization

Many researchers have investigated sex-related differences in spatial visualization directly or indirectly for many years. Some concluded that differences exist between girls and boys in spatial visualization. Others said that there are no significant gender differences in such skills. Still some others put themselves between the "yes-no" boundaries. In this part of the review an attempts is made to discuss some of the findings in this regard.

Early in 1970s the analysis of research work done by Maccoby and Jacklin (1974) revealed that boys excel girls in visual-spatial ability. Such male-excellence was not detected during childhood but during adolescence and adulthood with increased advantages through the high school years. In addition, Johnson and Meade (1987) argued that male's superiority in spatial visualization starts by age 10 (fourth grade) and its magnitude remains constant through age 18. They further noted the largest sex differences occurred at grades 10-12.

On the contrary, the meta-analysis employed using the studies on spatial visualizations conducted between the years 1974 and 1982 by Linn and Peterson (1985) disclosed that there is no uniform gender-related difference in spatial skills across all the factors of spatial visualization. This conclusion opposes the view that the difference is first detected during adolescence.

In addition, Caplan et al (1985), criticizing the research reports on male's excellence on spatial visualization and considering the fact that sex difference in spatial tasks are modest and inconsistent across different tasks, concluded that gender difference does not exist or at least it is not clear as yet. However, contrary to the above view points, Voyer et al (1995) concluded that their meta-analysis evidenced the existence of sex differences in favor of males especially in mental rotation and spatial perception but little or no significant sex difference on the spatial visualization category.

Further investigations on this area also revealed the fact that the age, at which differences in higher spatial reasoning between the two sexes begin, is not fixed (Robinson et al, 1996). As cited in Robinson et-al (1996), Kerns and Berenfaum (1991) reported differences in spatial abilities among normally developing boys and girls aging 9 to 13; whereas other scholars like Maccoby & Jacklin (1974) and Waber (1977) have reported such differences as occurring after puberty.

Due to the inconsistency of the findings of various studies regarding the onset of differential spatial and mathematical performances Robinson and his colleagues carried out a study, in 1996, on 778 preschoolers and kindergartners and came up with a result that showed greater level of performance of boys on measures of mathematical skills and visual spatial working memory span. Moreover, spatial and quantitative factors were highly correlated. This gave not only a further evidence on the existence of gender difference in both skills even at early ages but also showed the interdependence of the two skills to a certain extent.

In Ethiopia, very limited studies have been conducted on sex-related differences in spatial visualization. The study by Temechegn (2003) examined gender differences in spatial ability of students of government and non-government schools in grades 7 – 12. The result revealed that both girls and boys have generally low spatial visualizations and their spatial skills are not adequately developed to interpret two-dimensional diagrams into three-dimensional objects. Moreover, boys and girls have shown little or no significant differences in their spatial visualizations. The researcher attributed the underdeveloped spatial ability of the students to the inadequate focus of the school curriculum on geometrical figures and shapes. The insignificant sex differences in the students' spatial visualizations are explained by Temechegn as resulting from lack of interaction among the three factors, namely social conformity, the presence of spatial tasks in schools, and in the culture.

The arguments presented by the above researcher in his study seem quite reasonable since in the curriculum of some subjects that are more spatial in nature, spatial tasks are likely to be underrepresented and usually left uncovered in classes. For instance, the geometry sections of the mathematics lesson often comes towards the last chapters and are likely to be skipped or left undiscussed due to shortage of time in most occasions.

To conclude, the existing research reviewed above indicate that consensus has not been reached among researchers concerning the issue of gender difference in spatial visualization, despite the considerable attempts made for decades. In addition, gender difference in math self-efficacy and in mathematics achievement in different countries, including Ethiopia, follow a similar pattern. However, the exploration of gender differences in mathematics achievement in relation to self-efficacy and spatial visualization in our country seems to be scant. Therefore, the present study focuses on these research questions, which have primary implications to mathematics learning mainly at the high school level.

1.3. Statement of the Problem

Examining the roots of gender difference in mathematics learning is an essential next step after identifying its real existence. This may help find solution to the question why women are dramatically under represented in mathematics and science based careers. Consequently, the present study further dealt with two potentially major factors for differential mathematics performance between boys and girls (math self-efficacy and spatial ability).

In the first place, as argued by scholars (e.g. Mekonnen, 1987), non-cognitive factors have potential influences in facilitating or hindering cognitive development. Among these factors, self-efficacy perception, more than any other variable, is highly associated with students' academic motivation. It has significant power for predicting and explaining academic performance in various domains, including mathematics (Bandura, 1977).

This probably leads to the conclusion that people develop either high or low self-efficacy based on their own perception and thought of the capability they possess in doing a particular task.

In our context, some researchers (e.g. Eshete, 2001; Yalew, 1996; Yalew, 1997) have carried out similar studies and found results that support the above viewpoints. However, as compared to worldwide research efforts that have been done, local studies seem to be very scant. Moreover, in the specific locality, in Guji Zone, few or no studies that examined gender related differences in mathematics achievement resulting from gender differences in math self-efficacy have been conducted. Therefore, conducting a research on gender difference in self-efficacy and its effect on mathematics achievement is timely and crucial in order to figure out solutions that basically focus on females' problems.

Secondly, it seems that most local studies have given more research attention to non-cognitive factors as causal factors for gender related differences in mathematics achievement. However, the present study additionally examined gender related differences in math achievement as a function of differences between boys and girls in their spatial visualization.

Although this issue has been the focus of many researchers, there seems to exist little agreement on the commonly accepted male superiority in spatial tasks and its effect on mathematical achievement.

In Ethiopia, male and female high school students in Addis Ababa have, on the average, low spatial skills. In addition, no significant differences had been found between boys and girls' spatial abilities although its relationship to mathematical achievement had not been the focus of the study. This is due to the non-existence of a measure of spatial ability for students in schools and in the environment as a whole (Temechegn, 2003).

Therefore, it seems that the existence of sex difference in spatial visualization, particularly in our schools, and its importance for mathematical reasoning is highly controversial and questionable since repeated investigations found contradictory findings that led to different conclusions. As a result, conducting a research on gender related difference in spatial visualization as well as its impact on mathematical achievement at a local level, if any, is timely and vital for possible remedial measures.

The purpose of the present study, therefore, is to examine gender difference in students' mathematics achievement, math self-efficacy, and spatial visualization. Furthermore, the study investigates the effects of math self-efficacy and spatial visualization on mathematics achievement. Accordingly, the study is designed to answer the following specific research questions

1. Do male and female students show a statistically significant difference in their mathematical performance?

2. Are there statistically significant gender differences in math self-efficacy and spatial visualization?

3. Do gender, math self-efficacy, and spatial visualization predict students' mathematics achievement?

4. Is there significant gender difference in math achievement due to gender differences in math self efficacy and spatial visualization?

1.4. Significance of the Study

Gender difference in math performance is an extensively researched area around the world. However, very limited local studies, especially concerning spatial skill as a specific cognitive factor that could significantly contribute to variations in mathematical performances, have been conducted. Therefore, investigating such issue at local level is timely and essential in order to determine the degree of its influence on mathematics achievement. This would help to suggest possible remedial solutions that may help minimize its negative consequences.

Hence, the present study would help to

1. plan some intervention programs that can help improve girls' performances and narrow the gap in performance between boys and girls.

2. give insights to math teachers and counselors to pay a bit more attention to girls, on the basis of which they can encourage them to improve their participation and performances in some male dominated subjects like mathematics.

3. initiate counseling intervention that arranges some extra time training programs in spatial skills and tutorial classes in mathematics that may contribute to the improvement of students' mathematics achievement, giving more attention to girls.

4. initiate counseling interventions that help build up self-confidence and achievement motivation in the students with special attention to female students.

5. direct the attention of education policy makers, curriculum designers, counselors, concerned teachers, etc. to gender difference in students' math performances in general and to the influence that spatial skill has on math ability in particular and take possible remedial measures to alleviate it.

1.5. Delimitation of the Study

There are a number of specific cognitive and non-cognitive factors that may account for gender difference in math performance. These factors like prior knowledge of mathematics, interest, teachers' expectations, and attitude, which might have carry over effects and potential influence on the students' mathematics achievement, could have been controlled so that clear picture of mathematics performance could be found. However, that was impossible due to financial and time constraints. Therefore, this study has focused only on two of them, namely, math self-efficacy and spatial ability. Moreover, the present study was confined to only grade nine students in Guji Zone High Schools.

1.6. Operational Definitions of Terms

***Math Achievement*:** - Refers to the students' math scores earned on the achievement test that was developed by the researcher and subject teachers based on grade nine mathematics textbook and syllabus

Math Self-efficacy - Refers to the students' aggregate scores on the math self-efficacy scale, a five-point scale, developed by the researcher. The scale addressed students' confidence in their ability to do Mathematics or in attempting to solve mathematical problems.

Spatial Ability: **-** Refers to students' scores on the spatial and visualization test, which was designed to assess their ability to manipulate shapes and figures mentally in space. The test was adapted from the Differential Aptitude Test by the researcher.

CHAPTER TWO

Method

2.1 Variables

In analyzing gender differences, gender served as an independent variable whereas math self-efficacy, spatial ability, and mathematics achievement scores served as dependent variables. In the regression analysis gender, math self-efficacy, and spatial ability scores served as independent variables (predictor variables) whereas math achievement score served as a dependent variable. In the analysis of covariance (ANCOVA), gender was used as an independent variable whereas math achievement score was used as dependent variable, using self-efficacy and spatial ability scores as covariates.

2.2 Sample

Most studies on gender difference in mathematics achievement, in general, indicated the superiority of boys, on average, to girls on tests of mathematical ability (e.g. Hyde, Fennema, and Lammon, 1990; Maccoby and Jacklin, 1974). Some researchers like Carr and Jessup (1997), Doolittle and Cleary (1991), and Marshal & Smith (1987) suggested that although some gender differences in some mathematical skills like strategy use and fact retrieval are eminent during preadolescent years, critical differences in mathematical reasoning often appear around adolescence.

Since investigating the existence of gender difference in mathematics achievement was the primary objective of the present study, based on the above research evidence, grade nine students were selected for the study. This was so because the researcher believed that students at this grade level are most likely to be in their early adolescence at which the mathematical achievement variations between boys and girls come to light.

From among the five senior secondary schools (Negelle S.S.S, Adola S.S.S, Oddo Shakisso S.S.S., Bore S.S.S., and Uraga S.S.S.), Uraga Senior Secondary School was randomly selected for the pilot study. The pilot study, which was intended to improve the quality and contents of the test instruments, was administered to a random sample of 60 ninth grade (28 female and 32 male) students from the above school. Three male students and seven female students were excluded from the try out analysis for they did not work on more than 50% of the task. In the case of the pilot spatial visualization test, three students (2 males and 1 female) were excluded from item analysis for the same reason. Thus, the sample for the pilot study consisted of fifty (21 girls and 29 boys) for math achievement test and math self-efficacy scale and fifty-seven (27 girls and 30 boys) for spatial visualization test.

In the main study, the sample was selected from the remaining four high schools of the Zone namely Negelle Senior Secondary School, Adola Senior Secondary School, Oddo Shakisso Senior Secondary School, and Bore Senior Secondary School (See appendix. H)

In the present study, it was decided to take equal sample size of female and male students from the total population of ninth grade students in the four high schools. The number of the sample size for this study was determined following the table developed for such purpose by Krejcie & Morgan (1970). Thus, from the total population of 2,400 (1000 females and 1400 males), 400 students (200 females and 200 males) were chosen for the main study using stratified random sampling.

The sample was selected on the basis of the proportions of girls and boys from each school after they were separately stratified into male and female groups (See appendix I). However, among the selected students four girls and two boys were not present on the test administration date. Thus, the number of participants was reduced to 394 students (196 females and 198 males) with a mean age of 16.5 years and standard deviation of 0.87.

2.3 Instruments

2.3.1 The Math Achievement Test

The mathematics achievement test was initially developed by a post graduate student from Mathematics Department in Addis Ababa University, who had been teaching the subject in Negelle high school for about fifteen years. After a thorough analysis of the mathematics textbook and syllabus, objectives were formulated and a table of specifications was prepared. Accordingly, a 45-item multiple-choice test with four alternatives was first constructed. Moreover, considering the fact that the test would be administered before the time when students could hardly cover the geometry portions, the geometry items were taken from grade eight textbook and syllabus. Then, the test was given to three ninth grade mathematics teachers from Negelle high school for judging its face validity. Based on their comments on the content reprsentativeness of the sample items, eight items were discarded while the remaining items were reserved with minor modifications. So, 37 items were used in the pilot test for item analysis.

The test was then administered to the pilot sample and item analysis was carried out. Indices of item difficulty and discrimination and the relative worth of each destructor were analyzed for the upper 27% and the lower 27% scorers (Mehrens & Lehmann, 1984). Finally, a 30-item test with few items of extreme value of difficulty indices and discrimination indices above

.20 had been selected for the final study. Most of the items had difficulty indices ranging from 30% to 66%. The internal consistency reliability of the final test scores as estimated by KR 20 was 0.83. (See appendix A for more details of the grade nine-math achievement test)

2.3.2 The Math Self-Efficacy Scale

The scale for assessing students' math self-efficacy was developed exactly the same way as suggested by Pajares and Miller (1994). All the items used in math achievement test without their alternatives have been used in this scale. The participants were asked to estimate their level of confidence in solving each mathematical problem on a five-point scale that ranges from not confident (a score of 1) to fully confident (a score of 5). The alpha coefficient of the scale was 0.94. (See appendix C for the math self-efficacy scale).

2.3.3 The Spatial Ability Test

In developing the spatial and visualization test, first 25 items were selected from IQ test books (Azzopardi, 2003; Barrett & Williams, 1990; Matland, 1997; Pelshenke, 1993). The items assessed students' ability to make mental picture of three-dimensional figures and to manipulate shapes and figures in space. The test was then administered in the pilot study for a random sample of 57 students and item analysis was carried out.

Accordingly, five very difficult items with difficulty indices below 20% have been discarded. Four items with difficulty indices between 20% and 30% were included after some revisions whereas the remaining 16 items with good difficulty and discrimination indices (ranging from 30% to 75 % and from .38 to .88, respectively) were retained for the main study. This yielded a 20-item test. The reliability coefficient of the spatial ability test scores was 0.80, using KR-20. (See appendix B for the spatial visualization test used in the study)

2.4 Procedures of Data Collection

In this study the math self-efficacy scale was administered first followed by the math achievement test and the spatial ability test. This was done following Bandura's (1986) suggestion (cited in Pajares and Miller, 1994), that both self-efficacy and performance must be assessed within close time intervals and self-efficacy assessment must precede performance assessment.

First, the necessary orientations with practical illustrations were given to students in an attempt to make them aware of how they should fill out the math self-efficacy scale. The students were given five practical examples that ranged from very difficult to very easy math questions. This allowed them to understand that they would only assess their confidence in handling each question but not solve it and write the answer on the rating scale. Then, all the test instructions were briefed, so participants would work independently and give their authentic responses. During the test administration session subject teachers from each school were assigned to supervise the independent work of each student.

2.5 Methods of Data Analysis

Initially, the data were organized and tabulated. Then, descriptive statistics were computed. Based on these, mean difference tests (t-tests) between females and males and zero-order correlations between the study variables for females, for males, and for the two groups combined were computed. To investigate gender difference in math achievement as a function of math self-efficacy and spatial ability, analysis of covariance (ANCOVA) was performed using self-efficacy and spatial ability scores as covariates. In addition, in order to examine the effect size of the predictor variables on the criterion variable, a stepwise regression analysis and coefficients of multiple determinations (R squared) were computed. The test of significance in all instances was set at 0.05 (95%) level.

CHAPTER THREE

RESULTS

This section of the study deals with the results of the statistical analysis. The descriptive statistics presented in Table 1 below shows the nature of the distribution of the test scores for the total sample (See also Appendices J, k, & L for details of frequency and percentage distribution of the test scores). In addition, the corresponding distribution curve plotted as histogram for each of the test scores was fairly normal (see appendix D). Further analyses of the distribution of the scores, as computed by the Kolmogorov-Smirnov (K-S) test, also confirmed that the distribution of the scores for each variable did not significantly deviate from normality (see also appendix E).

3.1 Descriptive Statistics

Table 1. Descriptive statistics of the variables treated in the study

Variable	Statistics (N = 394)				Maximum Possible Score
	M	S.D	Range of Scores		
			Min.	Max.	
MSE	92.53	25.305	27	150	150
SPV	8.21	3.302	1	17	20
MPER	10.25	4.365	2	26	30

Note: M = Means; SD = Standard Deviations; MSE = Math Self-Efficacy; SPV = Spatial Visualization; MPER = Mathematics Performance

However, tests of homogeneity of variance were carried out for all variables and the assumption of homogeneity of variance was violated except for MSE scores. So, in order to perform ANCOVA, the raw scores on the mathematics achievement test and spatial visualization test were transformed in to their logarithms. Then, the Levene's test showed that the variance within the group was homogeneous (See appendix M). In addition, the Levene's test of equality of error variance showed that the error variance of the dependent variable was equal across the groups (see appendix N).

3.2 Gender Differences in Math Self-Efficacy, Spatial Visualization, and Math Achievement

Table 2. Means and Standard Deviations for gender sub groups on MSE, SPV, and MPER

Variable	Male (N = 196)		Female (N = 198)		t
	M	S.D	M	S.D	
MSE	102.34	23.477	82.617	23.177	8.390**
SPV	8.763	3.555	7.643	2.927	3.411**
MPER	12.081	4.715	8.403	3.017	9.212**

*df = 392

** $p < .001$

The primary interest of the present study was examining gender differences in all the variables dealt with in the study. To see these, the means were compared using independent samples t - test. Accordingly, gender differences in all the variables were evident. As shown in Table 2 above, the mean scores of grade nine male and female students on the math self-efficacy scale were significantly different ($t_{(392)} = 8.39$, $p < .001$), indicating that boys reported significantly higher math self-efficacy than girls. Similarly, their scores on spatial Visualization also differed significantly ($t_{(392)} = 3.411$, $p < .001$), which again indicated that grade nine male students had greater spatial Visualization than grade nine female students. Moreover, the mathematics achievement mean scores of female and male students were also significantly different ($t_{(392)} = 9.212$, $p < .001$), which still indicated the superiority of boys to girls on mathematics achievement.

In summary, the above results showed that female and male students differed significantly in their math self-efficacy, spatial Visualization, as well as math performance, males having higher scores on all the variables.

3.3 Correlation Analysis of the Variables in the Study for the Total Sample

Table3. Zero-order Correlation Coefficients of the variables for the total Sample (N = 394)

Variable	Gender	MSE	SPV	MPER
Gender	1.000			
MSE	.386**	1.000		
SPV	.170**	.103*	1.000	
MPER	.422**	.405**	.225**	1.000

** $p < .01$

* $p < .05$

According to the intercorrelation shown in Table 3, all the variables were correlated to one another significantly. Gender was significantly related to MPER ($r = o.422$, $p < 0.01$), MSE ($r = 0.386$, $p < 0.01$), and SPV ($r = 0.170$, $p < 0.01$). In addition, MSE had a significant correlation with MPER ($r = .405$, $p < 0.01$) and a fair correlation to SPV ($r = 0.103$, $p < 0.05$). These results suggest that as the students' self-efficacy on solving mathematical problems increased so did their actual performance on mathematics and spatial tasks. Similarly, SPV has also correlated with MPER ($r = 0.225$, $p < 0.01$), indicating that high performance on spatial tasks tends to result in high performance on the mathematics test.

3.4 Correlation Analyses of the variables in the study for the Gender Sub-group

Table 4. Intercorrelations between the study variables

Variable	MSE	SPV	MPER
MSE	---	.069	.243**
SPV	.017	---	.181*
MPER	.327**	.169*	---

** p < .01

* p < .05

Note: correlations above the main diagonal are for girls (N = 196) and those below the diagonal are for boys (N = 198).

As presented in Table 4, MSE was positively and significantly correlated with MPER both for female (r = 0.243, p < 0.01) and male students (r = 0.327, p <0.01). Likewise, the correlations between SPV and MPER for girls and boys were positive and significant (r = 0.181, p < 0.05 and r = 0.169, p < 0.05, respectively). However the correlations between MSE and SPV for both sexes were not significant (r = 0.069, p > 0.05 for girls and r = 0.017, p > 0.05 for boys). This indicates that, as opposed to the pooled sample, when the two variables (MSE & SPV) were treated for each gender sub-group separately, they did not have significant relationship to each other.

3.5 Effects of the Predictor Variables on the Criterion Variable

Table 5. Summary Table for Regressions of MPER on Gender, MSE, and SPV

Predictor Variable	R	R Square	Adjusted R Square	R Square Change	F Change
Gender	.422[a]	.178	.176	.178	84.838**
Gender, MSE	.485[b]	.235	.231	.057	29.302**
Gender, MSE, SPA	.506[c]	.256	.250	.021	10.793**

**p < .01

The results in Table 5 above illustrate the proportion of variance explained by the independent variables on the dependent variable. Gender, math self-efficacy, and spatial visualization together accounted for 25.0% of the total variability in mathematics achievement and this was a significant contribution ($F_{(3, 390)} = 44.690$, $p < 0.01$).

Furthermore, the hierarchical variance decomposition (see Table 5 above) showed that the independent contribution of each variable added up to the total variation explained by the three variables. Accordingly, gender alone accounted for 17.6% of the variance in mathematics achievement, adding significantly to the prediction of achievement in mathematics ($F_{(1,392)} = 84.838$, $p < 0.01$). When MSE is added, the variance in MPER that was accounted for was raised significantly to 23.1% ($F_{(2,391)} = 60.133$, $p < 0.01$). Of this, MSE independently contributed 5.7% to the prediction ($F_{(2,391)} = 29.302$, $P < 0.01$). A regression model that included the third predictor variable (SPV), on the other hand, showed some contribution to the prediction of math achievement. Some 2.1% of the variance in performance was accounted for by spatial visualization ($F_{(3,390)} = 10.793$, $p < 0.05$).

3.6 Math Achievement as a Function of Math Self-Efficacy and Spatial visualization

Table 6 ANCOVA Summary Table (Gender Difference in MPER Controlling for MSE & SPV)

Source of Variation	Sum of Squares	df	Mean Square	F	Eta Squared
Corrected Model	3.314	3	1.105	44.690**	.256
Log SPV	.267	1	.267	10.793**	.027
MSE	.700	1	.700	28.301**	.068
Gender	1.006	1	1.006	40.698**	.094
Residual	9.640	390	.02472		
Corrected Total	12.953	393			

** p < 0.01

In order to investigate the extent to which the gender variation in math performance was attributable to math self-efficacy and spatial visualization, Analysis of Covariance (Controlling for MSE and SPV) was employed.

As can be observed from Table 6 above, even after statistically controlling differences in MSE and SPV scores, the gender difference in math achievement was still significant ($F_{(1,390)} = 40.698$, $p < 0.01$). Based on the pairwise comparisons among the adjusted means, the effect size as measured by Eta squared was .094. This indicates that gender had accounted for about 9.4% of the total variation in mathematics achievement, after controlling for the covariates. In other words, male students still had substantially higher mean scores (adjusted mean = 11.503) than female students (adjusted mean = 8.987). However, the previous effect of gender (17.6%) on mathematics achievement was reduced by 46.6% (to 9.4%) after controlling the effects of the two variables. This indicates that some amount of gender differences was accounted for by the gender differences in math self-efficacy and spatial visualization.

In addition, in order to find out which of the two covariates has strongly accounted for the gender difference in math achievement, each covariate was separately controlled. When MSE was statistically controlled, gender accounted for 10.2% of the variation in mathematics achievement. That means MSE alone reduced 42.0% of the gender variation in mathematics achievement (see appendix F).

On the other hand, When SPV was statistically controlled (see appendix G), gender accounted for 16.6% of the variation in mathematics achievement. That means SPV alone reduced only about 5.7% of the gender difference in math performance.

In summary, the present study has found gender related differences in the students' math self-efficacy, spatial visualization, and mathematics achievement. Moreover, gender, math self-efficacy, and spatial visualization significantly correlated with mathematics achievement though the magnitudes of the relationship were low in all cases.

Gender, math self-efficacy, and spatial ability together accounted for a significant amount (25%, $F_{(3,390)} = 44.690$, $p < 0.01$) variation in mathematics achievement. Of this gender explained the largest variance followed by self-efficacy and the least variation by spatial visualization. In addition, gender difference in mathematics achievement was evident even after controlling for the gender difference in the students' math self-efficacy and spatial ability. However, the effect size of gender was reduced significantly which showed the existence of gender difference in mathematics achievement as a function of math self-efficacy and spatial visualization.

CHAPTER FOUR

DISCUSSION

The present study had two major purposes. The major one was investigating gender related differences in all the three variables (MPER, MSE, and SPV) under study. This was done by comparing students' mean scores on math achievement test, math self-efficacy scale, and spatial visualization test. The second objective was examining gender difference in mathematics achievement as a function of math self-efficacy, and spatial visualization.

4.1 Gender Difference in Mathematics Achievement

The present study has shown that the average math achievement test scores of both males (Mean = 12.081) and females (Mean = 8.403) were generally low (see table 2). As the result revealed in the previous section, the test of mean difference for the gender sub group showed that gender difference in mathematics achievement was evident ($t_{(392)} = 9.212$, $p < 0.001$). Males had significantly higher achievement scores in mathematics (M = 12.081), than did girls (M = 8.403). So, this result provides an answer to the first research question: Is there significant difference in math performance between male and female students?

This result is consistent with the findings of many other studies that examined gender difference in mathematics achievement, particularly at the high school level (Byrnes & Takahira, 1993; Fennema and Carpenter, 1981; Gallagher, 2002; Hyde, Fennema and Lamon, 1990).

In the Ethiopian Context, similar studies had found better academic performance of male students compared to their female counterparts (Genet, 1991; Yalew, 1997). As compared to male students, female students were found to have lower mathematics achievement scores (Genet, 1991; Seleshi, 1995). The present study, thus, provides additional evidence that high school boys perform better than high school girls in mathematics.

One explanation for female students' poor mathematics performance may be the lower confidence they have in their capability to do mathematics. Such a lower judgment they have about their math ability may have resulted in their lower mathematical performance (Pajares & Miller, 1994). The result of the present study which revealed significant gender difference in the students' math self-efficacy ($t_{(392)} = 8.390$, $p < .001$) in favor of boys, could be taken as additional evidence that supports the above explanation. Moreover, as evidenced some studies (e.g. Hackett, 1985), girls' lack of confidence on math ability as well as stereotyping math as a male subject, were also attributable to their lower performance in mathematics.

Unlike the condition in foreign countries, in Ethiopia, though the present condition seems to improve, the local culture often discourages females' education by providing insufficient educational encouragements, supports, and opportunities (Genet, 1991). This might have potentially contributed to gender related difference in mathematics achievement. The aforesaid explanation seems to suggest that the girls' poorer mathematics performance is probably associated to their life styles. Most girls in our culture are usually confined to house hold tasks like cooking, taking care of younger siblings, and helping mothers with a variety of household chores which, consequently, spare them very little time for their studies.

In addition to the cultural biases mentioned above, attitudinal differences between boys and girls toward mathematics to some extent explain the variations in mathematical performance. For instance, gender difference in both mathematics and attitude were evident in favor of male students at ninth, tenth, and eleventh grade levels, and the largest variance in the students' mathematics scores (14%) was accounted for by attitude scores (Seleshi, 1995)

Besides the above-mentioned reasons, though not supported by some studies, another factor that could potentially contribute to gender difference in mathematics achievement is spatial visualization. Spatial visualization, especially visual imagery, is supposed to contribute to some of the sex related variations in students' math performances. Possessing a good deal of spatial skill is not only helpful in solving visual problems but also likely to permit greater insight in dealing with other sorts of problems as well (Badger, 1981). The present study that discovered significant relationship between spatial visualization score and math achievement score ($r = 0.225$, $p < 0.01$) as well as moderate amount of variance in mathematics scores (2.1%) accounted for by spatial visualization scores, seem to support the above explanations.

4.2 Gender Difference in Math Self-Efficacy

As mentioned in earlier studies, examining the importance of math self-efficacy in learning mathematics is becoming a primary issue in understanding the latent factors that contribute to deferential mathematics performances between male and female students.

In her earlier studies, Marcia C. Linn (1991) a leading researcher on gender difference in mathematics education had found some gender differences (in favor of males) in mathematics performance. However, in her later studies, though the case may be different in our context, she found that the gap in mathematics performance between the two gender groups had closed substantially. In middle schools girls at least earn as equal as boys and in some cases surpass the boys in mathematics performance (Linn & Hyde, 1998). The researcher's claim now focuses on the idea that the main gender difference is more in confidence levels of the students than in their actual performances.

Similarly, in the present study, the mean difference tests for the gender sub groups indicated that gender difference in math self-efficacy was evident and statistically significant. Boys were more confident in solving math problems than were girls ($t_{(394)} = 8.390$, $p < 0.01$). So, this result provides the answer to the second research question: Is there a significant gender difference in the students' math self-efficacy?

In the correlational analysis carried out for the gender sub-groups, the magnitude of relationship of math self-efficacy and math performance for girls ($r = 0.243$, $p < 0.01$) was not as strong as the magnitude of relationship for boys ($r = 0.327$, $p < 0.01$).

The above finding is consistent with other findings that revealed males' superiority in math self-efficacy compared to females. For instance, Fennema & Sherman (1977), found significant differences in mathematics confidence as well as on perception of mathematics as a male domain (which are important contributing sources of self-efficacy information), with boys repeatedly averaging higher on both variables. In addition, further evidence also showed that the gender gap in mathematics confidence and perceptions widens in middle schools and more increasingly in high schools (Fennema & Sherman, 1978).

In our context, a study that investigated gender differences in physics self-efficacy (Yalew, 1997) and in math-self-efficacy (Eshete, 2001), disclosed that boys have superior self-efficacy judgments in the respective subjects compared to girls. So, the result found in the present study is not the first of its kind. As mentioned earlier, the present study also disclosed that boys have higher self-efficacy beliefs than girls in solving math problems.

There are a number of possible explanations for such gender discrepancies in mathematics self-efficacy. On one hand, because expectations for success are so much lower for girls than for boys, girls tend to feel less confident in their mathematical ability. In this regard, Salmon (1984) argued that students feel self-efficacious when they are able to picture themselves succeeding in challenging situations, which in turn determines their level of effort toward the task. In addition, confidence gap between boys and girls further widens when girls find teachers repeatedly call on boys for "correct" answers in classrooms. This provides boys than girls more vicarious experiences through observation. As Cited by Yalew (1997), what Bandura (1986) argued about the important source of feeling of competence being the observation of similar others seems viably reasonable here. In this case, teachers' expectations and reinforcement could be considered as important factors that may facilitate or inhibit the development of students' self-efficacy perceptions.

Most math teachers tend to reinforce boys than girls for math proficiency. And some others seem to convey the idea that math is more relevant and important for boys than girls. Consequently, they are more likely to nominate boys than girls to solve math problems in classes, which tend to provide boys with more opportunity to build up their math self-efficacy. Personal experiences and communication with some math teachers and students of both sexes in the study area have supported the aforementioned observations.

On the other hand, female students themselves are not likely to admit their ability in mathematics and are not as likely as boys to attribute their success in mathematics to their own competence (Hackett, 1985). This indicates that males often have higher beliefs than females in mathematical ability even though both earn equivalent scores (Tiedeman, 2000; cited in Eshete, 2001). And these tend to increase boys' percepts of math self-efficacy and to the contrary decrease females' percepts, even if they have competent skills as males do.

Another explanation, which could influence the development of math self-efficacy perceptions on students and potentially contributes to gender difference in such perceptions, is the nature and dissimilarity of parental encouragement for male and female students. Although most parents indirectly discourage math courses for girls, some few parents tend to directly discourage girls from studying mathematics (Atsede, 1991). These parents are more likely to encourage their sons than daughters to enroll in sciences and mathematics. In other words, such parents seem to provide more support to males than females for excellence in mathematics and sciences. Such stereotyping of mathematics as a male domain, in general, could be a mediating variable that affects sex differences on a variety of attitudes like confidence in learning mathematics as well as perceptions of its usefulness (Fennema & Sherman, 1977),

4.3 Gender Difference in Spatial visualization

The results of the present study revealed that, though the test of mean difference showed the existence of significant difference in spatial visualization between male and female students, the spatial skills of both gender sub-groups in the selected schools were generally low (Mean = 8.763 and 7.643, respectively). This indicates that the spatial visualization of the students on the average was not sufficiently developed to easily create mental images of three-dimensional objects and manipulate them mentally.

As the majority of visual-spatial tests implement geometrical shapes and diagrams, it may be quite reasonable to say that getting practical experiences with geometrical figures in the schools as well as in the surrounding environment could contribute much to the development of one's spatial Ability. Hence, the scarcity or absence of such practices in the school and the environment seems to be the possible factor that contributes to their poor spatial visualization.

The above argument is well supported by a study conducted in our country that discovered lower average spatial visualization but little or no differences in such abilities of male and female students in two types of schools, government or non government schools (Temechegn, 2003).

As indicated earlier, the present study had found gender related difference in spatial skills, as evidenced by other studies, (e.g. Johnson & Meade, 1987; Kerns & Berenfaum, 1991; cited in Robinson et-al, 1996; Maccoby & Jacklin, 1974; Waber, 1976). The results of the studies revealed significant gender differences in students' spatial skills in favor of male students at different age levels and in different types of spatial skills. Thus, the result of the present study indicated above provides the answer to the second additional research question: Is there significance gender difference in the students' spatial visualization?

The presence of somehow conservative local culture that places great focus on the conformity of male and female children to the rules set by the society, especially in our context, can be the major explanation for the existence of gender difference in spatial visualization.

The Ethiopian culture frequently limits girls at homes with mothers to engage in house hold tasks after school. On the contrary, the majority of boys are allowed to go away from homes for out-door activities around the neighborhood. This seems to provide boys rather than girls with some opportunities to engage themselves in different activities including spatial kind of plays by constructing different types of play objects like cars, animals, houses, etc. with wires, sticks and mud. Although there are no spatial tasks made available to students by the society and the culture in their surroundings and the school environment, such experiences of boys with local and self-made play objects may have contributed to their better performance in the spatial test.

4.4 Effects of Gender, Math Self-Efficacy, and Spatial Visualization on Math Achievement

The other central objective of the present study was two fold. The first was examining the effects of the predictor variables on the criterion variable. In other words, how much of the variance in mathematics achievement could be explained by differences in gender, math self-efficacy, and spatial visualization. The second objective was to examine the existence of gender difference in mathematics achievement when gender differences in math self-efficacy and spatial visualization are statistically controlled. In order to answer these questions hierarchical regression analysis and analysis of covariance were computed.

As could be observed from the results of the present study in the preceding chapter, gender differences in all the variables treated were substantial, in all cases favoring male students. In addition, the correlation analysis performed for the total sample disclosed that each variable (gender, $r = 0.422$ $p < 0.01$, math self-efficacy, $r = 0.405$ $p < 0.01$, and spatial visualization, $r = 0.170$ $p < 0.05$) was significantly related to math performance.

The separate correlation analysis performed for males and females also showed a similar trend of relationship for boys and girls. Both math self-efficacy and spatial visualization were significantly and positively related to math performance. However, the correlation between math self-efficacy and spatial visualization was not significant. This could probably indicate that students' self-efficacy judgment or their confidence in doing mathematics could not affect their scores on spatial ability test.

As indicated in the hierarchical variance decomposition, the independent contribution of each variable has added up to the variation explained by the three variables operating jointly (Adjusted $R^2 = .250$, $F (3,390) = 44.690$, $p < 0.01$). This answers the third research question: Do gender, math self-efficacy, and spatial visualization predict students' mathematics achievement? However, this does not mean that the three predictor variables are the only variables that affect students' mathematics achievement. Instead, other non-cognitive and cognitive variables such as students' academic motivations and performances are either enhanced or stunted by the levels of self-efficacy judgments they possess about their academic ability (e.g. Hackett, 1995; Mone et al, 1995; Pajares & Miller, 1994; Vrugt, 1994). According to Pajares and Miller (1994), such finding supports Bandura's (1986) claim that of all cognitive or affective factors self-efficacy beliefs best explain students' motivations for success or their further performances.

The contribution of math self-efficacy to gender difference in math performance may further suggest that more girls than boys considered mathematics as a male domain since they are less likely to receive enough self-efficacy information about their abilities in science fields like engineering, physics, and mathematics (Hackett & Betz, 1989). Or most young girls are provided with less opportunity and encouragement to pursue their studies in science fields (Atsede, 1991). This in turn might have led them to develop little confidence in their math ability or not to attribute their success to their own ability (Hackett, 1985).

Overall, as can be inferred from the findings, more specifically, from the strength of the effects of the two covariates controlled separately and as measured by the Eta squared values in the analysis of covariance, math self-efficacy (Eta squared = .070) had the greater contribution than spatial Ability (Eta squared = .029) to the variation in mathematics performance between boys and girls. Hence, compared to spatial visualization, self-efficacy seems to be a better predictor of academic performance in general and better predicts achievements, particularly, with respect to mathematics learning.

CHAPTER FIVE

5. SUMMARY, CONCLUSION, AND RECOMMENDATION

The objective of the present study was to investigate gender related differences in mathematics achievement as a function of math self-efficacy and spatial Ability among ninth grade students in Guji Zone High Schools. The necessary data were gathered using three measures (Math Achievement Test, Math Self-Efficacy Scale, and Spatial visualization Test), after pilot testing and improving each of those instruments using item analysis.

The study sought to answer the following research questions.

1. Do male and female students show a statistically significant difference in their mathematical performance?

2. Are there statistically significant gender differences in math self-efficacy and spatial visualization?

3. Do gender, self-efficacy and spatial visualization predict students' mathematics achievement?

4. Is there significant gender difference in math achievement due to gender differences in math self efficacy and spatial visualization?

From the five high schools found in the zone four of them were selected for the main study, excepting the one, which was randomly selected and used for the pilot study. From these sample schools 394 participants (Females = 196 & Males = 198) were randomly selected from grade nine students.

Mean difference test (t-test), correlation analysis, regression analysis, and ANCOVA were employed to analyze the data. The results disclosed that there were statistically significant differences between males' and females' mathematics performance, math self-efficacy, and spatial visualization. All results were in favor of boys. The correlation analyses indicated that both math self-efficacy and spatial visualization were significantly related to math achievement. Analysis of covariance further revealed that even when math self-efficacy and spatial visualization were statistically controlled significant difference in mathematics achievement was evident between male and female students. However, the effect of gender on math achievement was reduced as a result of gender differences in math self-efficacy and spatial visualization, which were statistically controlled in the analysis. In addition, when each covariate was controlled separately, MSE reduced bigger amount (42.0%) of gender difference in math achievement. According to the R squared values, gender was the strongest predictor of mathematics achievement followed by MSE.

Based on the findings mentioned above, one may draw the following conclusions.

1. Gender related differences were found in all the variables in the study. This indicates that grade nine male students have higher self-efficacy beliefs and better performances in mathematics as well as in spatial ability than grade nine female students.

2. Math self-efficacy is more and closely related to mathematics achievement as compared to spatial visualization and plays a vital role in the learning of this subject.

3. Though spatial visualization seems to have relatively low relationship with math performance, its contribution cannot be undermined as far as mathematics learning is concerned.

4. Gender, self-efficacy and spatial visualization, either collectively or separately, accounted for the variance in the mathematics performance of high school grade nine students. Here, gender was found to be the strongest predictor of mathematics achievement followed by self-efficacy. However, this does not mean that the three predictor variables are the only variables that affect students' mathematics achievement. Instead, other variables, which were not included in the present study, have accounted for much of the variances of mathematics performance.

5. Math self-efficacy has not only statistically significant prediction power on math achievement but also predicts mathematics performance which indicates that one's self efficacy belief may be as important as one's knowledge of the subject matter in performing a specific task.

In general, the present study does not provide complete and novel evidences compared to the existing theoretical and empirical evidences, especially concerning spatial visualization. However, viewed from the point of view of the shortage of similar studies in Ethiopia and the scarcity of ready made localized test instruments, particularly, on spatial visualization, the present study may have considerable contribution in shading light on the relationship between the variables. Finally, the present findings seem to have the following practical implications.

1. The mathematics performance of ninth grade students as a whole is generally low. Therefore, it would be advisable for teachers, educators, curriculum designers, and counselors, etc., to notice that knowing only the subject matter on the part of teachers by itself doesn't guarantee the smooth transmission of knowledge to students. Rather, focusing on other potential factors (cognitive and non-cognitive) and integrating them in the teaching learning process would make better contribution in the educational process as a whole.

2. Mathematics teachers in particular and other teachers and school practitioners in general could try to understand the level of self-

confidence of their students since it has an important role to play in academic performance. By so doing, very low or extremely high self-efficacy beliefs of students can be identified as early as possible so that appropriate remedial measures can be taken through special programs like academic oriented self-confidence enrichment programs and/or individual or group counseling services that aim at changing and building students self-efficacy beliefs.

3. As the level of spatial visualization of the ninth grade students is generally low, math teachers may draw their attention to the importance of spatial visualization in mathematics learning and its effect on math performance. Hence, keeping in mind that spatial visualization is a skill that can be improved or even developed by educational interventions; they could try to help students in visualizing geometrical models, interpreting data displayed on charts, and mentally manipulate three-dimensional figures, so students' mathematics performance can eventually be improved.

4. Due attention by curriculum designers, counselors, teachers, and educators could be given to the existence of gender difference in mathematics learning and work cooperatively in order to minimize the gap of mathematics performance between male and female students.

5. Teachers as well as parents may encourage girls for excellence in mathematics. As a result, many professional areas will become less sex-

math anxiety (Seleshi, 1995; Eshete, 2001), confidence in learning mathematics, teachers' expectations, math as a male domain, motivation in math, (sherman, 1979), prior knowledge and strategy, (Byrnes and Takahira, 1993), vocabulary, mathematics concepts (Sherman, 1980), and possibly others, which were not included in the present study, might have accounted for about 75% of the variation in mathematics achievement.

The effect size statistic as measured by R squared showed that gender and MSE accounted for 17.6% and 5.7% of the total variation in math achievement, respectively. Furthermore, the above findings suggest that although all the independent variables have relationships and effects on mathematics achievement, gender and self-efficacy are more important and interrelated variables to mathematics learning as compared to spatial visualization. This finding is consistent with other findings. For instance, the finding of Pajares and Miller (1994) suggests that the effects of gender and background in mathematics are significantly related to self-efficacy. The findings of Pajares and Miller as well as the present study seem to support Bandura's assertion of the mediational role of self-efficacy on performance. In other words, gender becomes stronger predictor of mathematics achievement when it is operating jointly with math self-efficacy,

The present study, generally, revealed considerable gender differences in mathematics achievement, in math self-efficacy, and in spatial visualization, in favor of male students. Besides, not only gender ($r = .422$, p <. 01) but also math self-efficacy and spatial visualization(r = .405, p < .01 and r = .225, p< .01) were significantly related to math achievement. Hence, it was logical to find out whether or not gender difference in achievement could be entirely attributed to gender difference in self-efficacy and spatial visualization.

The ANCOVA results showed that by statistically equating gender differences in self-efficacy and spatial visualization gender difference in math achievement could not be totally diminished, though it was reduced to some extent. This finding, indeed, suggests the existence of other contributing variables above and beyond students' self-efficacy and spatial Ability. However, it does not mean that gender difference in self-efficacy and spatial skill did not have any effect on gender difference in achievement. Examination of the effect size statistic (Eta squared) revealed that the effect of gender was reduced to 9.4% and the covariates, MSE (6.8%) and SPV (2.7%) jointly reduced about 47.2% of the gender discrepancy in mathematics achievement. So, this provides the answer to the last research question: Is there significant gender difference in mathematics achievement due to gender difference in math self-efficacy and spatial ability? In this case, of the two variables, math self-efficacy had accounted for the largest variation of math performance.

The above result about the predictive power of self-efficacy in mathematics performance is in agreement with other researchers who maintained that exaggerated and mathematics will not remain a critical filter that hinders many women from advancing to lucrative and scientific professions.

6. Further research, especially on the importance and effect of spatial visualization on mathematics learning, could be conducted, so that prompt measures would be taken to minimize, if not totally eliminate, gender differences in mathematics achievement.

7. Future research could also focus on the development and standardization of spatial visualization test instruments that can be used in our context, so students spatial skills would be assessed for research and other essential purposes

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Appendix A The Math Achievement Test

ADDIS ABABA UNIVERSITY

COLLEGE OF EDUCATION GRADUATE PROGRAM

DEPARTMENT OF PSYCHOLOGY

MATHEMATHICS ACHIEVEMENT TEST (GRADE NINE)

Code ____ Sex ____ School _______Time Allowed 1 hour

General Direction: - This test is developed to collect data on students' mathematics performance that will be used for writing my master's thesis in partial fulfillment of the requirements for program of graduate studies in Addis Ababa University. The test contains mathematics achievement questions. Thus, you are kindly requested to complete the test carefully and honestly for your responses are the only ways to reach a reliable research result.

Direction one: - This test booklet consists of 30 multiple-choice items. Each item is followed by four possible answers. There is only one best answer for each question. Read each question carefully and choose the one that best answers the question and then blacken the circle corresponding to the letter of your choice on the answer sheet provided.

1. The expanded form of 121.85 is

A/ 1X 1000 + 2X1000 + 1X100 = 8X10 + 5
B/ $1X100 + 2X10 + 1 + 8x100^{-1} + 5X10^{-2}$
C/ 1 + 2 + 1 + 1 +0.8 + 0.05
D/ $1X100 + 2X10 + 1 + 8X10^{-2} + 5X10^{-1}$

2. (½ ÷ ½) ÷ ½ = ________________

A/ 1 B/ 2 C/ ½ D/ ¼

3. When the denominator is rationalized $\frac{\sqrt{5}}{\sqrt{5}-2}$ is equal to

A/ √5 + 2 B/ √5 - √2 C/ 2√5 D/ 5 + 2√5√

4. The sum of two numbers is 24. One of the numbers is 7 times more than the other. What is the smallest number?

A/ 8 B/ 7 C/ 3 D/ 1

5. Potential energy: W = m x g x h. Find m.

A/ $m = \frac{h \times g}{w}$ B/ $m = \frac{w}{h \times g}$ C/ $m = \frac{w - g}{h}$ D/ $m = \frac{w}{h + g}$

6. When simplified $\sqrt{\frac{72}{25}} \times \sqrt{\frac{50}{12}}$ is equal to

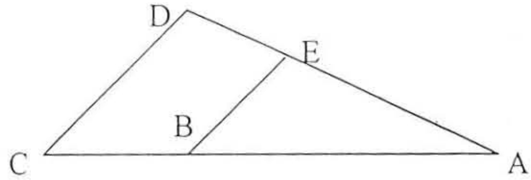
A/ 9 B/ 2√3 C/ √6 D/ 6

7 In ΔABC, x, y, and z are the interior angles. If $x = 60^0$ and $y = 75^0$, then z is equal to

A/ 45^0 B/ 55^0 C/ 65^0 D/ 35^0

8. In the figure below, BA = 2BC, EA = 2DE, and BE = 16. What is the length of DC?

A/ 18
B/ 16
C/ 24
D/ 21



9. What number is equal to $\frac{37}{6}$ when increased by its reciprocal?

A/ 1/3 or 3 B/ 1/6 or 6 C/ ¼ or 4 D/ 1/7 or 7

10. Volume of a cylinder $V = \frac{4}{3}\Pi r^2 h$. Find h

A/ $h = \frac{3v}{4\Pi r^2}$ B/ $h = \frac{V}{3\Pi r^2}$ C/ $h = \frac{3V}{4\Pi} r^2$ D/ $h = \frac{3V}{4r^2} \Pi$

11. If ½ x + 2/3 =1/4 x – 1/6, then x = ______

A/ -10/3 B/ 10 C/ 3/10 D/ 3

12. (√3 - √2) (√3 + √2) is equal to

A/ 2 B/ 4 C/ 3 D/ 1

13 A mother is now 24 years older than her daughter. In four years the mother will be 3 times as old as the daughter. What is the present age of the daughter?

A/ 8 B/ 32 C/ 40 D/ 24

14. The sum of two numbers is 36. If the smaller one divides.the larger of the two numbers, the quotient is 3. Then the product of the numbers is

A/ 243 B/ 324 C/ 369 D/ 936

15. Which of the following triplets can be the length of the three sides of a triangle?

A/ 1,2,3 B/ 2,7,4 C/ 5,9,4 D/ 3,4,5

16. 25 + 5 X 10 – 40 ÷ 5 + 3 – 14 ÷7 = ____________________

A/ 68 B/ 5.86 C/ 40.72 D/ 82

17. What is the numeral that immediately follows (TE) twelve?

A/ (110) twelve B/ (E1) twelve C/ (E0) twelve D/ (ET) twelve

18. If (243) x = 73, then the value of x is

A/ 9 B/ 8 C/ 7 D/ 5

19. What is the simplified form of $\frac{1}{(16^{3/8})^{-2/3}}$.

A/ ¼ B/ 4 C/ 2 D/ ½

20. If A is a sub set of a universal set U, then which of the following is WRONG?

A/ A U ϕ = A B/ A U U' = U

C/ A n U = A D/ n(A) + n(A') = n(U)

21. x – 2 and x + 3 are factors of

A/ 2x + 1 B/ $x^2 – 9$ C/ $x^2 – 6$ D/ $x^2 + x - 6$

22. Let the operation * and Δ be defined on the set of real numbers by $a*b = \frac{a+b}{2}$,

and $a \Delta b = (3a + b)^2$. What is the value of (2 * 6) Δ (-4 * 2)?

A/ 8 B/ 376 C/ 169 D/ 121

23. $(2002)_{three} – (102)_{three}$ is equal to

A/ (1200) three B/ (21) three C/ (13) four D/ (12) five

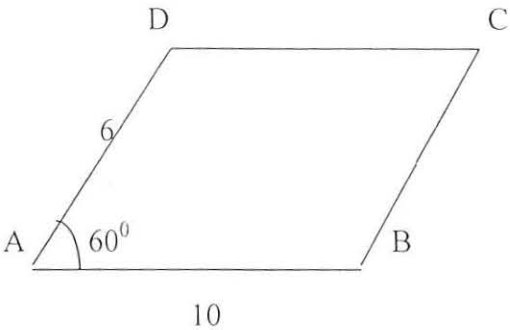
24. Which of the following is an irrational number?

A/ $\sqrt{9}$ B/ $\sqrt{2}$

C/ 2.3555….. D/ $\frac{13}{9}$

25. The two sides of a parallelogram are 6cm and 10cm long and the included angle is 60^0. What is the area of the parallelogram?

A/ $30\sqrt{3}$
B/ 60
C/ 30
D/ $60\sqrt{3}$



26. The volume of a regular square pyramid whose lateral faces are equilateral triangle of side $\sqrt{2}$ is

A/ $\sqrt{2}$ B/ $2\sqrt{2}$ C/ 4/3 D/ 2/3

27. If the roots of the equation $2x^2 - 7x - 4 = 0$ are α and β, then the value of

$$\frac{1}{\alpha + 1} + \frac{1}{\beta + 1}$$ is

A/ - 9/5 B/ 0 C/ -11/5 D/ 11/5

28. A is 4 times as old as B. In six years A will be twice as old as B. What is the age of A now?

A/3 B/ 7 C/ 4 D/ 12

29. The altitude of a triangle is 3 units more than twice its base. If the area of a triangle is 4.5sq. unit, then the altitude of the triangle is

A/ 12 units B/ 6 units C/ 15 units D/ 9 units

30. If n(A) =7, then n(P(A)) = __________

A/ 14 B/ 128 C/ 32 D/ 64

Appendix B <u>The Spatial Visualization Test</u>

ADDIS ABABA UNIVERSITY

COLLEGE OF EDUCATION GRADUATE PROGRAM

DEPARTMENT OF PSYCHOLOGY

Code________Sex ______ School ________Time Allowed <u>40 min</u>.

Spatial Visualization Questions

General Direction: - This test is developed to collect data on students' spatial ability that will be used for writing my master's thesis in partial fulfillment of the requirements for graduate program in Addis Ababa University. This part contains spatial ability questions.

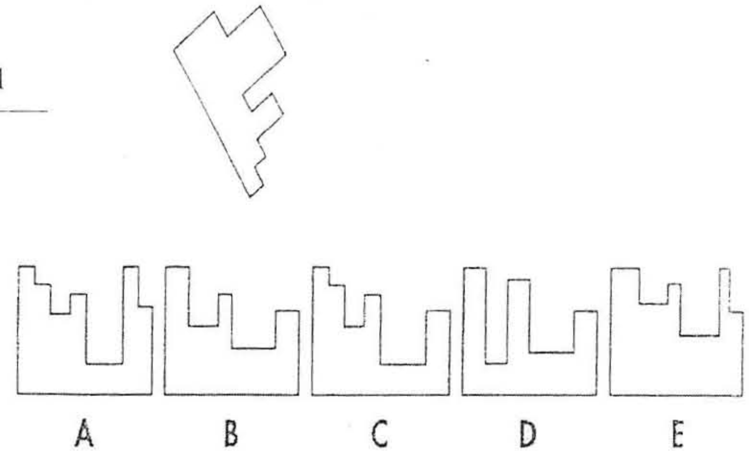
Direction: - This test booklet consists of 20 items that are developed to assess your ability to easily visualize and manipulate shapes and figures mentally in space. Basically, the items involve such tasks as *fitting shapes together*, *creating solid objects from flattened solid shapes*, and *unfolding solid figures*. You are required to manipulate the shapes in your mind to find answers for the questions.

N.B: Follow the examples given before the test items.

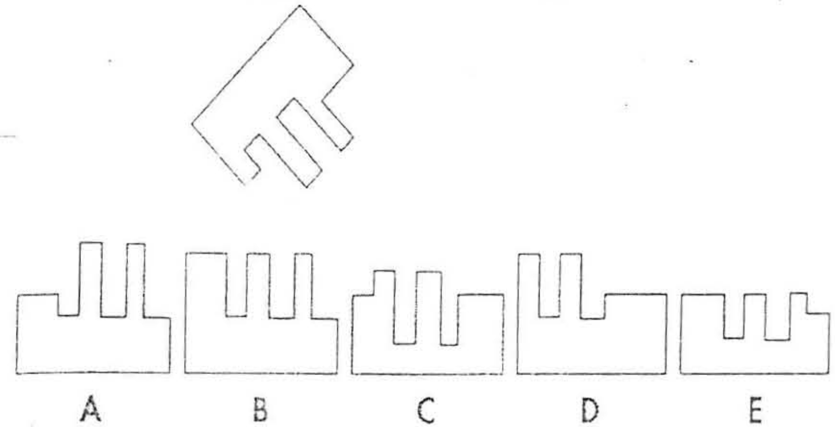
Q. 1. 2. 3. 4.

From the alternative figures (a, b, c, d, or e) given under each of the upper 4 shapes (fig. 1, 2, 3,and 4) identify the one that can fit together with it.

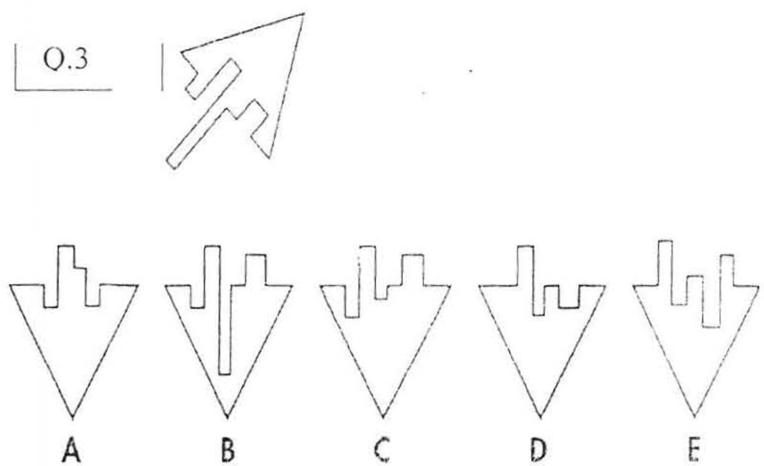
Q.1



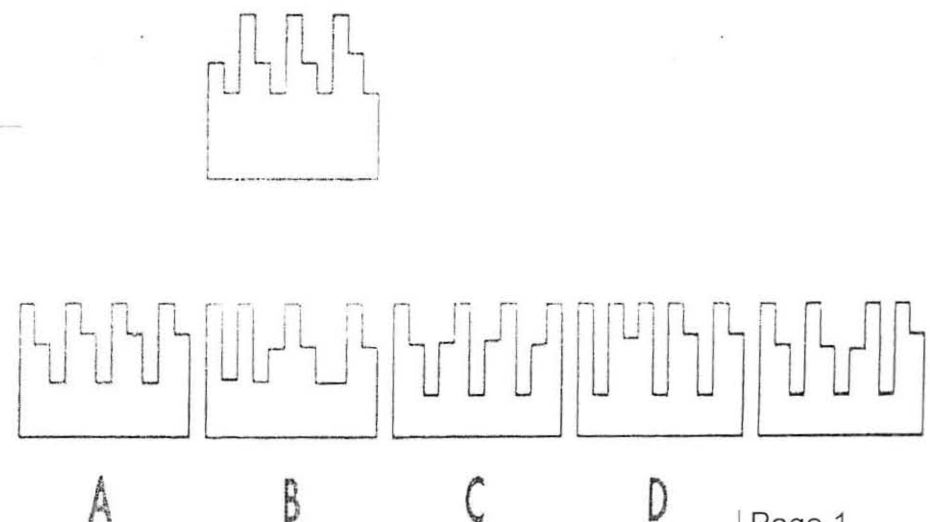
Q.2



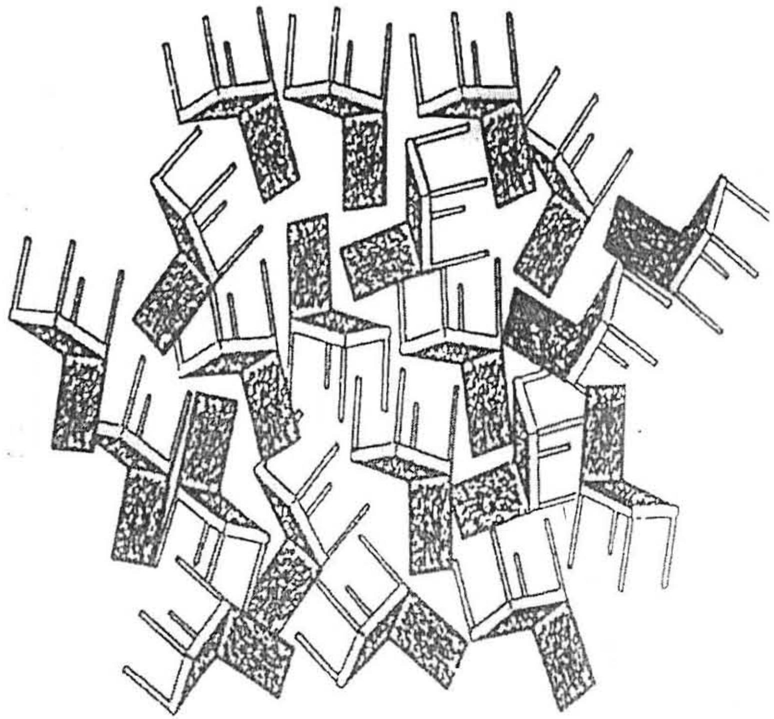
Q.3



Q. 4

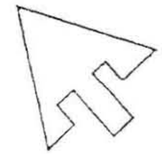


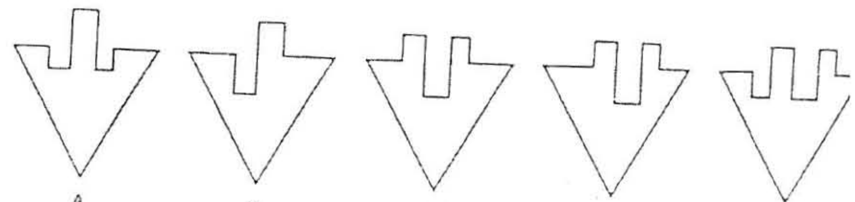
Q.5 Look at the pictures below carefully. How many chairs are there



Q. 6. 7.
Which one of the alternative figures does it fit together with the upper shape?

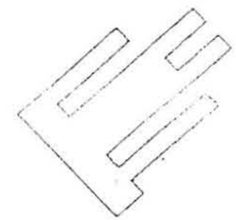
Q.6

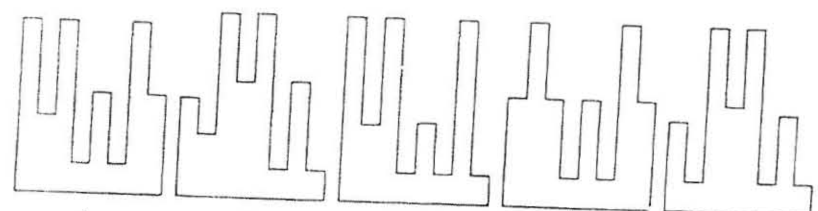




A B C D E

Q.7



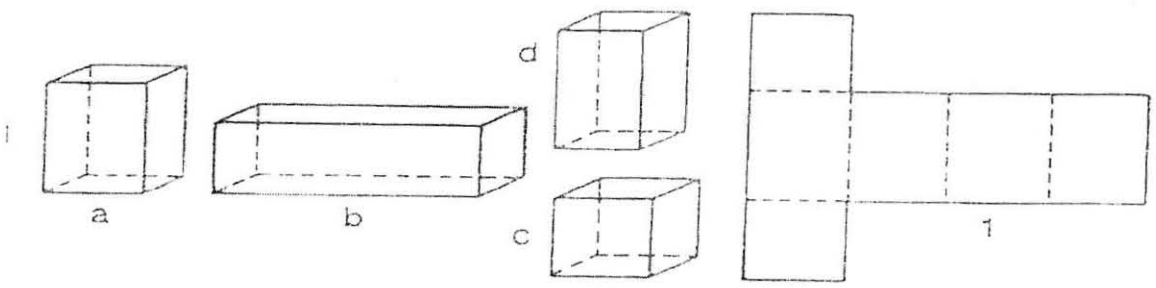


A B C D E

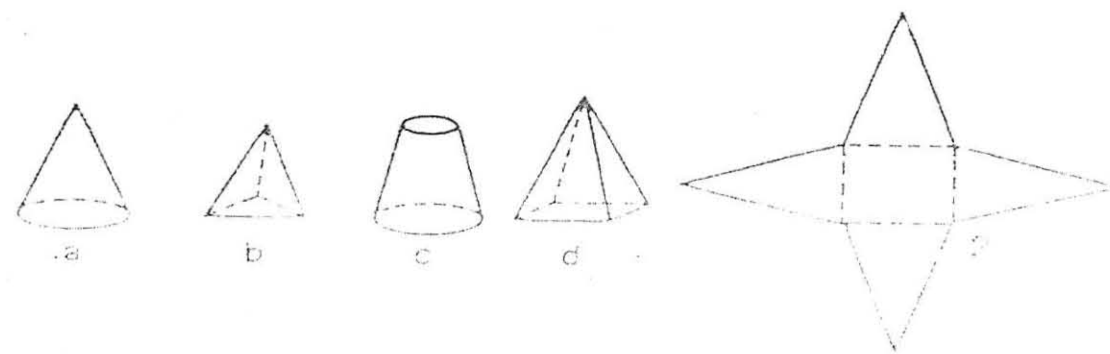
Q.8. 9. 10

Out of the four solid geometry figures (a, b, c, or d), select the one which represents the flattened version (1, 2, or 3) on the right.

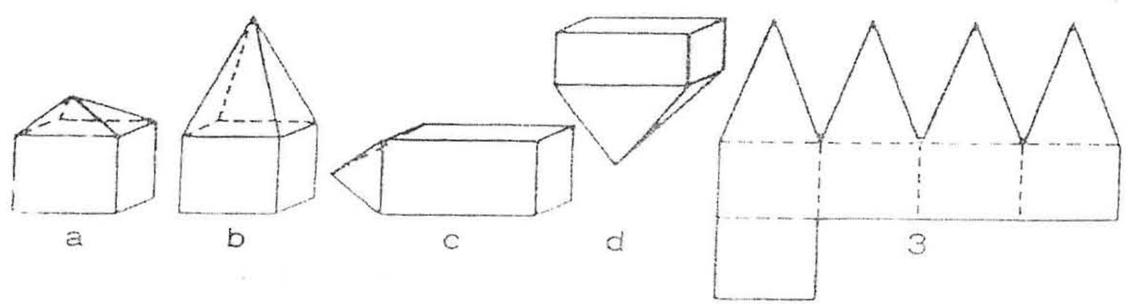
Q. 8



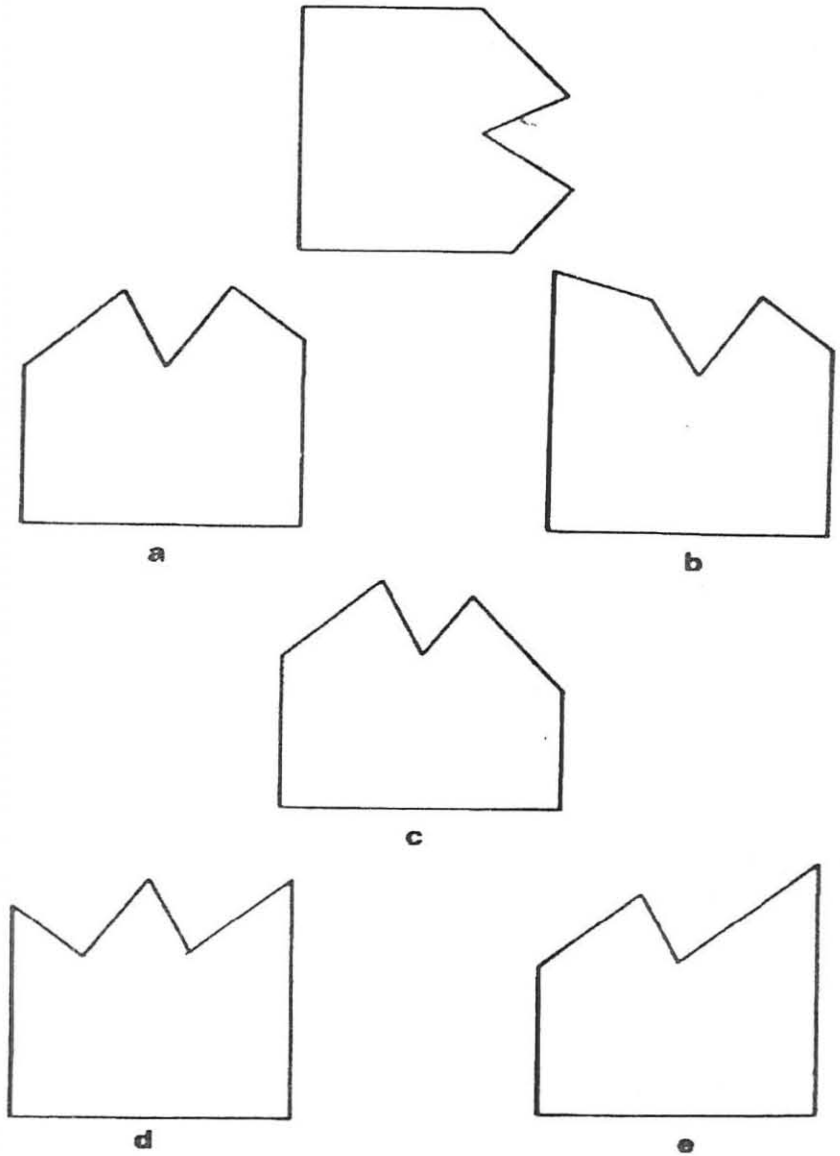
Q.9



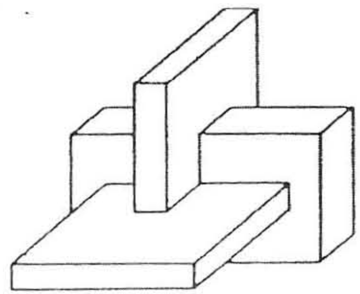
Q.10

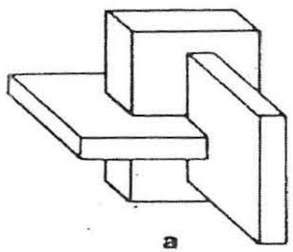


Q.11. Look at the upper shape. With which other shape (a, b, c, d, or e) does it form a rectangle?

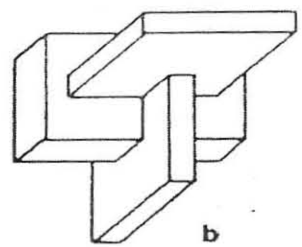


Q.12. Look at the upper shape carefully. With which figure does it become when it is rotated 90^0 <u>clockwise?</u>

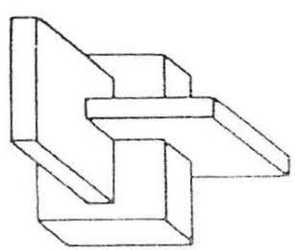




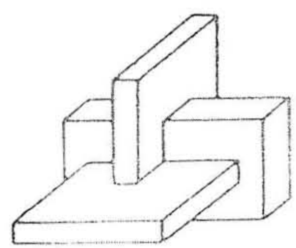
a



b



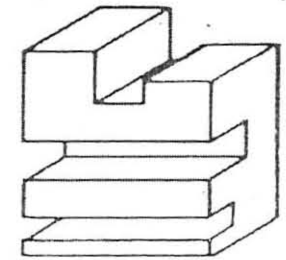
c

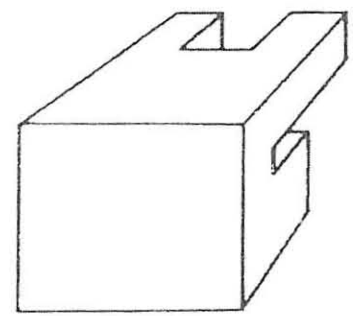


d

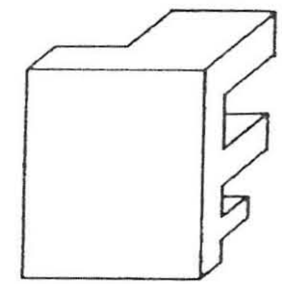
Q.13. Look at upper shape below. With which

other shape (a b or c) does it fit to become a

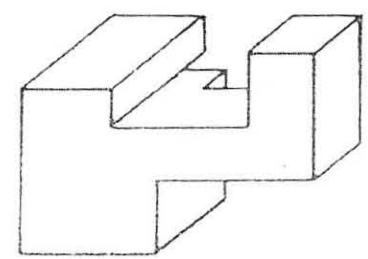




a



b



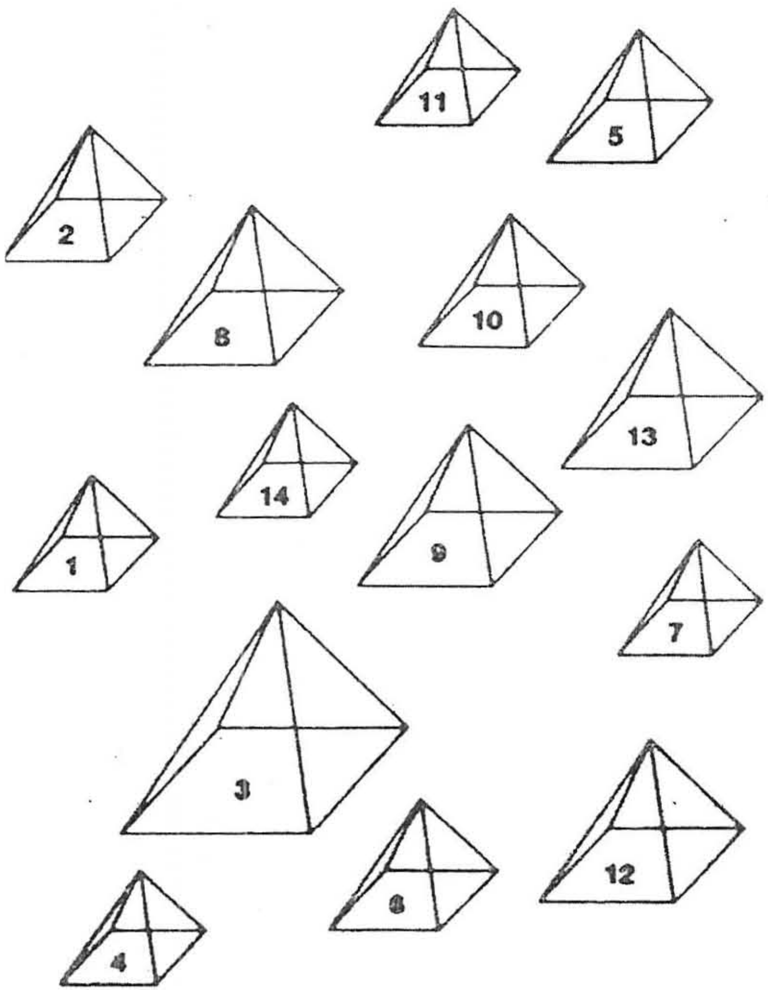
c

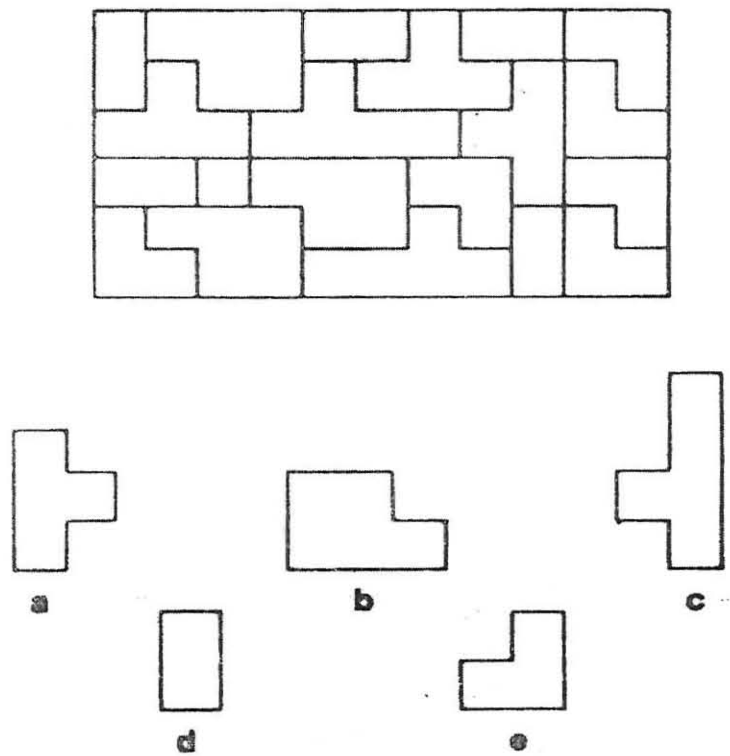
Q.14.

Look at the 14 figures below for a moment. Then indicate which ones are of the same height.

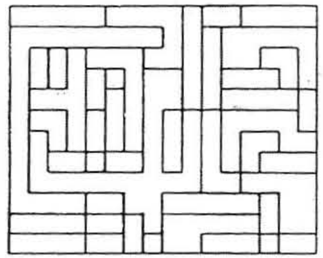
Q.15

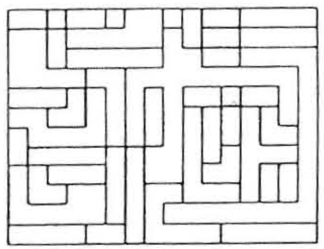
In the mosaic below, how many times are shapes a, b c, d, and e represented within it?



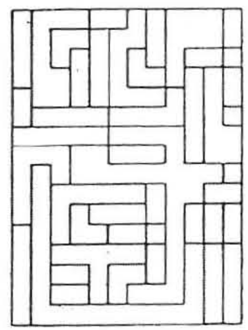


Q.16. Look at the mosaic below. Which figure does it become (a, b, c, or d) when it is turned 90^0 anticlockwise?

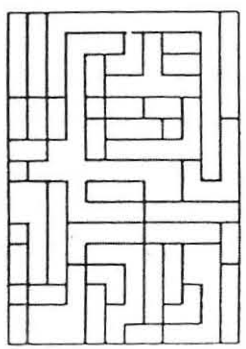




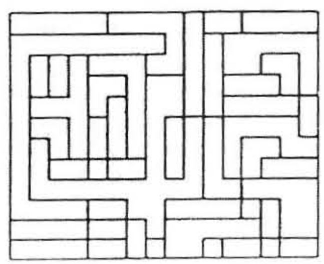
a



b

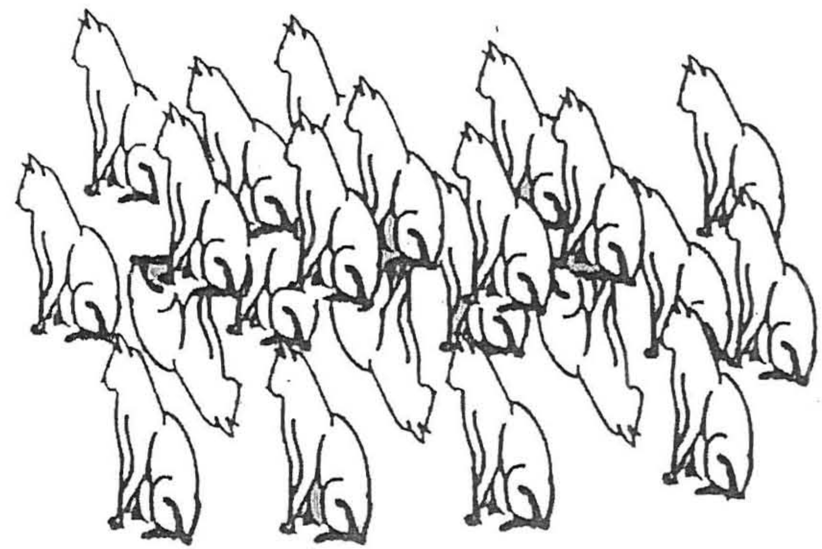


c

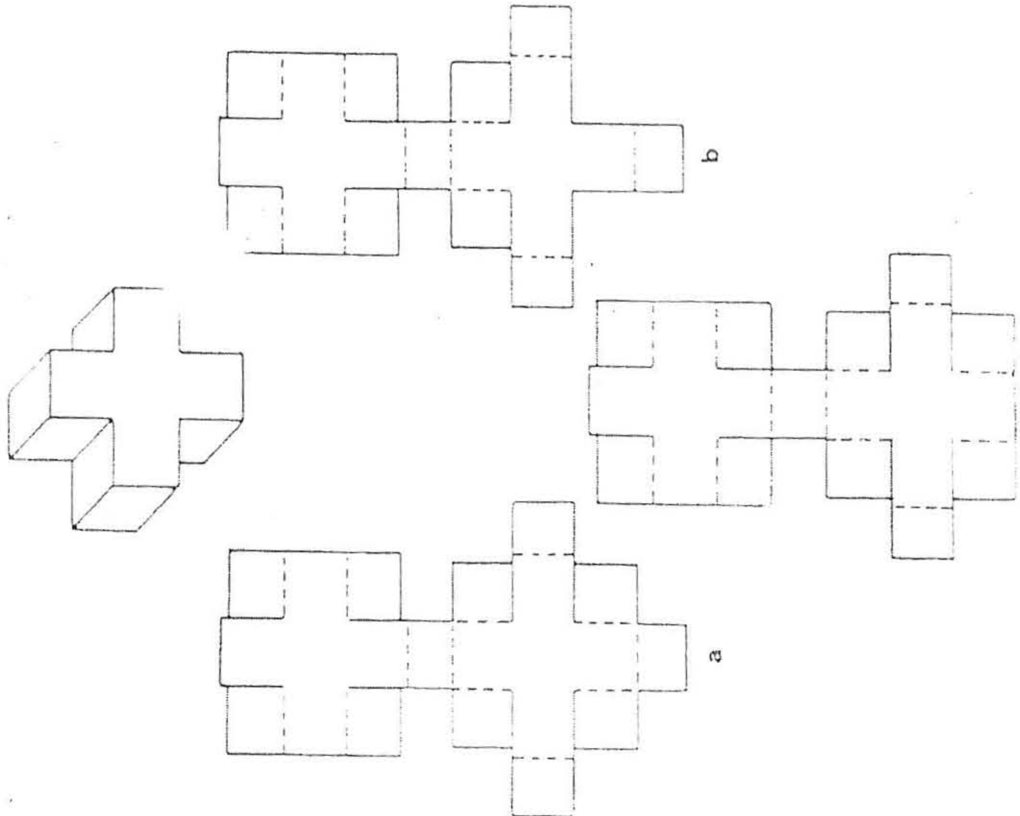


d

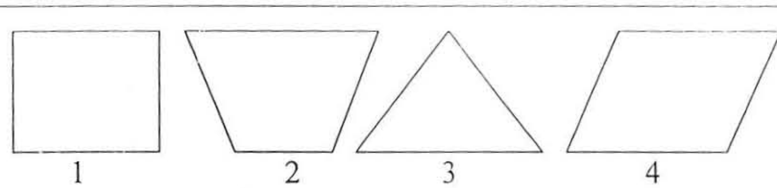
Q.17. Look at the picture below. How many cats are there?

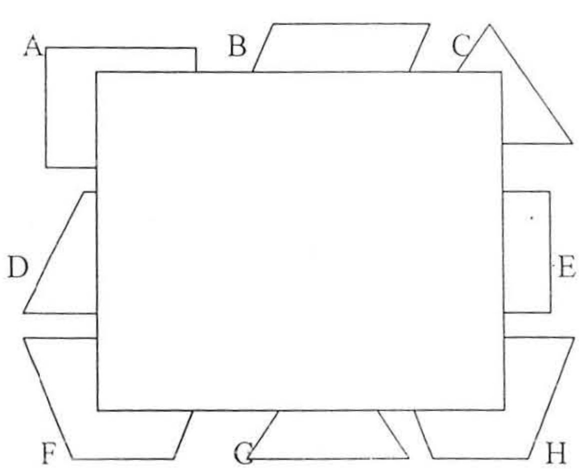


Q.19. Look at the upper shape. It has been mad[e] by folding one of the three figures below it (a, b, or c). Which one?



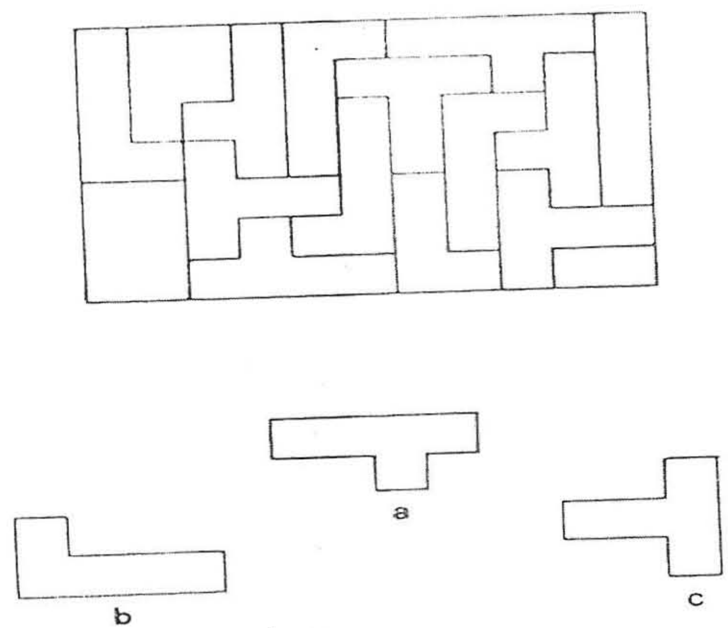
Q.18. The figures 1-4 are partly hidden under an opaque sheet. The letters on the visible parts of the figures have to be matched up with the numbers 1-4.
e.g. If the figure marked A belongs to the square with the number 1, it must be labeled as A – 1





Q.20

In the upper figure below how many times are shapes a, b, and c represented within it?



Appendix C <u>The Math Self-Efficacy scale</u>

ADDIS ABABA UNIVERSITY

COLLEGE OF EDUCATION GRADUATE PROGRAM

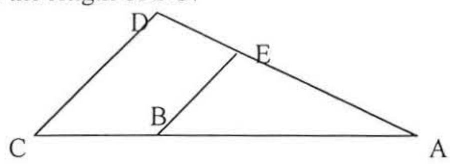
DEPARTMENT OF PSYCHOLOGY

Code________Sex______School__________Time Allowed 30 min.

General Direction: - This scale is developed to collect data on students' math self-efficacy that will be used for writing my master's thesis in partial fulfillment of the requirements for program of graduate studies in Addis Ababa University. Thus you are kindly requested to complete the scale carefully and honestly for your responses are the only ways to reach a reliable research result.

Direction 1: - Below is a scale that addresses your ability to do mathematics and how comfortable and confident you feel in solving mathematical problems. You are only required to estimate (check by "X"), on a five-point scale the extent of your ability to solve and provide answers to each problem. The five points are

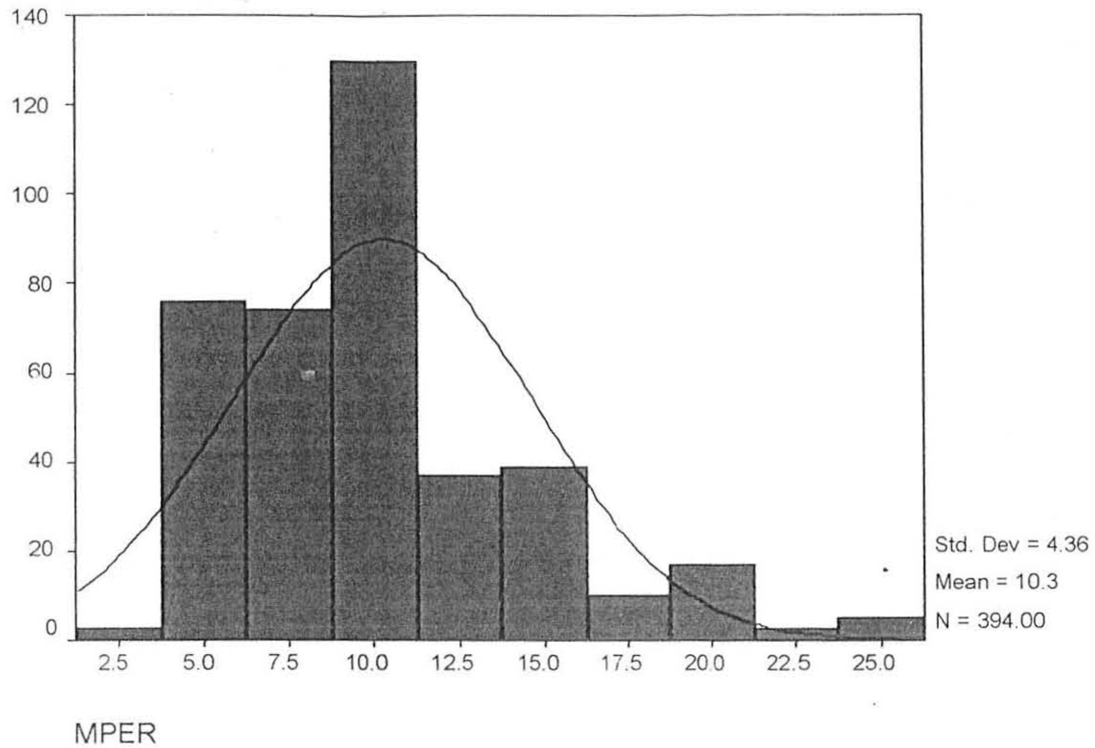
1. Not confident 2. Little confidence 3. Uncertain
4. Much confidence 5. Fully confident

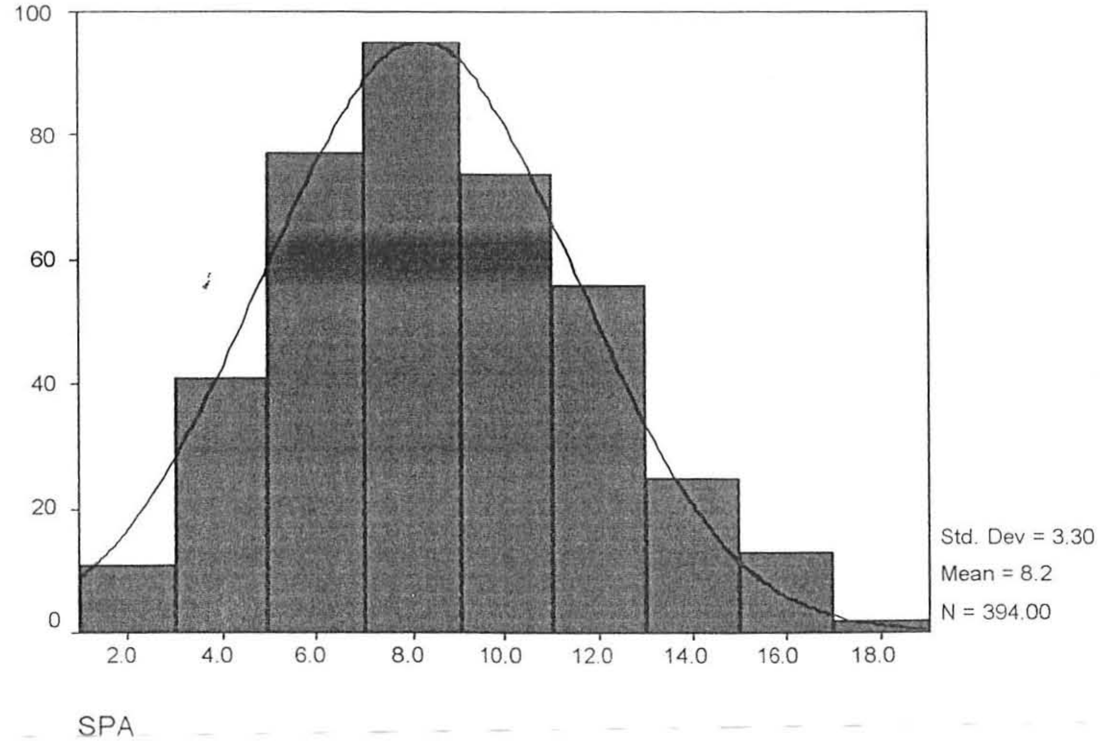
Items	No confidence	Little confidence	Uncertain	Much confidence	Full confidence
1. The expanded form of 121.85 is					
2. $(\frac{1}{2} \div \frac{1}{2}) \div \frac{1}{2}$ = ________________					
3. When the denominator is rationalized $\frac{\sqrt{5}}{\sqrt{5}-2}$ is equal to					
4. The sum of two numbers is 24. One of the numbers is 7 times more than the other. What is the smallest number?					
5. Potential energy: W = m x g x h. Find m.					
6. When simplified $\sqrt{\frac{72}{25}} \times \sqrt{\frac{50}{12}}$ is equal to					
7. In ΔABC, x, y, and z are the interior angles. If $x = 60^0$ and $y = 75^0$, then z is equal to					
8. In the figure below, BA = 2BC, EA = 2DE, and BE = 16. What is the length of DC? A/ 18 B/ 16 C/ 24 D/ 21  					
9. What number is equal to $\frac{37}{6}$ when increased by its reciprocal?					
10. Volume of a cylinder $V = \frac{4}{3}\Pi r^2 h$. Find h					
11. If ½ x + 2/3 =1/4 x – 1/6, then x = ______					
12. $(\sqrt{3} - \sqrt{2})(\sqrt{3} + \sqrt{2})$ is equal to					

13.A mother is now 24 years older than her daughter. In four years the mother will be 3 times as old as the daughter. What is the present age of the daughter?					
14.. The sum of two numbers is 36. If the larger of the two numbers is divided by the smaller one, the quotient is 3. Then the product of the numbers is					
15. Which of the following triplets can be the length of the three sides of a triangle? A/ 1,2,3 B/ 2,7,4 C/ 5,9,4 D/ 3,4,5					
16 $25 + 5 \times 10 - 40 \div 5 + 3 - 14 \div 7 =$ ________________					
17 What is the numeral that immediately follows (TE) twelve?					
18 If $(243)_x = 73$, then the value of x is					
19. . What is the simplified form of $\frac{1}{(16^{3/8})^{-2/3}}$					
20. If A is a sub set of a universal set U, then which of the following is WRONG? A/ $A \cup \phi = A$ B/ $A \cup U' = U$ C/ $A \cap U = A$ D/ $n(A) + n(A') = n(U)$					
21 . x – 2 and x + 3 are factors of					
22. . Let the operation * and Δ be defined on the set of real numbers by $a*b = \frac{a+b}{2}$, and $a \Delta b = (3a + b)^2$. What is the value of (2 * 6) Δ (-4 * 2)?					
23 $(2002)_{three} - (102)_{three}$ is equal to					
24. Which of the following is an irrational number? A/ $\sqrt{9}$ B/ $\sqrt{2}$ C/ 2.3555….. D/ $\frac{13}{9}$					
25. The two sides of a parallelogram are 6cm and 10cm long and the included angle is 60^0. What is the area of the parallelogram?					
26. The volume of a regular square pyramid whose lateral faces are equilateral triangle of side $\sqrt{2}$ is					

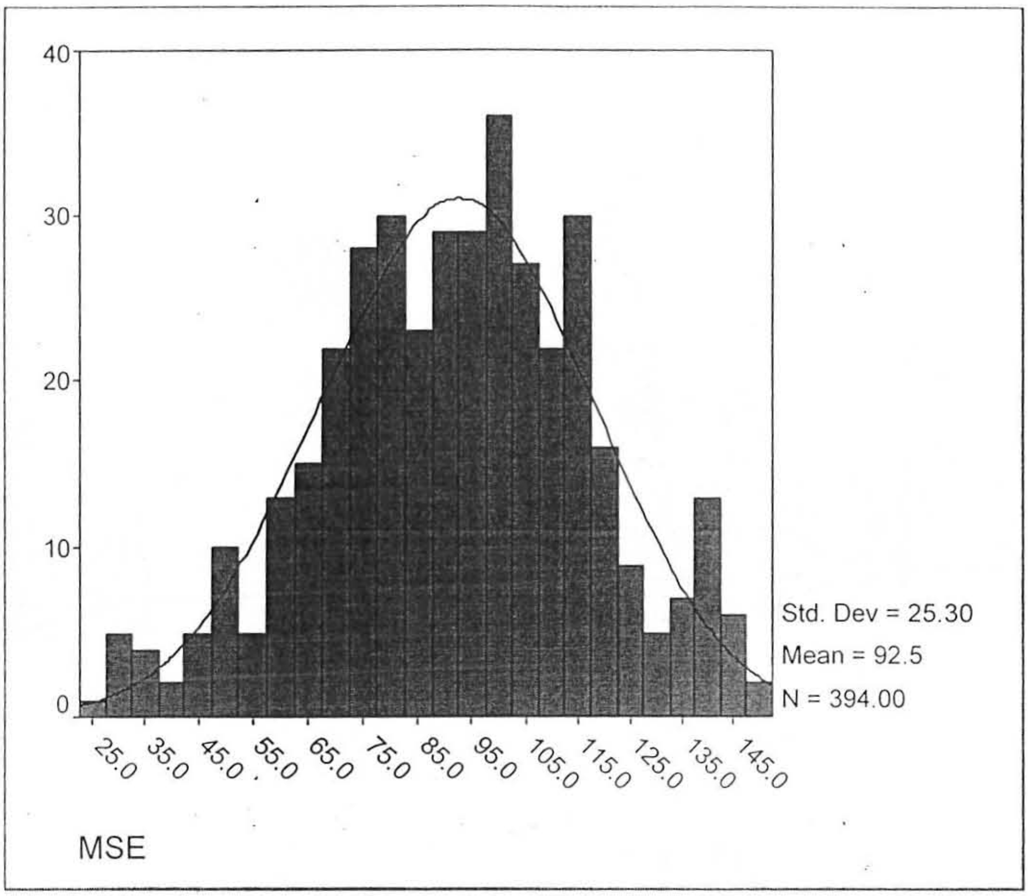
27. If the roots of the equation $2x^2 - 7x - 4 = 0$ are α and β, then the value of $\frac{1}{\alpha + 1} + \frac{1}{\beta + 1}$ is					
28. A is 4 times as old as B. In six years A will be twice as old as B. What is the age of A now?					
29. The altitude of a triangle is 3 units more than twice its base. If the area of a triangle is 4.5sq. unit, then the altitude of the triangle is					
30. If n(A) =7, then n(P(A)) = __________					

Appendix D: <u>Histograms of the Students' Scores on Math Achievement Test, Spatial Ability Test, and Math Self-efficacy Scale</u>





Appendix D: (Contd.)



Appendix E Kolmogorov-Smirnov Normality Test for the Distribution of the Test Scores

		MPER	SPA	MSE
N		394	394	394
Normal Parameter Mean a b		10.251	8.206	92.528
Std. Deviation		4.365	3.302	25.305
Most Extreme Differences	Absolute	.150	.093	.029
	Positive	.150	.093	.027
	Negative	-.081	-.077	-.029
Kolmogorov-Smirnov Z		.981	.853	.579

$p > .05$

a. Test distribution is normal

b. Calculated from data

Statistics

		MPER	SPA	MSE
N	Valid	394	394	394
	Missing	0	0	0
Mean		10.251	8.206	92.528
Std. Error of Mean		.220	.166	1.275
Median		9.50	8.00	93.00
Skewness		.783	.239	-.133
Std, Error of Skewness		.123	.123	.123
Kurtosis		.504	-.435	-.176
Std. Error of Kurtosis		.245	.245	.245
Minimum		2.00	1.00	27.00
Maximum		26.00	17.00	150.00

Appendix F Result of ANCOVA controlling for MSE

Source of Variation	Sum of Squares	df	Mean Square	F	Eta Squared
Corrected Model	3.047	2	1.524	60.133	.235
MSE	.742	1	.742	29.302	.070
Gender	1.127	1	1.127	44.483	.102
Error	9.906	391	.02534		
Corrected Total	12.953	393			

$p < .01$

Appendix G Result of ANCOVA controlling for SPV

Source of Variation	Sum of Squares	df	Mean Square	F	Eta Squared
Corrected Model	2.614	2	1.307	49.433	.202
SPV	.310	1	.310	11.710	.029
Gender	2.051	1	2.051	77.581	.166
Error	10.339	391	.02644		
Corrected Total	12.953	393			

$p < .01$

Appendix H School Wise Distribution of Female and Male Students

School	Female	Male	Total
Negelle S.S.S.	301	349	650
Adola S.S.S.	356	532	888
Oddo Shakisso S.S.S.	129	183	312
Bore S.S.S.	214	336	550
Total	**1000**	**1400**	**2400**

Appendix I Size of the Sample by Gender and School

School	Female			Male			Total
	No of Students	p	Sample Size	No of Students	p	Sample Size	Sample Size
Negelle S.S.S.	301	.301	60	349	.25	50	110
Adola S.S.S.	356	.356	71	532	.38	76	147
Oddo Shakisso S.S.S.	129	.129	26	183	.13	26	52
Bore S.S.S.	214	.214	43	336	.24	48	91
Total	**1000**	**1.00**	**200**	**1400**	**1.00**	**200**	**400**

Appendix J <u>Distribution of Scores on Math Achievement Test by Gender</u>

Score	Mid Point	Female				Male			
		Freq.	Cum Freq	Per. (%)	Cum. Per.	Freq.	Cum. Freq.	Per. (%)	Cu m. Per.
.5-2.5	1.5	1	1	.5	.5	0	0	0	0
2.5-4.5	3.5	8	9	4.1	4.6	4	4	2.0	2.0
4.5-6.5	5.5	56	65	28.6	33.2	10	14	5.1	7.1
6.5-8.5	7.5	38	103	19.4	52.6	36	50	18.2	25.3
8.5-10.5	9.5	52	155	26.5	79.1	32	82	16.2	41.4
10.5-12.5	11.5	25	180	12.8	91.8	40	122	20.2	61.6
12.5-14.5	13.5	6	186	3.1	94.9	25	147	12.6	74.2
14.5-16.5	15.5	8	194	4.1	99.0	18	165	9.1	83.3
16.5-18.5	17.5	0	194	0	99.0	10	175	5.1	88.4
18.5-20.5	19.5	2	196	1.0	100	9	184	4.5	92.9
20.5-22.5	21.5	0	196	0	100	8	192	4.0	97.0
22.5-24.5	23.5	0	196	0	100	4	196	2.0	99.0
24.5-26.5	25.5	0	196	0	100	2	198	1.0	100
Total		196 (N)		100		198 (N)		100	

Appendix K <u>Distribution of Scores on Math Self-Efficacy Scale by Gender</u>

Score Interval	Mid Point	Female				Male			
		Freq.	Cum. Freq	Per. (%)	Cum. Per.	Freq.	Cum. Freq.	Per. (%)	Cum. Per.
24.5-34.5	29.5	9	9	4.6	4.6	1	1	.5	.5
34.5-44.5	39.5	5	14	2.6	7.1	0	1	-	.5
44.5-54.5	49.5	7	21	3.6	10.7	6	7	3.0	3.5
54.5-64.5	59.5	16	37	8.1	18.9	5	12	2.5	6.1
64.5-74.5	69.5	28	65	14.3	33.2	13	25	6.6	12.6
74.5-84.5	79.5	41	106	20.9	54.1	16	41	8.1	20.7
84.5-94.5	89.5	30	136	15.3	69.4	25	66	12.6	33.3
94.5-104.5	99.5	25	161	12.8	82.1	40	106	20.2	53.5
104.5-114.5	109.5	20	181	10.2	92.3	25	131	12.6	66.2
114.5-124.5	119.5	8	189	4.1	96.4	36	167	18.2	84.3
124.5-134.5	129.5	3	192	1.5	98.0	10	177	5.1	89.4
134.5-144.5	139.5	3	195	1.5	99.5	15	192	7.6	97.0
144.5-154.5	149.5	1	196	.5	100	6	198	3.0	100
Total		**196 (N)**		**100**		**198 (N)**		**100**	

Appendix L <u>Distribution of Scores on Spatial Visualization Test by Gender</u>

Score	Female				Male			
	Freq.	Cum. Freq	Per. (%)	Cum. Per.	Freq.	Cum. Freq.	Per. (%)	Cum. Per.
1	1	1	.5	.5	0	0	0	0
2	3	4	1.5	2.0	7	7	3.5	3.5
3	13	17	6.6	8.7	7	14	3.5	7.1
4	11	28	5.6	14.3	10	24	5.1	12.1
5	22	50	11.2	25.5	16	40	8.1	20.2
6	23	73	11.7	37.2	15	55	7.6	27.8
7	23	96	11.7	49.0	19	74	9.6	37.4
8	25	121	12.8	61.7	28	102	14.1	51.5
9	13	134	6.6	68.4	11	113	5.6	57.1
10	29	163	14.8	83.2	21	134	10.6	67.7
11	16	179	8.2	91.3	15	149	7.6	75.3
12	7	186	3.6	94.9	18	137	9.1	84.3
13	4	190	2.0	96.9	12	179	6.1	90.4
14	3	193	1.5	98.5	6	185	3.0	93.4
15	0	193	0	98.5	7	192	3.5	97.0
16	3	196	1.5	100	4	196	2.0	99.0
17	0	196	0	100	2	198	1.0	100
Total	**196 (N)**		**100**		**198 (N)**		**100**	

Appendix M Levene's Test of Homogeneity of Variance for MSE, Log of SPV, and Log of MPER

Variables	Levene Statistic	df1	df2	p
MSE	.077	1	392	.781
Log of SPV	.870	1	392	.351
Log of MPER	.486	1	392	486

Appendix N Levene's Test of Equality of Error Variances across the Gender Groups

F	df1	df2	p
.366	1	392	.545

Declaration

I hereby declare that this thesis is my original work, a study I conducted, under the guidance of Dr. Seleshi Zeleke. All the relevant sources used in this thesis are duly acknowledged.

Samson Wubshet D.

Signature ______________________

Date of submission 03/03/2006

This thesis has been submitted for examination by my approval as a university advisor.

Name Seleshi Zeleke (PhD)

Signature ______________________

Date of submission 03/03/2006