1983

Factors Predicting Pattern of Math Courses and Mathematical Aptitude Test Scores Among High School Women and Men

Mary A. Kanarian
University of Rhode Island

Follow this and additional works at: https://digitalcommons.uri.edu/oa_diss

Recommended Citation

Kanarian, Mary A., "Factors Predicting Pattern of Math Courses and Mathematical Aptitude Test Scores Among High School Women and Men" (1983). *Open Access Dissertations*. Paper 982.
https://digitalcommons.uri.edu/oa_diss/982

This Dissertation is brought to you for free and open access by DigitalCommons@URI. It has been accepted for inclusion in Open Access Dissertations by an authorized administrator of DigitalCommons@URI. For more information, please contact digitalcommons-group@uri.edu.

FACTORS PREDICTING PATTERN OF MATH COURSES
AND MATHEMATICAL APTITUDE TEST SCORES
AMONG HIGH SCHOOL WOMEN AND MEN

BY

MARY A. KANARIAN

A DISSERTATION SUBMITTED IN PARTIAL FULFILLMENT OF THE
REQUIREMENTS FOR THE DEGREE OF
DOCTOR OF PHILOSOPHY
IN
PSYCHOLOGY

UNIVERSITY OF RHODE ISLAND

1983

ABSTRACT

The present investigation was designed to extend the research on cognitive and social factors predicting both pattern of enrollment in mathematics courses across the high school years and twelfth grade mathematical aptitude test scores among women and men. A total of 226 seniors enrolled in a high school located in an upper-class neighborhood in New England volunteered to participate and completed a booklet containing: a student consent form, the Attitudes toward Mathematics Scales (Fennema & Sherman, 1976), the Agency and Communion Competency Scale (White, 1979), and a background questionnaire. A member of the school staff obtained eighth grade Space Relations Test (DAT) scores and twelfth grade Scholastic Aptitude Test (SAT-M) scores from the school records for 169 of the students who volunteered. These 169 students (80 men and 89 women) for whom scores on the cognitive measures were available were the participants in the present study.

No group-related differences of practical significance, as assessed by the Eta statistic, were found between students in the participant and non-participant groups. Few differences of practical significance were found between the senior men and women in the participant group. The men and women were found to have similar backgrounds. No significant sex-related difference was found for either eighth grade Space Relations Test score or twelfth grade SAT-M score.

Significant sex-related differences in favor of the men were found on the variables of experience in math- and space-related courses and activities, perception of encouragement to study math, pattern of math courses completed, traditionality of career choice, and Attitude toward Mathematics, but only the last two reached a level of practical significance of .40.

The results of Multiple Regression Analyses, using a forward stepwise procedure to isolate factors predicting pattern of math courses completed across the high school years revealed that, for both the men and the women, SAT-M score was the most important correlate of pattern of math course enrollment. SAT-M score contributed approximately 56 percent of the total variance accounted for in pattern of math courses for both men and women. When entered into the equations after SAT-M, the effects of eighth grade Space Relations Test score, traditionality of career choice, Agentic Competency score, and Attitude toward Mathematics were negligible.

The results of Path Analyses of factors predicting twelfth grade SAT-M score of men and women revealed that pattern of math courses was the most important determinant of men's SAT-M score, whereas eighth grade Space Relations Test score was the most important determinant of women's SAT-M score. For the men, eighth grade Space Relations Test score was found to be the second most important determinant of SAT-M score, whereas pattern of math courses

Space Relations Test score or twelfth grade SAT-M score. Significant sex-related differences in favor of men were found on the variables of experience in math- and space-related courses and activities, perception of encouragement to study math, pattern of math courses completed, traditionality of career choice, and Attitude toward Mathematics, but only the last two reached a level of practical significance of .40.

The results of Path Analyses of factors predicting twelfth grade SAT-M scores of men and women revealed that both pattern of math courses and eighth grade Space Relations Test score were important determinants of men's and women's SAT-M score. It was concluded that both cognitive and social variables are important determinants of men's and women's twelfth grade mathematical aptitude test scores, as Fennema and Sherman have posited.

ACKNOWLEDGEMENTS

In keeping with the spirit of this dissertation, I would like to thank those who have been significant models and sources of support for me during the evolution of this research. First and foremost, I would like to thank my major professor, Dr. Kathryn Kerns Quina. At every stage of my doctoral program, Dr. Quina has been a most constant source of support, encouragement, and guidance. The combination of competence, nurturance, and enthusiasm which she has exemplified will continue to be a model for me as I work as a professional psychologist in years to come.

My thanks to the other members of my doctoral committee is more than a matter of protocol. Dr. Bernice Lott has been a most constant and valued source of support and guidance. From the initial stages of this research, she has consistently pointed out issues of conceptualization which have enhanced this project immensely. Dr. John Stevenson has been a constant source of encouragement and advice. Even during his sabbatical leave, he willingly consulted with me on matters of methodology and statistics. Dr. Alfred Killilea has also been a supportive and enthusiastic committee member. It has been a pleasure to have had the opportunity to work with this committee and with the members of my oral examination committee, Dr. Joel Cohen and Dr. Janet Kulberg.

I am most grateful to a number of other individuals. I would like to thank Peter Kanarian for his assistance in collecting and coding the data for this research. I would also like to thank Patricia Jefferds for her assistance in preparing this manuscript. This task was made easier by her efforts and support.

The enthusiastic support of my family and friends also made possible the completion of this dissertation. Specifically, I would like to thank Steven and Susan Kanarian for their encouragement at every stage of my college education. Finally, I would like to thank Ann Marie Ficorilli, Dr. Joseph S. Neuschatz, Dr. Lorraine B. Dennis, Dr. Joan H. Rollins, and Dr. Albert J. Lott for having encouraged my academic aspirations and for sharing with me the excitement of my achievements.

TABLE OF CONTENTS

Chapter		Page
I	INTRODUCTION	1
	Statement of the Problem	1
	Significance of the Study	3
	Review of the Literature	5
	Visual-Spatial Ability	5
	Mathematical Ability	15
	Attitudes toward Mathematics	28
	Factors Related to Pattern of Enrollment in Math Courses	35
	Summary and Implications of Literature Review	40
	Objective of the Present Study	41
	Hypotheses	42
II	METHOD	48
	Participants	48
	Measures	49
	Procedure	54
	Analysis of Data	54
III	RESULTS	55
	Participants and Non-Participants	55
	Participants	58
	Longitudinal Analyses of Attitudes toward Mathematics	76

Chapter		Page
	Correlational Analyses	79
	Factors Related to Pattern of	
	Math Courses	83
	Factors Predicting to Twelfth Grade	
	SAT-M Scores	87
	Findings Relevant to Hypotheses	96
IV	DISCUSSION AND CONCLUSIONS	103
	Visual-Spatial Ability	103
	Scholastic Aptitude Test	104
	Perception of Encouragement to	
	Study Math	107
	Attitude toward Mathematics	108
	Pattern of Math Courses	109
	Longitudinal Change in Attitudes	
	toward Mathematics	110
	Factors Related to Pattern of	
	Enrollment in Math Courses	111
	Factors Related to Twelfth Grade	
	SAT-M Scores	116
	Limitations and Implications of	
	Present Research	118
	Strategies for Social Change	123
	REFERENCES	125

Chapter	Page
APPENDIX A	134
Student Consent Form	135
Attitudes toward Mathematics Scales	137
Agency and Communion Competency Scales ..	146
Background Questionnaire	147
APPENDIX B	151
Supplementary Table 15	152
Supplementary Table 16	153
BIBLIOGRAPHY	154

LIST OF TABLES

Table		Page
1	Patterns of Mathematics Course Participation Across the High School Years	51
2	Background of Participants	59
3	Pattern of Parental Employment	61
4	Eighth Grade Differential Aptitude Test Scores: Space Relations and Mechanical Reasoning Ability	62
5	Experience in Math- and Space-Related Courses and Activities	64
6	In-School and Out-of-School Experiences for Men and Women	65
7	Perception of Social Support to Study Math ..	67
8	Patterns of Mathematics Courses Completed Across the High School Years by Men and Women	68
9	Traditionality of Career Choice	71
10	Attitudes toward Mathematics	73
11	Summary of Data from Analyses of Variance ...	78
12	Correlations for Men's Twelfth Grade Scores	81
13	Correlations for Women's Twelfth Grade Scores	82

Table		Page
14	Factors Predicting Pattern of Enrollment in Math Courses	84
15	Factors Predicting Pattern of Math Courses with Hierarchical Procedure	152
16	Factors Predicting SAT-M Scores with Stepwise Procedure	153

LIST OF FIGURES

Figure		Page
1	Variables Determining Senior Year SAT-M Scores	88

CHAPTER I

INTRODUCTION

Statement of the Problem

A steadily decreasing percentage of both boys and girls enroll in advanced mathematics courses during the middle school and high school years, but this decline is sharpest for girls beyond the geometry course (Brush, 1980; de Wolf, 1977; Fennema & Sherman, 1977; Sherman, 1981). Consequently, men outperform women on some mathematics achievement and aptitude tests (see review by Fox, 1980), men are able to major in more areas of study in college than women (Sells, 1978), and men are able to pursue more careers (Fox, 1980; Tobias, 1978) in which mathematical skills are required.

Within recent years, much research attention has been devoted to this phenomenon of lower enrollment in advanced mathematics courses by women and their lower mathematical aptitude test scores. Among the explanations for differential selection of mathematics courses and differential mathematical aptitude are sex differences in visual-spatial ability, sex differences in mathematical ability, and sex differences in attitudes toward mathematics (see reviews by Brush, 1980; Fox, 1980). At present, however, there is considerable debate about the magnitude and nature of sex differences in each of these three areas, since recent research on sex differences has yielded inconsistent results.

Two major camps have formed in this debate. Researchers in one camp "...hypothesize that sex differences in achievement in and attitude toward mathematics are the result of superior male mathematical ability, which may in turn be related to greater male ability in spatial tasks. This male superiority is probably an expression of a combination of both endogenous and exogenous variables" (Benbow & Stanley, 1980, p. 1264). Concurrently, researchers in the other camp are arguing that sex-related differences in visual-spatial ability, mathematical ability, and attitudes toward mathematics may be primarily attributed to socio-cultural factors such as differential socialization practices, differential experiences in mathematics and "space-related" courses and activities, and societal sex-stereotyping of mathematics and science as areas of achievement within the "male domain" (Fennema & Sherman, 1977).

The main objective of the present investigation is to address issues raised by these two hypotheses and to extend the research to male and female high school seniors. The general hypothesis is that both individual differences and socio-cultural variables influence male and female high school students' patterns of advanced mathematics course enrollment and mathematical aptitude test scores.

The individual difference variables to be considered as potential predictors of pattern of enrollment in mathematics

courses across the high school years are: eighth grade visual-spatial ability test scores, eighth grade mechanical reasoning ability test scores, twelfth grade Agentive Competency scores, and twelfth grade Attitude toward Mathematics scores. The socio-cultural variables to be considered are: social class, perception of encouragement to study math from parents and teachers, and traditionality of career choice. The same variables will also be considered as potential predictors of twelfth grade SAT-M scores. In addition, pattern of mathematics courses completed across the high school years will also be considered as a potential predictor of twelfth grade SAT-M scores.

Significance of the Study

To date, a great deal of research attention has focused on sex differences in visual-spatial ability, sex differences in mathematical ability, and sex differences in attitudes toward mathematics, all factors believed to be related to sex differences in advanced mathematics course enrollment and mathematical achievement in the past. However, despite the widespread publicity and debate surrounding the issue of sex-related differences in these factors, relatively few attempts have been made to isolate factors predicting pattern of participation in advanced mathematics courses across the high school years and mathematical aptitude test scores among male and female students of varying ability, grade,

and social class levels. It seems imperative, therefore, that an attempt be made to extend the research in this way.

The relevant literature on sex differences in visual-spatial ability, sex differences in mathematical ability, sex differences in attitudes toward mathematics, and factors related to enrollment in mathematics courses will be reviewed in order to clarify some of the salient issues in this debate. Next the implications of the literature review for further research are outlined and the objectives of the present research are stated. Finally, a description of the present research project and the results of this research are presented and discussed.

REVIEW OF THE LITERATURE

Visual-Spatial Ability

Visual-spatial ability is usually measured by tests that require an individual to mentally manipulate or rotate an object in two-dimensional or three-dimensional space and to select a representation of that object when viewed from a different angle. Visual-spatial performance scores on such tests have been found to be correlated highly with performance measures of field independence/dependence and with tasks involving spatial decontextualization, suggesting that a common factor is involved (Sherman, 1967; 1974; Kagan & Kogan, 1970). Spatial visualization has also been found to be important for successful performance in various aspects of mathematics, engineering, architecture, and science and has been found to be related to skills such as drafting, working with machines, and watch repair (see review by Hoyenga & Hoyenga, 1979; also Bennet, Seashore & Wessman, 1973; Bishop, 1973; Bock & Kolokowski, 1973; Fennema & Sherman, 1977; McCallum, Smith & Eliot, 1979; Sherman, 1967; Sherman & Fennema, 1977).

In early studies of sex differences in visual-spatial ability, researchers found that adolescent and adult men performed better than adolescent and adult women on many tests of visual-spatial ability (see reviews by Anastasi, 1958; Maccoby, 1966; Maccoby & Jacklin, 1974; Vandenberg &

Kuse, 1979). Some evidence was also presented in support of the view that "...there is a heritable component to spatial ability" (see review by Vandenberg & Kuse, 1979, p. 71). Some observers have concluded, therefore, that males are naturally superior to females in spatial ability and have offered a genetic explanation for these observed sex differences (e.g., Stafford, 1961).

X-Linked Hypothesis. One genetic explanation, the X-linked hypothesis, posits that fewer females than males inherit "good potential" for spatial visualization and mathematical problem solving because genes responsible for coding these abilities are both X-linked and recessive (Stafford, 1961; 1972). According to the X-linked hypothesis, a greater incidence of superior spatial ability among males is expected because females must receive the recessive allele from both parents, while males must only receive it from their mothers. If spatial ability is in fact X-linked and recessive, the proportion of females showing this ability would be the square of the proportion of males showing this ability (Sherman & Fennema, 1978; Wittig, 1976).

The expected proportions were first reported by O'Connor (1943) for the Identical Blocks Test and have also been found by Stafford (1961) for the Identical Blocks Test, by Hartlage

(1970) for the spatial section of the Differential Aptitude Test, by Bock and Kolakowski (1973) for the Guilford-Zimmerman Spatial Ability Test, and by Yen (1975) for the Mental Rotations Test and the Form Board Task. However, the expected differences in the proportion of males and females showing high spatial ability were not found by Corah (1965) for the Embedded Figures Test, by Sherman and Fennema (1978) for the spatial section of the Differential Aptitude Test, or by more recent researchers using the Mental Rotations Test (e.g., McGee, 1978).

The X-linked hypothesis also leads to the prediction that specific patterns of correlations for spatial ability will be found between parents and their children (see Wittig, 1976; Vandenberg & Kuse, 1979). Supportive evidence for X-linkage of spatial visualization has been provided by several researchers who have found expected patterns of intrafamily correlations of spatial visualization test scores based on the predictions of the X-linked hypothesis (Bock & Kolakowski, 1973; Corah, 1965; Guttman, 1974; Hartlage, 1970; Stafford, 1961; Yen, 1975). In all of these studies, the father-son correlation in spatial abilities was essentially zero, and boys and men consistently scored higher than girls and women (cited in Hoyenga & Hoyenga, 1979). In a study by Bock (1967), however, no relationship was found between scores of daughters who "excelled" in spatial ability, as

measured by the Embedded Figures Test, and their fathers' scores. This research provided evidence that is not consistent with the prediction of the X-linked hypothesis which posits that that father-daughter correlations greater than zero would be expected since daughters who "excel" in tests of spatial ability must have received one recessive allele from both their fathers and their mothers.

Research testing spatial visualization ability of women with Turner's Syndrome has also provided evidence considered to be non-supportive of the X-linked hypothesis. Since females with Turner's Syndrome have only one allele of each gene located on the X chromosome, and no competing allele on a second X chromosome, as in normal males, they would be expected to show an incidence of superior spatial ability equal to men (Garron, 1970). However, several researchers have found that women with Turner's Syndrome, who have an XO sex chromosome complement, were poorer in spatial ability than chromosomally normal women, even though they performed as well as normal females on verbal tests (see reviews by Hoyenga & Hoyenga, 1979; Wittig, 1976; Vandenberg & Kuse, 1979).

In an attempt to explain the inconsistent results, Bock (1970) and Bock and Kolakowski (1973) suggested a modification of the X-linked hypothesis and proposed that the gene determining spatial ability is both X-linked recessive and

testosterone-limited in its expression (cf. Wittig, 1976). This means that a certain level of testosterone is necessary for good visual-spatial ability (Hoyenga & Hoyenga, 1979). This modification appeared to explain the consistent superiority of adolescent and adult males on tests of visual-spatial ability starting at age 13 when the testosterone level of males reaches a given level. This modification also appeared to explain the data for women with Turner's Syndrome who do not produce testosterone (Wittig, 1976) as well as the data for Kwoshiorkor men who are testosterone insensitive (Hoyenga & Hoyenga).

Buffrey & Gray (1972) hypothesized that sex differences in spatial ability have resulted from natural selection pressures which have caused sex differences in brain organization to appear over the course of time. They have attributed these sex differences in part to an X-linked recessive gene and in part to exposure to optimal amounts of androgen, both before birth and during puberty, which enables the gene to be fully expressed. Some early studies of brain lateralization and spatial ability of young children apparently have provided evidence supportive of this view. However, as Hoyenga and Hoyenga (1979) state in their review, "...the hypothesis of Buffrey and Gray was not strongly supported by recent data" (p. 257-259).

Within the past decade, the X-linked hypothesis has been challenged on theoretical grounds because alleles involved in biologically advantageous traits like IQ and visual-spatial ability tend to be dominant, not recessive (Hoyenga & Hoyenga, 1979; Wittig, 1976). In addition, many of the early studies that were supportive of the X-linked hypothesis have been critized because they are "frought with logical and experimental difficulties" (Fennema, 1974; Sherman 1975; Stage, 1981; Tobias, 1978; Vandenberg & Kuse, 1979; Wittig, 1976). At the present time, the X-linked hypothesis seems to be losing favor as an explanation for sex differences in visual-spatial ability, particularly since the results of many recent studies do not support its predictions (See reviews by Hoyenga & Hoyenga, 1979; Vandenberg & Kuse, 1979; Wittig, 1976; also Brush, 1980; de Wolf 1977; Nash, 1979; Schratz, 1978; Sherman, 1979; Sherman & Fennema, 1978).

Hormonal Influence. Broverman, Klaiber, Kobayashi and Vogel (1968) hypothesized that some of the observed sex-related differences in spatial ability may be attributed to the physiological effects of different levels of androgens and estrogens. This hypothesis seems to be supported by some, but not all, of the relevant research cited in recent reviews of the literature on spatial ability (see reviews by Hoyenga & Hoyenga, 1979; Vandenberg & Kuse, 1979). For

example, it seems possible that the lower spatial ability of women with Turner's Syndrome, cited earlier, could be explained by their lack of fetal androgens. Kwoshiorkor men, with reduced androgen and increased estrogen, also have been found to have poor spatial ability (Dawson, 1972). Females' accuracy on the Rod-and-Frame Test, a task which correlates highly with visual-spatial ability, has been found to "decrease slightly " during the high estrogen phase of the menstrual cycle (Klaiber, Broverman, Vogel & Kobayashi, 1974).

For college women, external signs of androgenicity (e.g., narrowness of hips, smallness of breasts, muscularity) which are assumed to be accompanied by high androgen levels were found to be correlated positively with spatial performance scores (Petersen, 1976; cf. Hoyenga and Hoyenga, 1979). For men, however, an inverse relationship has been found between spatial performance scores and measures which are related to testosterone production (urinary 17-Ketosteroid levels) and external signs of androgenicity (Klaiber, Kobayashi & Broverman, 1967; Petersen, 1976). This finding is "...paradoxical..." as Vandenberg and Kuse (1979) have noted, since both spatial performance scores and testosterone levels have been found to increase in males during adolescence. Vandenberg and Kuse conclude, therefore, that, "Although sex hormones have been found to influence spatial

scores, the effects appear complex. Therefore, attempts to invoke sex hormones to explain sex-related differences in spatial ability seem premature..." (1979, p. 74-75).

Socio-Cultural Factors. Researchers have also found evidence to support the contention of Sherman (1967) that some of the observed sex-related differences in spatial ability may be attributed to sociocultural factors. For example, greater sex-related differences in spatial ability in favor of men have been found in authoritarian cultures in which traditional male and female roles are rigidly defined (Berry, 1976; 1977; cf. Hoyenga and Hoyenga, 1979). In societies in which both boys and girls are socialized to be independent and assertive, both men and women have high spatial ability and minimal sex differences are found (see reviews by Witkin, 1967; Kagan and Kogan, 1970; Vandenberg and Kuse, 1979; Hoyenga and Hoyenga, 1979).

Several studies reviewed by Nash (1978) and Lott (1981) also appear to support the view that successful functioning in visual-spatial tasks may be related to gender stereotypes rather than to sex, per se. Nash (1975) has found a relationship between gender role orientation and spatial performance (as measured by the Space Relations section of the Differential Aptitude Test, DAT) for 11- and 14-year-old boys and girls. Boys who chose traditionally "masculine"

sex-stereotyped adjectives "related to intellectual functioning" to describe their "real selves" (e.g., logical, competent) had better spatial visualization performance scores than boys who chose more traditionally "feminine" sex-stereotyped adjectives to describe their "real selves" (e.g., warm, generous). Girls who chose traditionally "masculine" sex-stereotyped adjectives to describe their "ideal selves" also had better spatial visualization performance scores than girls who chose the more traditionally "feminine" sex-stereotyped adjectives to describe their "ideal selves." Both boys and girls who said they preferred to be boys scored significantly higher on the DAT than children who stated they preferred to be girls (Nash, 1975). In a study testing high school girls on tests of verbal fluency and spatial ability, Maracek (1978) found the same pattern of relationship between non-traditional gender role orientation and higher visual-spatial ability for high school girls that Nash found.

Fennema (1974) and Sherman (1975) suggested that adolescent and adult men in our society may have traditionally outperformed women in tests of spatial visualization because they have traditionally participated in more activities in which they have had opportunities to develop and practice skills related to spatial visualization (e.g., sports, drafting, woodworking, mechanics). They studied high school

students who were designated as "typical for their grade" in four high schools and found significant sex differences in favor of boys in spatial visualization, as measured by the DAT, in only two of the four high schools sampled. The boys in these two high schools reported engaging in significantly more space-related activities (e.g., sports) than the girls outside of school and also took more space-related courses (e.g., drafting) in school. The sex differences in spatial ability became nonsignificant when the number of space-related courses taken was used as a covariate, indicating that learning in space-related courses may affect spatial performance (Fennema and Sherman, 1977).

Practical Significance of Previous Findings. In view of the contradictory evidence regarding sex differences in spatial visualization, several researchers have re-examined the findings of earlier studies. Sherman (1978) re-reviewed some of the evidence and concluded that for supposedly "well established" sex differences, their magnitude seems "quite small." A recent meta-analysis by Hyde (1981) of data from some of the spatial visualization studies included in the well-known Maccoby and Jacklin (1974) review and of the data included in Sherman's (1978) review supported this conclusion.

The omega square values reported by Hyde for studies including middle and high school students reveal that the

proportion of variance of the entire distribution of visual-spatial performance scores that can be accounted for by sex of subject ranged from 0 to .14. These sex differences, even when statistically significant, are of little practical significance. (Only five out of the nine studies analyzed by Hyde were of middle school or high school students.)

Summary. Sex differences in favor of adolescent and adult males were found in early studies of visual-spatial ability, a skill assumed to be important for achievement in mathematics (Bishop, 1973; Hills, 1957; McCallum, Smith & Eliot, 1979). More recent research, however, has yielded inconsistent results and evidence supportive of the influence of socio-cultural factors. There is a growing skepticism about the magnitude and nature of the sex-related differences in spatial ability that were once considered to be "well-established" sex differences. Using meta-analysis techniques to re-examine the magnitude of sex differences in some of the early studies in which statistically significant sex differences were reported, the sex differences were found to be "very small" (Hyde, 1981; Sherman, 1978).

Mathematical Ability

Mathematical achievement and aptitude tests are usually used to measure the mathematical ability of middle and high school age students. In some studies, researchers have used

total or composite test scores as a general measure of mathematical ability and have used these composite scores to assess the extent of differences in mathematical ability between boys and girls. In other studies, researchers have compared boys' and girls' scores on various subscales of mathematical achievement and aptitude tests which purport to measure various skills (e.g., computation skills, quantitative reasoning ability) in an attempt to identify specific sex differences in mathematical ability and aptitude.

In many of both of these types of studies, sex differences in favor of males have been found with adolescent boys, aged 13 and over, scoring higher than their female counterparts (see reviews by Aiken, 1970; 1971; 1976; Maccoby and Jacklin, 1974). As with spatial ability, a variety of explanations have been offered for the observed sex differences in mathematical ability.

X-Linked Hypothesis. As noted in the previous section on visual-spatial ability, it has been suggested that sex differences in favor of males may be expected on tests of spatial ability and mathematical ability because fewer females than males inherit "good potential" for these abilities since genes responsible for coding them are both X-linked and recessive (Stafford, 1972). As with research on spatial visualization, researchers have tested this X-linked hypothesis for mathematical ability using distributional analyses

techniques and intrafamily correlational studies. Unlike the studies of spatial ability, however, the results of these studies have uniformly failed to provide evidence supportive of the X-linked hypothesis.

Distributional analyses of data collected on both monozygotic and fraternal twins by Stafford (1972) using the Mental Arithmetic Problems Test did not support the predictions of the X-linked hypothesis (as noted by Sherman & Fennema, 1978, p. 161). Non-supportive results were also obtained in a study by Sherman and Fennema (1978) who used the same measure of mathematical reasoning ability that Stafford had used to test a large sample of ninth graders who were designated as being "representative of the population of students in their grade" at a public high school.

Stafford (1965) and Guttman (1974) tested the X-linked hypothesis in studies examining observed patterns of intrafamily correlations and comparing these with theoretical values expected on the basis of predictions which would be considered supportive of X-linkage of mathematical ability. Stafford used the Mental Arithmetic Test and Guttman used Raven's Progressive Matrices. The patterns of correlations obtained in both of these studies were not consistent with those that would be predicted by the X-linked hypothesis.

Studies of mathematical ability of women with Turner's Syndrome have also been non-supportive of the X-linked

hypothesis (see review by Hoyenga and Hoyenga, 1979). For example, Shaffer (1962, p. 405) found that females with Turner's Syndrome "had great difficulty understanding mathematics, especially algebra." Since women with Turner's Syndrome have only one X-chromosome like normal males, the X-linked hypothesis would predict an incidence of superior mathematical ability equal to the incidence in normal males (Garron, 1970), unless a high level of testosterone is also present as has been suggested by Bock and Kolakowski, 1973.

Hormonal Influence. The findings from studies of women with Turner's Syndrome and research on testicular-feminized males (Dawson, 1972), have pointed to the possibility that sex-related hormones may play a role in mathematical ability. However, data in this area have been inconsistent, as Hoyenga and Hoyenga (1979) have noted in their review of the literature. In one study, Hoyenga and Hoyenga cited, for example, Dalton (1976) found that young boys and girls whose mothers had been administered progesterone during their pregnancies to treat toxemia were superior to other children in numerical ability. However, this effect was not found for the older children studied and has not been replicated (e.g., Reinisch, 1977, cited in Hoyenga and Hoyenga, 1979).

Socio-Cultural Factors. Within the past few years, several researchers have attempted to identify sociocultural factors related to the differences between the scores of

adolescent boys and girls on mathematical ability and achievement. At present, there seems to be evidence to suggest that some of the sex-related differences in mathematical achievement which have been found to emerge in adolescence (Maccoby and Jacklin, 1974), may be attributed to differential socialization and traditional sex role stereotyping of boys and girls.

For example, the results of several studies reported by Tobias (1978) suggest that females' successful functioning in mathematics may be related to their gender-role orientation, rather than their sex per se. Girls in West Germany who chose traditionally "feminine" sex-stereotyped adjectives to describe themselves (e.g., warm, generous) were found to be "underachievers" in math by Schildkamp-Kuendiger (1974) (see Tobias, 1978). Also, Potter (1974) (see Tobias, 1978) found that women high in math ability "responded positively to a cluster of attributes usually considered to be positively 'masculine valued' or agentic ones, such as logical, persistent, and intellectual as well as to attributes usually considered to be positively feminine ones such as warm and generous." The results of this study and others (see review by Lemkau, 1978), strongly suggest that women who perceive themselves to be logical and competent may have higher math ability than more traditionally oriented women.

For females, a relationship has also been found between self-esteem, locus of control, and mathematical reasoning aptitude test scores, as measured by the Mathematics portion of the Scholastic Aptitude Test (SAT-M). Starr (1979) found that SAT-M scores of a sample of "college-bound" high school senior women, were significantly correlated with high self-esteem and internal locus of control, while no significant relationship was found between these personality factors and comparable "college-bound" high school senior men's SAT-M scores.

Fennema and Sherman (1977) have suggested that differential advanced mathematics and science course participation is responsible for some of the observed sex differences in mathematical achievement and aptitude test scores. To date, several researchers have tested the Fennema-Sherman hypothesis, but these studies have yielded inconsistent results. For example, Hilton and Berglund (1974) first attempted to test this differential course-taking hypothesis in a longitudinal study in which the number of mathematics courses "college-bound" and "vocational" students had taken was controlled. In this study, the Sequential Test of Educational Progress (STEP) and the School and College Ability Test (SCAT) were given to 10-year-old students, who were retested at ages 12, 14, and 16. No significant sex differences were found among 10-year-olds on the mathematics portion of

the STEP. However, boys in the the "college-bound" group scored significantly higher than "college-bound" girls at ages 12, 14, and 16. On the SCAT, "college-bound" girls scored higher than boys at age 10, but boys scored higher than girls at age 16. Since, the number of mathematics courses previously taken by these students was controlled, this factor can not account for the sex differences found in mathematics achievement in this study.

Fennema and Sherman (1977) also controlled for students' mathematics preparation in a large study testing high school students designated as "typical for their grades" in four public high schools. However, they controlled the specific mathematics courses the students had taken, rather than just the total number of courses as Hilton and Burglund had done. In the Fennema-Sherman study, significant sex differences in favor of boys in mathematics achievement, as measured by the Test of Academic Progress (TAP), were found in only two of the four schools tested, and these differences were reportedly "very small" in magnitude.

In one of the two schools in which boys and girls differed significantly in mathematics achievement, they also differed significantly in the number of "math-related" (science) courses taken. When the number of these "math-related" courses taken was used as a covariate, the sex differences in mathematics achievement became non-significant.

The results of this study, then, support the contention that controlling for previous coursework in mathematics (both number and type of courses) and other "math-related" areas tends to reduce obtained sex differences in mathematical achievement.

Wise, Steel, and MacDonald (1979) also provided evidence that controlling for mathematics coursework is important in this type of research. In their study, data collected from Project Talent, a longitudinal study of 400,000 high school students in 1960 were reanalyzed to determine the extent of sex differences with and without controlling for the effects of differential course-taking. Without controlling for previous coursework taken, no sex differences had been found among the ninth graders in the Project Talent Study in 1960, but by 1963 these same students differed significantly. The gains by males on the test were reported to be more than twice the gains of females in the three year interval. However, when the data were reanalyzed to control for the number of mathematics courses taken in high school, the sex differences among the seniors disappeared (in Fox, 1980, p. 10).

In a survey of 13-year-olds and high school seniors (Armstrong, 1979, cf. Fox, 1980) sex differences in favor of males in the composite test score disappeared in all but one of seven participation groups when exposure to mathematics courses was controlled. Significant sex differences in

favor of males were found on the problem solving subtest among boys and girls who had enrolled in, or who had not gone beyond, courses in general mathematics. However, no differences were found for males and females who were enrolled in, or who had completed, geometry, precalculus, or calculus.

Without controlling for previous math courses taken, the National Assessment of Educational Progress second mathematics assessment also found significant sex differences among samples of 13-year-olds and 17-year-olds on two of the three subtests used. At age 13, females scored higher than males on the computation subtest and males scored higher on the applications subtest. Males at age 17 continued to outperform females on the applications subtest, but no significant sex difference was found on the computations subtest at this age.

When the data on 17-year-olds were reanalyzed to control for the amount of mathematics studied, males at each level of study scored significantly higher on the applications subtest. Males whose highest level of study was algebra II outscored females at this level on computations, but not on algebra. Males who went beyond algebra II scored higher than their female counterparts in both algebra and computations (Armstrong 1979, cf. Fox, 1980). Armstrong has noted that "the boys' higher scores seem to be due to a group of very bright boys who do so well that they pull up the boys' averages" (cf. Fox, 1980; Kolata, 1980).

Sex differences in quantitative ability among college-bound high school juniors was also examined by de Wolf (1977) in a study in which the pattern of mathematics and physics coursework previously taken was controlled. The Washington State Pre-College Test was used as a measure of quantitative ability in this study, and boys' and girls' scores on several subtests were compared. Without controlling for pattern of previous coursework, the results of t-tests indicated that the boys had taken more math courses and scored higher on tests of achievement, but the girls had earned higher course grades. When grouped according to pattern of coursework in mathematics and physics taken, both t-tests and Multiple Regression Analysis revealed that there were no significant sex differences in mathematics achievement (i.e., algebra and geometry knowledge) or spatial visualization ability, although there were significant sex differences in favor of boys for mechanical reasoning (i.e., physics principles applied to mechanical devices).

The differential course taking hypothesis of Fennema and Sherman has also been tested in a study by Benbow and Stanley (1980), who have reported evidence inconsistent with it. In this study, Benbow and Stanley found significant sex differences in favor of boys in mathematical reasoning ability among "mathematically talented" seventh and eighth grade students before any differential course-taking had occurred.

These data are impressive because they were obtained over a seven-year period and because both mathematics preparation and ability of students' were controlled. Over 9,000 seventh and eighth grade students who were designated as mathematically talented on the basis of previously administered standardized achievement test scores (test unidentified) participated in six talent searches by the Study of Mathematically Precocious Youth (SMPY) between the years 1972 and 1979. Of these students, 57 percent were boys and 43 percent were girls. The mathematics section of the Scholastic Aptitude Test (SAT-M), a pre-college test designed for juniors and seniors in high school, was used as a measure of mathematical reasoning ability in this study. Benbow and Stanley reported finding "large sex differences" in favor of boys in mathematical reasoning ability in every year the talent search was conducted. They noted that the sex differences found could be accounted for by the "lack of high scoring girls" in these talent searches since "...no girl ever earned the highest SAT-M score." Examination of their data reveals that differences between boys' and girls' highest scores decreased over these seven years, however, ranging from 190 points for eighth graders in 1972 to 30 points in 1979.

Benbow and Stanley (1980) also reported finding sex differences in favor of men in a follow-up survey of talent

search participants which revealed that the 40-point mean difference on the SAT-M scores in favor of boys at the time of the talent search in which this group of students participated, had increased to a 50 point mean difference by the time of their high school graduation in 1977.. This increase was reported to have occurred even though an equal proportion of these men and women (83 percent) had taken mathematics in the eleventh grade. However, these researchers have also pointed out that approximately 35 percent fewer girls than boys had taken calculus in high school. Benbow and Stanley concluded that the sex differences they found in SAT-M scores among the seniors "stemmed mainly from this differential course-taking." They attributed the differential course-taking to initial sex differences in mathematical reasoning ability, however, rather than the reverse as Fennema and Sherman have suggested.

Practical Significance of Previous Findings. In many studies of mathematical ability or achievement of adolescents and adults, researchers have reported finding statistically significant sex differences in favor of boys and men. However, the practical significance of these findings is now being questioned. For example, Hyde (1981) applied meta-analysis techniques to some of the early studies of quantitative ability cited by Maccoby and Jacklin (1974), assessing the magnitude of these reported sex differences. The result

of the meta-analysis indicated that these sex differences are "quite small." Only three of the studies included in Hyde's meta-analysis sampled middle or high school students. The omega square values found by Hyde for these studies ranged from only .01 to .17. Therefore, very little of the variance in "quantitative ability" in these studies can be accounted for by sex differences.

Rossi (1981) applied meta-analysis techniques to the Benbow and Stanley (1980) data. He reported that, "For the entire sample of 9927 students, the differences between boys' and girls' scores on the mathematics portion of the Scholastic Aptitude Test (SAT-M) averaged 0.44 standard deviation and accounted for less than five percent of the total variance" (p. 3). Rossi concluded, therefore, that sex of subject accounted for a very small proportion of the total variance in the Benbow and Stanley data.

Summary. In early studies of sex differences in mathematical ability and aptitude, sex differences in favor of adolescent and adult males were often found. As with spatial ability, more recent studies have sometimes yielded ambiguous results, and the magnitude of the statistically significant sex differences in mathematical ability and aptitude that have been reported is being challenged.

Attitudes toward Mathematics

Attitudes toward mathematics among adolescents and adults are most commonly assessed with Likert-type scales that measure the extent of rater agreement/disagreement with statements about mathematics operations and/or mathematics course participation. Several scales have been designed to assess general attitudes toward mathematics and were used in many of the early studies in this area (e.g., see reviews by Aiken, 1976; Brush, 1980). The majority of studies in which these general attitude scales were utilized have found that adolescent and adult males held more positive attitudes toward mathematics than adolescent and adult females. Since positive attitudes toward mathematics were found to be associated with advanced mathematics course participation, it appeared to some observers that females' negative attitudes toward mathematics discouraged them from pursuing advanced study in this area.

Within recent years, scales have been designed to attempt to assess more specific components of attitude toward mathematics, such as self-confidence in math and attitude toward success in mathematics (e.g. Fennema & Sherman, 1976). Recent research, in which these more specific attitude toward mathematics scales have been utilized, has yielded an inconsistent, but interesting pattern of results.

Perceived Usefulness of Mathematics. Researchers have found that, in general, adolescent and adult men in our country perceive mathematics as a more interesting area of study than adolescent and adult women, and that more men than women view mathematics as relevant to their future education and career goals (Brush, 1980, Ernest, 1976; Haven, 1971; Hilton & Berglund, 1974; Keeves, 1973). Evidence has also been found that the extent to which both boys and girls perceive mathematics as useful to their future educational goals and career plans decreases across the high school years (Brush, 1980). Sex differences in perceived usefulness of math were not found among "mathematically talented" seventh and eighth graders who participated in SMPY Talent Searches (Benbow & Stanley, 1980), however, suggesting that level of student ability may also be a factor influencing perceptions of usefulness of mathematics to future educational and career goals.

Students' perceptions of usefulness of mathematics to future educational and career goals have been found to be positively related to mathematics achievement in a study of 13- and 17-year-old students (Armstrong, 1979; cf. Fox, 1980) and of twelfth grade girls in a study of "typical" high school students (Fennema & Sherman, 1977). However, perceived usefulness of mathematics was not found to be related to mathematical reasoning aptitude (SAT-M) scores among

"mathematically talented" seventh and eighth grade boys and girls (Benbow & Stanley, 1980). To date, there do not appear to be any studies focusing on the relationship between attitudes toward mathematics and mathematical reasoning aptitude (SAT-M) scores among "mathematically-talented" and/or "academically-talented" high school students or among high school students not enrolled in advanced mathematics courses.

Self-Confidence in Math. Evidence has been found to indicate that adolescent girls and adult women have less self-confidence in their ability to succeed in math courses than adolescent boys and adult men (see reviews by Fox, 1980; Tobias, 1978; also, Brush, 1980; Dornbusch, 1974; Ernest, 1976; Feinberg & Halperin, 1976; Fennema & Sherman, 1977; Sherman, 1979; Weigers & Frieze, 1977). For girls, self-confidence in their ability to perform in math courses has been found to be negatively related to both anxiety about mathematics and stereotyping of mathematics as a "male domain" (Fennema & Sherman, 1977; Sherman, 1979).

A relationship was also found between high school students' traditionality of career choice and their expectations for success in mathematics courses (Weigers & Frieze, 1977). Girls who reported they intend to pursue "non-traditional" careers had higher expectations for success and greater perceived math ability than girls who were planning to pursue "traditional" careers. Even so, the boys in the Weigers and

Frieze study were found to have higher perceived "mathematical aptitudes" than did any of the girls tested. A positive relationship was also found between self-confidence in math and actual achievement in mathematics for "typical" high school students of both sexes (Fennema & Sherman, 1977).

Effectance Motivation in Mathematics. Effectance motivation in mathematics is viewed as "a problem solving attitude" (Fennema & Sherman, 1976) or "joy and intrigue in problem solving" (Sherman, 1981), an attitude which has been associated more highly with boys and men than with girls and women in the past (e.g., Kagan, 1964). However, in the one recent study that examined effectance motivation in mathematics among "typical" high school students in grades 9 to 12, no significant sex-related differences were found in this dimension among students enrolled in math classes (Fennema & Sherman, 1977). There do not appear to be any studies examining sex-related differences in effectance motivation among either "mathematically-talented" students or among students not enrolled in mathematics courses.

Attitude toward Success in Mathematics. Horner (1972, 1973) reported finding that some "highly capable" college women from middle-to-upper middle class families, who were pursuing "traditionally masculine" careers tended to manifest a "fear of success" or a motive to avoid success, in intellectual areas traditionally assumed to be within the male

domain. In addition, an association has been found between "fear of success," area of achievement, and gender with the greatest number of "fear of success" themes being written by both men and women in response to cues of success of either a man or woman in "opposite sex-stereotyped" areas of achievement (Hoffman, 1974).

In the one study in which "typical" high school students' attitudes toward success in mathematics were assessed, no significant sex-related differences were found among students enrolled in mathematics courses (Fennema & Sherman, 1977). However, social class differences in boys' and girls' attitudes toward success in mathematics were found in that study. Girls in mathematics courses at two high schools enrolling higher socio-economic class students showed "somewhat less positive attitudes toward success in mathematics than boys enrolled in mathematics courses." The opposite pattern was found at two high schools enrolling lower socio-economic class students.

Math as Male Domain. Researchers have found that children in our society usually begin to stereotype mathematics and science as areas of achievement more appropriate for males than for females somewhere around the age of eleven (Husen, 1967; Nash, 1975; Stein & Smithells, 1969). However, more recent studies (Brush, 1980; Fennema & Sherman, 1977) have found that middle school and high school girls view

middle school and high school boys. For girls, a negative relationship has been found between stereotyping of math as a "male domain" and self-confidence in math (Fennema & Sherman, 1977; Sherman, 1979), as noted earlier, and between stereotyping of math as a "male domain" and achievement in mathematics (Fennema & Sherman, 1977).

Perception of Social Support to Study Math. There appears to be a great deal of anecdotal evidence to indicate that differential messages are communicated to boys and girls by parents and teachers about their ability to succeed in math courses (e.g., see reviews by Fox, 1980; Tobias, 1978; also, Koff & Makros, 1978). However, recent research testing the notion that boys perceive more encouragement than girls to study math has yielded inconsistent results. Fennema and Sherman (1977) found significant sex-related differences in favor of boys in perceptions of encouragement by parents to study math among "typical" high school students enrolled in mathematics courses, but they did not find significant sex-related differences in perceptions of encouragement by teachers. Brush (1980) did not find significant sex-related differences in students' perceptions of encouragement to study math from parents, teachers, or peers in the students' "social milieu" among middle school and high school students.

There has been some anecdotal evidence to suggest that parents, teachers, and peers of "mathematically-talented"

girls may discourage them from pursuing advanced study in math (see reviews by Fox, 1980; Tobias, 1978), and in one study (Fennema & Sherman, 1977) a positive relationship was found between students' perceptions of parental encouragement to study mathematics and achievement in mathematics among "typical" high school students enrolled in mathematics courses. In the same study, perceptions of encouragement from fathers and teachers were found to be especially important factors predicting achievement in mathematics among twelfth grade girls enrolled in math courses.

Summary. Early studies of sex differences in attitudes toward mathematics typically reported that adolescent and adult men held more positive attitudes toward mathematics than adolescent and adult women (e.g., see reviews by Aiken, 1976; Brush, 1980). Within recent years, however, some research has yielded inconsistent results (see review by Fox, 1980). Some of the disagreement appears to be attributable to differences in choice or measurement of key variables, as Fox has pointed out. However, there also appear to be gender, grade, ability level, and social class effects for some specific attitudes toward mathematics, such as perceived usefulness of math, attitude toward success in math, and perception of social support to study math.

Factors Related to Pattern of Enrollment in Math Courses

Visual-Spatial and Mathematical Ability. Level of spatial ability and mathematical ability of students prior to differential course-taking in high school has been found to predict participation in high school mathematics courses. In a study focusing on factors predicting future mathematics course plans among middle school and high school students, "ability" of student was found to be a predictor of mathematics course plans for high school students, but not for middle school students (Brush, 1980). In that study, I.Q., mathematics ability, and spatial ability test scores were combined into one ability measure for the high school sample, whereas only I.Q. and mathematical ability test scores were combined into one ability measure for the middle school sample.

In a recent report of a longitudinal study of factors postdicting years of enrollment in theoretical mathematics courses among "typical" high school students, eighth grade spatial visualization ability level was found to be the most important predictor of years of enrollment for girls and the least important predictor of enrollment for boys (Sherman, 1981). Verbal ability was found to be the second most important predictor of enrollment for girls, whereas achievement in mathematics was the second most important factor for boys.

Attitudes toward Mathematics.

1. Perceived Usefulness of Mathematics. Sex-related differences in the perception of the usefulness of math to future education and career plans have been found to contribute to the differential advanced math course enrollment of boys and girls (see review by Tobias, 1978; also, Fennema & Sherman, 1977). In a recent review of the relevant literature, Fox (1980) concluded that "There is considerable evidence to suggest that the decision to study advanced mathematics courses in high school is influenced by students' career interests in grade 9 or even as early as grade 7" (p. 21). Students of both sexes who are planning to pursue traditionally "masculine" career interests or are undecided about their future education and career plans perceive math as a more useful area of study and select more advanced mathematics courses than do students who are planning to pursue traditionally "feminine" careers.

The importance of the perceived usefulness of math as a selection factor differentially affecting advanced math course enrollment has been demonstrated in a study by Wexler (1980). In that study, sex differences in advanced math course enrollment at one high school "sharply diminished" after boys and girls participated in a career awareness program in which the relationship of advanced math to future career goals was stressed.

2. Self-Confidence in Math. Self-confidence in math is another factor which predicts mathematics course plans among high school students (Brush, 1980) and postdicts years of enrollment in theoretical mathematics courses (Sherman, 1981). For men, self-confidence in math was the most important factor postdicting years of enrollment in theoretical mathematics courses across the high school years, whereas for women, self-confidence was the fourth most important factor postdicting enrollment.

3. Attitude toward Success in Mathematics. Despite the fact that there appears to be a great deal of anecdotal evidence to suggest that negative attitudes toward success in mathematics, or "Fear of Success" in math, may be an important selection factor for high ability women (e.g., Fox, 1980; Tobias, 1978), there do not seem to be any empirical investigations in which this hypothesis was tested. However in one study in which sex differences in attitudes toward success in mathematics among "typical" students enrolled in high school mathematics classes were assessed, girls from schools located in higher socio-economic class neighborhoods were found to hold less positive attitudes toward success in mathematics than girls at schools located in lower socio-economic class neighborhoods (Fennema & Sherman, 1977). Further investigation is needed to determine if attitude toward success in mathematics is a selection factor

for "academically talented" high school girls from high socio-economic class families.

4. Math as Male Domain. In a study of factors predicting mathematics course plans among middle school and high school students, perception of math as a "male domain" was not found to be a selection factor (Brush, 1980). In that study, however, students did not strongly stereotype math as a male area of achievement, and girls viewed mathematics as a more sex-neutral area of study than boys. In a longitudinal study of factors postdicting "typical" high school students' actual years of enrollment in theoretical mathematics courses across the high school years, stereotyping of math as a "male domain" was found to be an important selection factor for men (Sherman, 1981). A positive relationship was found between stereotyping of math as a "male domain" and years of enrollment in math courses for men but not for women in that study.

5. Perception of Social Support to Study Math. Brush (1980) did not find students' perceptions of encouragement to study math from people in the students' "social milieu" to be a factor predicting intended mathematics course plans among middle school and high school students. In a study of "typical" high school students actually enrolled in mathematics courses, however, students' perceptions of encouragement to study math from father and teachers were

found to be most positive among twelfth grade women, indicating that perception of encouragement from father and teachers may be important selection factors for girls as they grow older (Fennema & Sherman, 1977). This conclusion appears to be supported by evidence from retrospective reports in which perceived encouragement to study math from parents, teachers, and peers appeared to be especially important selection factors for women (Casserly, 1980; Luchins & Luchins, 1980; cf. Fox, 1980).

Mathematics Anxiety. It has been suggested that much of the math avoidance among adolescent and adult females may be due to "math anxiety" (Tobias, 1978) or "mathophobia" (Lazarus, 1974) caused by negative past experiences with math. However, a review of the relevant research on "math anxiety" does not appear to support this view unequivocally. Even though there is ample evidence to suggest that both "math anxiety" and avoidance of advanced mathematics courses are disproportionate among women (Tobias, 1978), "math anxiety" does not appear to be a phenomenon limited to women who avoid advanced math courses. Instead, "math anxiety" seems to be prevalent among students of both sexes who perform poorly in math courses (Seepie & Keeling, 1978), those who have inadequate preparation to pursue advanced study in math (Betz, 1978; Hendel, 1980; Rounds & Hendel, 1980), those who lack self-confidence in their mathematical ability (see

reviews by Aiken, 1970, 1976; Fennema & Sherman, 1978), those who fear negative evaluation of their course work (Hendel, 1980), and those who have high general test anxiety (Betz, 1978).

Summary. There seems to be some research evidence to suggest that a positive relationship may exist between mathematics course participation in high school and eighth grade visual-spatial and mathematical ability level of students as well as certain attitudes toward mathematics.

Summary and Implications of Literature Review

There is currently considerable debate about the magnitude and nature of sex differences in visual-spatial ability, mathematical ability, and attitudes toward mathematics; factors assumed to be related to advanced mathematics course participation and mathematical reasoning aptitude test scores. This debate has received widespread publicity both within and outside of the scientific community, but there have been few attempts to isolate the specific factors related to pattern of enrollment in advanced mathematics courses and mathematical reasoning aptitude test (SAT-M) scores among male and female high school students of varying ability, grade, and social class levels.

A review of the relevant literature has suggested the following directions for research: 1) Examine patterns of

relationship among a variety of potential predictors, including eighth grade visual-spatial ability; 2) Shift research interest from simple assessment of sex differences in mathematical aptitude to isolation of factors contributing to differences in aptitude scores for women and men, including levels of visual-spatial ability (Hyde, 1981; Wittig, Note 1) prior to differential course taking in high school; 3) Carefully examine the role of gender-related differences in socialization, such as encouragement of parents and teachers to study math; 4) Conduct longitudinal examination of attitudes toward mathematics and of factors related to pattern of mathematics courses selected across the high school years, rather than "years of theoretical mathematics courses" or "proposed course plans" which are less precise criterion measures.

Objectives of the Present Study

The goals of the present research are to:

1. examine patterns of sex-related differences in eighth grade Differential Aptitude Space Relations Test scores, perceptions of encouragement to study math from parents and teachers, traditionality of career choice, Agentic Competency scores, Attitude toward Mathematics, pattern of mathematics courses completed across the high school years, and mathematical aptitude test (SAT-M) scores;

2. examine patterns of change in attitudes toward mathematics among students who were tested as 11th graders in the spring of 1981, and who also participated in the present research project as seniors in the spring of 1982;

3. identify factors related to pattern of advanced mathematics course participation across the high school years for male and female students;

4. identify factors predicting mathematical aptitude test (SAT-M) scores of male and female high school seniors.

HYPOTHESES

The general hypothesis of the present investigation is that both individual differences and socio-cultural variables influence high school seniors' pattern of advanced mathematics course enrollment, and mathematical aptitude test scores. No prediction was made a priori about the relative magnitude of contribution of these variables since previous research has yielded inconsistent results for factors predicting pattern of math courses. To date, no study has isolated cognitive and social factors predicting SAT-M scores. However, based on correlational data provided in past research, a causal theory was posited a priori for factors predicting SAT-M scores.

In the present study, the following specific predictions will be tested:

1. The following variables will be positively related to advanced mathematics course participation for men and women:

- a. eighth grade visual-spatial test (DAT) score;
- b. eighth grade mechanical reasoning test (DAT) score;
- c. perception of encouragement from parents and teachers to pursue study in mathematics;
- d. agentic competency score;
- e. attitude toward mathematics; and
- f. twelfth grade Scholastic Aptitude Test (SAT-M) score.

2. Traditionality of career choice will be positively related to advanced mathematics course participation for men and negatively related to advanced mathematics course participation for women.

3. The following variables will be positively related to senior year mathematical aptitude test (SAT-M) score for men and women:

- a. eighth grade visual-spatial test (DAT) score;
- b. perception of encouragement from parents and teachers to pursue advanced study in math;
- c. attitude toward mathematics; and
- d. pattern of advanced mathematics course participation in high school.

4. Agentic competency score will be positively related to senior year mathematical reasoning aptitude test (SAT-M) scores for women. There will be no relationship between agentic competency scores and senior year mathematical reasoning aptitude test (SAT-M) scores for men.

5. There will be sex-related differences in the relative importance of the links between the cognitive and social factors included in a Path Analytical Model for factors predicting senior year SAT-M scores.

6. Variables other than level of spatial ability prior to math course-taking in high school will be found to be important determinants of SAT-M scores of men and women when entered into the equations in the order posited a priori for factors predicting senior year SAT-M scores. The posited order of influence of the cognitive and social variables is as follows:

- a. eighth grade visual-spatial test (DAT scores);
- b. perception of encouragement from parents and teachers to pursue advanced study in math;
- c. agentic competency and career choice;
- d. attitude toward mathematics; and
- e. pattern of advanced mathematics course participation in high school.

All of the variables outlined above which were included in the path analytic model for factors predicting SAT-M

scores have been found to be related to either enrollment in advanced mathematics courses in high school or twelfth grade achievement and/or aptitude test scores in previous research. The order of causal influence of these variables which was posited in the causal theory for the present path analysis was determined based on the following considerations:

1. The eighth grade visual-spatial test (DAT) score was positioned in first order in the causal model, because it historically preceded the other variable derived from current measures.

2. Perception of encouragement to study math from parents and teachers was positioned in second order for two reasons. It was assumed that:

- a. perception of encouragement to study math would be directly influenced by the initial ability level of the student to some extent; and

- b. perception of encouragement to study math from parents and teachers would directly influence both the student's Agentic Competency score (i.e., the student's view of self as an agentic and competent person); and

- c. traditionality of student's career choice (i.e., traditionally "masculine" career which usually requires math study or traditionally "feminine" career which did not usually require advanced math study in the past).

3. Both career choice and agentic competency were positioned in third order for three reasons. It was assumed that:

a. both of these variables were intermediary variables that result from both the indirect or direct influence of parents and teachers and societal values (Fox, 1980, p. 17).

b. these variables were relatively stable co-variates. While it was expected that both the actual career choice and the actual agentic competency score of the men and women might change across the high school years, it was assumed that the traditionality/non-traditionality of career choice and the student's self-identified view of agentic competency would not change during this time; and

c. both traditionality of career choice and self-identified agentic competency of student would directly influence their attitudes toward mathematics (e.g., perceived usefulness of mathematics to future education and career goals, attitudes toward success in mathematics, self-confidence in ability to learn mathematics).

4. Attitude toward Mathematics was positioned in fourth order for three reasons.

a. This variable is generally viewed as an intermediary variable related to math course enrollment that results from both the student's perception of encouragement

to study math from parents and teachers and from societal and personal values (Fox, 1980, p. 17).

b. Attitudes toward mathematics (e.g., perceived usefulness of math) have been found to be determined by traditionality of career choice;

c. Attitudes toward mathematics have been found to be predictors of math course enrollment among high school students.

5. Pattern of math courses was positioned in fifth order because it was assumed that:

a. this variable would be directly influenced by student's attitudes toward mathematics, such as perceived usefulness of mathematics, effectance motivation in mathematics, and attitude toward success in math or "fear of success" in math;

b. it was assumed that the pattern of completed math courses would have a strong direct influence on twelfth grade SAT-M scores of men and women.

CHAPTER 2

METHOD

Participants

In the spring of 1982, all of the twelfth grade students enrolled in English classes at a suburban high school located in a middle-to-upper middle class neighborhood in a New England state were asked by a member of the school staff to volunteer to participate in a study designed to assess attitudes toward mathematics. Permission for this study was obtained from both the school system administration and from the University of Rhode Island Institutional Review Board. Informed consent was obtained from each student prior to participation. The original research plan was to utilize a stratified sampling procedure to select 100 men and 100 women students from the group of seniors who would volunteer to participate. It was expected that this stratified sample of 200 seniors would compose the main sample in the present research project since there were 271 seniors enrolled in English classes at the time the research was designed. However, fewer than 200 students met the following criteria:

1. volunteered to participate in the study;
2. signed student consent forms;
3. had eighth grade Differential Aptitude Test scores in their student records; and

4. had senior year SAT-M scores in their student records.

Only 80 senior men and 89 senior women students met the criteria, and all of these were included in the sample.

Of the 51 students who had participated in a pilot project as juniors in the spring of 1981, 44 (22 men and 22 women) volunteered for the present study, and constitute the sub sample for the longitudinal analyses of Attitude toward Mathematics. Forty-one of these students were also included in the main sample.

Measures

1. Background Questionnaire. Students were asked to state their (1) sex, (2) age, (3) grade, and to indicate (4) all of the mathematics courses listed which they had completed, (5) the mathematics courses in which they were presently enrolled, and (6) their future career plans. They were also asked to indicate (7) whether they felt their background in math was sufficient to enable them to study advanced mathematics in college, and (8) whether they planned to study advanced math in college. The students were asked to state (9) whether they felt they would use mathematics in the occupation they were planning to pursue, (10) if their father and mother worked outside the home, and (11) to provide information about their birth order and number of brothers and sisters.

2. Attitudes toward Mathematics. A combined score from the following four scales of the Fennema-Sherman Mathematics Attitudes Scales (Fennema & Sherman, 1976) was utilized as a measure of attitudes toward mathematics:

- a. Self-Confidence in Ability in Mathematics;
- b. Perceived Usefulness of Mathematics to Future Education and Career Goals;
- c. Attitude toward Success in Mathematics; and
- d. Effectance Motivation in Mathematics.

Each of the twelve-items in each of these four scales provide 5-point Likert-type response possibilities; the reported split-half reliabilities range from .86 to .93 for a high school population (Fennema & Sherman, 1976).

3. Pattern of Enrollment in Advanced Mathematics Courses. Following de Wolf (1977), the actual pattern of prior and present enrollment in mathematics courses across the high school years was determined for the twelfth grade students through information collected about past and current enrollment in mathematics courses. This information was recorded by students on the Background Questionnaire. Eleven patterns of enrollment in mathematics courses were identified from the information obtained. The courses included in each of the eleven patterns and the total number of courses in each pattern are presented in Table 1.

Table 1
Patterns of Mathematics Course Participation
Across the High School Years

Course	Patterns										
	1	2	3	4	5	6	7	8	9	10	11
Algebra I	X	X	X	X	X	X	X	X	X	X	X
Algebra II	X	X	X	X	X	X	X	X	X	X	X
Geometry	X	X	X	X	X	X	X	X	X	X	X
Trigonometry		X			X	X		X	X	X	X
Analysis (pre-Calculus)			X		X		X	X	X		X
Analytical Geometry				X		X		X		X	X
Calculus							X		X	X	X
Total Courses Taken	3	4	4	4	5	5	5	6	6	6	7

4. Mathematical Reasoning Aptitude. The mathematical section of the Scholastic Aptitude Test (SAT-M), a commonly used pre-college measure of mathematical reasoning aptitude, was utilized as a measure of senior year mathematical reasoning aptitude. Students' first senior year scores were used in this study.

5. Initial Ability Measures. Following the suggestions of Fennema and Sherman (1977) and de Wolf (1977), students' eighth grade scores from two sections of the Differential Aptitude Test (DAT; Bennett, Seashore & Wessman, 1974) were obtained from school records and utilized as measures of student ability prior to mathematics course-taking in high school. These measures are:

- a. Space Relations Test and
- b. Mechanical Reasoning Ability Test.

6. Perceived Encouragement to Study Math. A combined score from three scales of the Fennema-Sherman Mathematics Attitudes Scales (Fenneman & Sherman, 1976) was utilized as a measure of perceived encouragement to study math in this study. These three scales are:

- a. Encouragement from Mother;
- b. Encouragement from Father; and
- c. Encouragement from Teachers.

Each of the twelve-items in each of the three scales provide 5-point Likert-type response possibilities; the

reported split-half reliabilities range from .86 to .91 for a high school population (Fennema & Sherman, 1976).

7. Career Choice. Following the procedure utilized by Lemkau (1978), traditionality of career choice was determined using statistics available from 1970 census data on the percentage of men and women employed in each of the various occupations which the students indicated on the Background Questionnaire that they planned to pursue in the future. Occupations in which there were 25 percent or fewer females employed were considered "traditionally masculine" occupations; occupations in which there were 25 percent or fewer males employed were considered "traditionally feminine" occupations.

8. Agentic Competency. In previous research, self-attribution of agentic traits which appear to be related to achievement and intellectual functioning (e.g., logical, persistent) was found to be related to cognitive measures such as visual-spatial test scores (Nash, 1978) and mathematics achievement test scores (e.g., see review by Tobias, 1978). These measures were commonly referred to as "masculinity" scales. In the present study, a similar measure was also included to assess self-attribution of traits which appear to be related to achievement and intellectual functioning (White, 1979). However, following White, the term "agentic competency" was used rather than "masculinity."

White's Agency Competency Scale (1979) is a self-report adjective checklist which purports to be unidimensional and contains 25 positive-valued agentic adjectives, e.g., rational, ambitious, determined. White's Communion Competency Scale, which contains 25 positively-valued communal adjectives related to effective interaction with others, was also administered, but not scored for the present study.

Procedure

A booklet containing a student consent form, the Fennema-Sherman Attitudes toward Mathematics Scales (Fennema & Sherman, 1976), The Agency and Communion Competency Scales (White, 1979), and a Background Questionnaire was distributed to each student during regularly scheduled twelfth grade English classes. These booklets were distributed by the students' regular teachers who read standardized instructions to each class.

Analyses of Data

Except where noted otherwise, the data were analyzed using the computer facilities of the University of Rhode Island and the Statistical Package for the Social Sciences (Nie, Hull, Jenkins, Steinbrenner, and Bent, 1975). The specific SPSS statistical procedures which were used are presented along with the results.

CHAPTER 3

RESULTS

In this chapter, differences between students who met the criteria for inclusion as participants in the present research project and those who did not will be discussed, and the data obtained on the actual participants will be presented. The findings are organized in four sections:

1. description of participants and non-participants;
2. comparison of male and female student participants' scores on all of the measures;
3. longitudinal analysis of attitudes toward mathematics of the 44 students who were tested both in the spring of 1981 as juniors and in the spring of 1982 as seniors; and
4. analyses of factors predicting pattern of enrollment in high school mathematics courses and senior year SAT-M scores.

Participants and Non-participants

A total of 169 seniors (80 men and 89 women) were participants in the main sample, and 57 seniors (25 men and 32 women) were in the non-participant group. No significant differences (i.e., $p > .05$) were found between the participant and the non-participant groups on age ($\chi^2(2) = 1.56$), sex ($\chi^2(1) = .09$), birthorder ($\chi^2(4) = 6.82$), number of siblings ($\chi^2(4) = 1.68$), experience in math- and space-related out-of-school activities ($\chi^2(6) = 9.73$, pattern of math

classes completed across the high school years ($\chi^2(9) = 16.60$), future plans to study math ($\chi^2(3) = 6.23$), or perceptions as to whether or not math will be required for the occupation they are planning to pursue in the future ($\chi^2(3) = 2.81$).

Between-group differences were observed for both the range of eighth grade DAT Space Relations Test scores and the range of twelfth grade SAT-M scores. The eighth grade DAT Space Relations Test scores of the 169 participants ranged from 4 to 99, whereas the available scores for the non-participants ($N = 15$) ranged from 15 to 95. The SAT-M scores for the participants ranged from 250 to 750, whereas the available scores of the non-participants ($N = 35$) ranged from 290 to 750. However, too few scores on these measures were available for the students in the non-participant group to warrant statistical analysis.

Statistically significant group-related differences were found between the participants and the non-participants on several variables. These are: experience in math-and space-related in-school courses, confidence in math background, pattern of parental employment, and traditionality of career choice. The participants reported having taken more math-related (e.g., physics) courses and space-related (e.g., woodworking) courses in school than the non-participants ($\chi^2(6) = 13.87$; $p < .05$; $\text{Eta} = .25$) and also expressed

more confidence in their math background being sufficient to enable them to go on and study more math in the future ($\chi^2(1) = 5.99$; $p < .05$; $Eta = .18$).

A significantly higher percentage of the participants' fathers worked outside the home when the students were in elementary school than the fathers of the students in the non-participant group ($\chi^2(2) = 7.38$; $p < .05$; $Eta = .18$). Also, a higher percentage of the non-participants' mothers were employed outside the home both while the students were in elementary school ($\chi^2(2) = 6.55$; $p < .05$; $Eta = .17$) and in high school ($\chi^2(2) = 9.01$; $p < .05$; $Eta = .19$) than the participants' mothers.

No significant difference was found between the percentage of students in the participant and non-participant groups who were planning to pursue either "traditionally masculine" or "traditionally feminine" careers. However, a significantly higher percentage of the students in the non-participant groups stated that they were undecided about their future career plans than the students in the participant group ($\chi^2(2) = 9.48$; $p < .05$; $Eta = .20$).

Practical Significance. The practical significance of the statistically significant group-related differences were assessed using the Eta statistic, provided above. The results of these analyses revealed that the few statistically significant differences found between the participants and

non-participants were of little practical significance. These were experience in math- and space-related courses, confidence in math background, pattern of parental employment, and career plans (all Eta values less than or equal to .25).

Participants

In this section, the data from the seniors in the main sample of the present research are presented. Descriptive statistics are provided to enable comparison of men's and women's average scores on all measures. The results of Chi Square and t- tests performed in order to test the significance of sex-related differences on the cognitive and affective measures are also included.

Age. As can be seen from the data in Table 2, the majority of the seniors were seventeen years old. Of the men, 51.2 percent were seventeen and 48.7 percent were eighteen. The majority of the women were seventeen (56.2 percent); 42.1 percent were eighteen, and 1.1 percent were nineteen. The difference in the men's and women's ages was not significant ($\chi^2(2) = 1.43$).

Birth Order. As the data presented in Table 2 shows, there was no significant sex-related difference found for the students' birth order ($\chi^2(3) = 2.04$). Of the senior men, 28.7 percent were firstborn children, 26.2 percent were secondborn, 26.2 percent were thirdborn, and 18.8 were

Table 2
Background of Participants

	Men	Women	$\chi^2(df)$
<u>Ages</u>			
% 17	51.2	56.2	
% 18	48.7	42.7	
% 19	-	1.1	
			1.43(2)
<u>Birth Order</u>			
% 1st born	28.7	30.3	
% 2nd born	26.2	27.0	
% 3rd born	26.2	18.0	
% 4th born	18.8	24.7	
			2.04(3)

fourthborn. Of the senior women, 30.3 percent were firstborn children, 27 percent were secondborn, 18 percent were third-born, and 24.7 percent were fourthborn.

Number of Siblings. There was no significant sex-related difference found in the number of siblings ($t(167) = 1.77$). The mean number of siblings for the senior men was 2.66 ($SD = 1.34$) and the mean number of siblings for the senior women was 3.00 ($SD = 1.14$).

Pattern of Parental Employment. As the data presented in Table 3 reveal, there were no statistically significant sex-related differences found for the pattern of parental employment across the elementary and high school years.

Eighth Grade DAT Spatial and DAT Mechanical Test Scores. As the data presented in Table 4 indicate, the men's eighth grade DAT Spatial Test scores ranged from a minimum of 5 to a maximum of 99; whereas the women's eighth grade DAT Spatial Test scores ranged from 4 to 99. The difference between the sexes was not found to be significant ($t(167) = .017$).

Both the men's and women's eighth grade DAT Mechanical Test scores ranged from a minimum of 5 to a maximum of 99. The means and standard deviations are presented in Table 4. As can be seen from an inspection of the means presented in Table 4, the DAT Mechanical Test scores for men and women were not significantly different ($t(167) = .033$).

Table 3
Pattern of Parental Employment

School	Men	Women	$\chi^2(df)$
Elementary			
% Fathers Employed	98.7	98.9	.01(1)
% Mothers Employed	36.3	39.3	.66(1)
High School			
% Fathers Employed	92.5	92.1	.02(2)
% Mothers Employed	65.0	71.9	.64(1)

Table 4
Eighth Grade Differential Aptitude Test Scores:
Space Relations and Mechanical Ability Test

	Men (N = 80)		Women (N = 89)		<u>t(df)</u> ^a
	<u>$\bar{X}$</u>	<u>SD</u>	<u>$\bar{X}$</u>	<u>SD</u>	
DAT Spatial	65.79	27.38	66.52	26.78	.17(167)
DAT Mechanical	66.59	22.87	65.33	25.89	.33(167)

Note. Maximum score possible for both DAT Space Relations and Mechanical Ability Tests = 99.

^a All statistics are based on two-tailed probabilities unless otherwise stated.

Experience in Math- and Space-Related Courses and Activities. As the data in Table 5 indicate, the senior men reported engaging in more math- and space-related courses in school than the senior women. This difference was found to be statistically significant ($t(167) = 7.67$; $p < .001$; $\omega^2 = .25$). The men also reported engaging in more math- and space-related activities outside of school than the senior women. As with the findings for the sex-related differences in the amount of in-school courses taken, the sex related difference in the number of math- and space-related out-of-school experiences was also found to be statistically significant ($t(167) = 4.62$; $p < .001$; $\omega^2 = .11$).

Further analyses were performed in order to identify which math- and space-related courses and activities were contributing to the significant sex-related differences discussed above. As can be seen from an inspection of the data presented in Table 6, there were significant differences in the number of men and women who reported taking in-school courses in drafting ($\chi^2(1) = 20.75$; $p < .001$; $Eta = .48$), woodworking ($\chi^2(1) = 28.70$; $p < .001$; $Eta = .49$), mechanical drawing ($\chi^2(1) = 32.25$; $p < .001$; $Eta = .45$), and physics ($\chi^2(1) = 25.30$; $p < .001$; $Eta = .40$). No significant sex-related differences were found for either art ($\chi^2(1) = 2.17$) or chemistry ($\chi^2(1) = 0$).

Table 5
Experience in Math- and Space-Related
Courses and Activities

	Men (N = 80)		Women (N = 89)		<u>t</u> (<u>df</u>) ^a
	<u>X̄</u>	<u>SD</u>	<u>X̄</u>	<u>SD</u>	
In-School Courses	3.14	1.24	1.79	1.05	7.67(167)***
Out-of-School Courses	2.83	1.46	1.88	1.21	4.62(155) ^b ***

Note. Maximum score possible for both in-school and out-of-school experiences = 6.

^a t-tests and Omega Square statistic used for analyses in which the data were treated at interval level.

^b Separate variance estimate used for t-tests where the probability of F < .10.

Table 6
In-School and Out-of-School Experiences
for Men and Women

	% Men (N = 80)	% Women (N = 89)	$\chi^2(\text{df})$
In-School Experience			
Art	42.5	55.0	2.17(1)
Drafting	32.5	4.5	20.75(1)***
Woodworking	45.0	7.9	28.70(1)***
Mechanical Drawing	37.5	14.6	32.25(1)***
Physics	72.5	32.6	25.30(1)***
Chemistry	63.7	64.0	0(1)
Out-of-School Experience			
Drawing	37.5	31.5	.44(1)
Woodworking	31.3	3.4	21.72(1)***
Modelbuilding	35.0	3.4	26.07(1)***
Sailing	41.2	39.3	.01(1)
Sports	82.5	66.3	4.93(1)*
Scouting	55.0	43.8	1.68(1)

* $\underline{p} < .05$

*** $\underline{p} < .001$

For math- and space-related out-of-school activities, several significant sex-related differences were also found. The men reported having more experience in woodworking ($\chi^2(1) = 21.72$; $p < .001$; $\text{Eta} = .50$), modelbuilding ($\chi^2(1) = .01$; $p < .05$; $\text{Eta} = .53$), and sports ($\chi^2(1) = 4.93$; $p < .05$; $\text{Eta} = .21$). No significant differences were found for drawing ($\chi^2(1) = .44$), sailing ($\chi^2(1) = .01$), or scouting ($\chi^2(1) = 1.68$).

Perceptions of Social Support to Study Math. As inspection of the data presented in Table 7 indicates, the senior men perceived more social support to study math from people in their social milieux ($\bar{X} = 136.54$) than the senior women ($\bar{X} = 128.30$). This difference was found to be statistically significant ($t(167) = 2.57$; $p < .01$; $\omega^2 = .03$). Further analyses were performed in order to determine if the men perceived more encouragement to study math specifically from their fathers, their mothers, and/or their teachers.

As can be seen from an inspection of the means presented in Table 7, the senior men perceived more encouragement to study math than the senior girls from all three of these sources, and in two cases, for mothers and teachers, these differences were statistically significant.

Patterns of Math Courses. As can be seen from the data in Table 8, the senior men completed higher patterns of math

Table 7
Perceptions of Social Support to Study Math

	Men (N = 80)		Women (N = 89)		<u>t</u> (<u>df</u>)
	<u>$\bar{X}$</u>	<u>SD</u>	<u>$\bar{X}$</u>	<u>SD</u>	
Perceptions of Social Support	136.54 ¹	19.41	128.30	22.03	2.57(167)**
Father	46.88 ²	9.52	45.43	8.32	1.05(167)
Mother	46.13	7.44	42.84	8.87	2.59(167)**
Teacher	43.54	7.61	40.03	9.69	2.63(164)**

1 Maximum score possible = 180.

2 Maximum score possible for each scale = 60.

** $p < .01$.

Table 8
Patterns of Mathematics Courses Completed Across
the High School Years by Men and Women

Patterns Completed												
	1	2	3	4	5	6	7	8	9	10	11	
% Men	26.2	18.8	--	1.2	16.2	8.7	2.5	2.5	21.2	1.2	1.2	1.2
% Women	46.1	13.5	--	1.1	13.5	4.5	--	5.6	15.7	--	--	--
Total Courses	3	4	4	4	5	5	5	6	6	6	6	7

courses ($\bar{X} = 4.58$) than the senior women ($\bar{X} = 3.58$) across the high school years. This difference in pattern of math courses completed across the high school years was found to be statistically significant ($t(167) = 2.03$; $p < .05$; $\omega^2 = .02$).

Confidence in Math Background. The senior men and women both expressed a great deal of confidence in their background in math when asked if it was sufficient to enable them to go on and study more math in the future. The senior men were the most confident group with 88.7 percent agreeing that their math background was sufficient and 11.2 percent disagreeing with this question. Of the women, 83.1 percent expressed agreement with the question about their background in math being sufficient to enable them to study more math in the future, and 16.9 percent expressed disagreement with this question. The difference between the percentage of men and women expressing confidence to this question was not found to be significant ($\chi^2(1) = .675$).

Future Plans to Study Math. The senior men were more likely to state that they planned to study math in the future than the senior women. Of the men, 72.5 percent expressed agreement with this question and 27.5 percent expressed disagreement. Of the senior women, 65.1 percent said they planned to study more math in the future, 30.3 percent said they did not have such plans, 3.4 percent were not certain

about their future plans to study math, and 1.1 percent did not answer the question. The difference between the percentage of men and women planning to study math in the future was not found to be significant ($\chi^2(3) = 4.04$).

Occupations Requiring Math. The majority of the students agreed that the occupation they were planning to pursue in the future would require them to use math. A higher percentage of the men agreed with this statement (78.7 percent) than the women (57.3 percent). Of the men, only 16.2 percent felt they would not use math in their future occupations and 4.9 percent were not sure if they would be using math or not. Of the women 34.8 percent felt they would not use math in their future occupations and 7.9 percent were undecided. The difference between the percentage of men and women perceiving math to be a requirement for their future occupation was found to be significant ($\chi^2(3) = 10.78$; $p < .05$; $\text{Eta} = .25$).

Traditionality of Career Choice. When asked to state the occupation or career they were planning to pursue in the future, the majority of the men (85 percent) named a career which has been "traditionally masculine" in the past, as the data presented in Table 9 show. None of the men named an occupation or career that has been considered "traditionally feminine". Of the men, 15 percent were undecided about their future job goals. In contrast to the findings for the men,

Table 9
 Traditionality of Career Choice

Career Type	Men	Women	$\chi^2(\underline{df})$
"Masculine"	85%	47.2%	39.82(2)***
"Feminine"	0	38.2%	
Undecided	15%	14.6%	

*** $\underline{p} < .001$

47.2 percent of the women named an occupation or career that has been considered to be "traditionally masculine", 38.2 percent named an occupation or career that has been considered to be "traditionally feminine", and 14.6 percent were undecided about their future goals. As can be seen from the data presented in Table 9, the difference between the men and women on traditionality of career choice was found to be significant ($\chi^2(2) = 39.82$; $p < .001$; $\text{Eta} = .49$).

Agentic Competency. The maximum score possible for the Agentic Competency scale is 25, the number of agentic adjectives on the scale. The senior men checked more agentic adjectives to describe themselves ($\bar{X} = 14.31$; $SD = 5.98$) than the senior women ($\bar{X} = 12.13$; $SD = 5.76$). This difference was found to be significant ($t(167) = 2.41$; $p < .05$; $\omega^2 = .03$).

Attitudes Toward Mathematics. The maximum score possible for Attitude toward Mathematics is 240 (based on 48 questions with scales 1-5). As the data presented in Table 10 show, the senior men held more positive attitudes toward mathematics ($\bar{X} = 187.46$) than the senior women ($\bar{X} = 169.66$). This difference was found to be highly significant ($t(167) = 3.78$; $p < .001$; $\omega^2 = .56$). Further analyses were performed, therefore, in order to learn more about the source of this significant difference in attitudes.

Table 10
Attitudes Toward Mathematics

	Men (N = 80)		Women (N = 89)		<u>t</u> (<u>df</u>)
	<u>X̄</u>	<u>SD</u>	<u>X̄</u>	<u>SD</u>	
Attitude Toward Mathematics ¹	187.46	27.73	169.66	32.96	3.78(167)***
Effectance Motivation ²	41.04	9.70	36.27	11.18	2.95(167)**
Attitude Toward Success	51.29	5.94	50.38	6.63	.094(167)
Perceived Usefulness	48.88	8.77	42.92	10.06	4.08(167)***
Confidence in Math Ability	46.26	10.01	40.09	13.44	3.41(162)***

¹ Maximum score possible = 240

² Maximum score possible for each scale = 60

** p < .01

*** p < .001

As inspection of these data reveal, there were significant sex-related differences in three of the four attitude scales used as a general measure of Attitudes toward Mathematics in the present study. The senior men scored higher on the Effectance Motivation in Mathematics Scale ($t(167) = 2.95$; $p < .001$), the Perceived Usefulness of Math Scale ($t(167) = 4.08$; $p < .001$), and the Confidence in Mathematics Scale ($t(162) = 3.41$; $p < .001$). As the data presented in Table 10 show, the men also scored slightly higher than the women on the Attitude Toward Success in Mathematics Scale. However, this difference was not found to be significant.

Scholastic Aptitude Test (SAT-M). No statistically significant difference was found between men's and women's twelfth grade scores for the mathematics section of the Scholastic Aptitude Test ($t(167) = 1.75$; $p > .05$). The mean for the men's SAT-M scores was 503.13 ($SD = 123.5$) and the mean for the women's SAT-M scores was 471.80 ($SD = 109.4$). The men's SAT-M scores ranged from 260 to 750 (median = 508), and the women's SAT-M scores ranged from 250 to 700 (median = 480). The highest score possible is 800. A test for heterogeneity of variance was nonsignificant ($F_{max} = 1.27$; $p = .26$).

Summary. No significant sex-related differences were found for age, birthorder, number of siblings, or pattern of parental employment across the elementary and high school

years. Likewise, no significant sex-related differences were found for either the eighth grade spatial ability measure, the eighth grade mechanical ability measure, or the twelfth grade SAT-M scores. Both the men and the women expressed a great deal of confidence that their math background was sufficient to enable them to go on and study more math. The majority of the men and women stated that they did plan to study more math in the future.

However, significant differences between men and women were found on some measures, particularly those dealing with experience, encouragement, future plans, and attitudes. The senior men reported having participated in significantly more math- and space-related in-school courses and out-of-school activities than the senior women, and men perceived significantly more social support or encouragement to study math from their mothers and teachers. The men completed significantly higher patterns of math courses across the high school years, and significantly more men than women stated that they felt they would need to use math in their future occupation or career. In addition, significantly more men than women named a career choice that was "traditionally masculine". The men also used significantly more agentic adjectives to describe themselves than the women and held significantly more positive attitudes toward mathematics than the women.

The Eta and Omega Square statistics were used to assess the practical significance of the statistically significant sex-related differences discussed above. The results of these analyses revealed that little of the variance in both in-school math- and space-related courses and out-of-school math- and space-related activities (Eta = .25 and .11, respectively), perception of social support to study math (ω^2 = .03), pattern of math courses completed across the high school years (ω^2 = .02), or Agentive Competency scores (ω^2 = .03) could be attributed to sex. The practical significance of the sex-related differences found for the other variables, however, was much larger. These are as follows: perception that math would be required for future occupation or career (Eta = .25), career choice (Eta = .49), and Attitude toward Mathematics (ω^2 = .56).

Longitudinal Analyses of Attitudes toward Mathematics

In this section, the results of the longitudinal analyses of attitudes toward mathematics of the 44 students (22 men and 22 women) who were tested both in the spring of 1981 as juniors and in the spring of 1982 as seniors are presented. For these analyses, separate 2 x 2 (sex x year in school) Analyses of Variance for Repeated Measures (Winer, 1971) were performed to investigate change in both Attitude toward Mathematics and Perception of Encouragement to Study Math from Parents and Teachers. The data obtained from these

analyses are presented in Table 11. Tests for heterogeneity of variance were found to be non-significant in all cases ($p > .05$).

As can be seen from inspection of the data shown in Table 11, both a significant main effect for sex of subject and a significant interaction between sex of subject and year in school were found for Attitude toward Mathematics. Tests of simple main effects revealed that the attitudes of the men and women were significantly different from one another in both the junior ($F(1,42) = 80.66, p < .01$) and senior years ($F(1,42) = 541.86, p < .01$). Examination of the means for the men and women for this variable revealed that the men held more positive Attitudes toward Mathematics than the women in both the junior and senior years. In the junior year, the mean score for the men was 195.95 and the mean score for the women was 188.3 (maximum score possible equals 240).

The men's scores for the Attitude toward Mathematics measure increased between the junior and senior years ($\bar{X} = 209.3$), whereas the women's scores for this variable decreased during this period of time ($\bar{X} = 183.0$). Tests of simple main effects revealed that the change in men's attitude from the junior year to the senior year was significant ($F(1,42) = 4.30, p < .05$), whereas the decrease in women's attitude was not significant ($F(1,42) = 1.02$).

Table 11
Summary of Data from Analyses of Variance

<u>Attitude toward Mathematics</u>				
	<u>df</u>	<u>SS</u>	<u>MS</u>	<u>F</u>
<u>Between Subjects</u>	43	<u>44134.4</u>		
A (sex)	1		7290.9	8.31**
Subjects within groups	42		877.2	
<u>Within Subjects</u>	44	<u>14196.5</u>		
B (year in school)	1		171.9	0.57
AB (sex x year)	1		1432.1	4.78*
B X Subjects within groups	42		299.8	
<u>Perception of Encouragement to Study Math</u>				
	<u>df</u>	<u>SS</u>	<u>MS</u>	<u>F</u>
<u>Between Subjects</u>	43	<u>17532.3</u>		
A (sex)	1		520.4	1.28
Subjects within groups	42		405.05	
<u>Within Subjects</u>	44	<u>9722</u>		
B (year in school)	1		117.6	.56
AB (sex x year)	1		804.7	3.84
B X Subjects within groups	42		209.52	

* $p < .05$ ** $p < .01$

As the data presented in Table 11 reveals, neither the main effects nor the interaction effect for perception of social support to study math reached a statistically significant level. Examination of the means for the men and women for this variable revealed that the women reported perceiving slightly more encouragement to study math in their junior year than the men did ($\bar{X} = 145.2$ and $\bar{X} = 144.0$, respectively). The reverse pattern was found for the men's and women's means for the senior year, however. Between the junior and senior years, there was an increase in the men's perception of encouragement to study math ($\bar{X} = 152.4$), whereas there was a decrease in women's scores on this variable ($\bar{X} = 141.5$) (maximum possible score equals 180).

Correlational Analyses

In this section, the results of correlational analyses performed to examine the patterns of relationship among a variety of potential predictors of pattern of enrollment in advanced mathematics courses and mathematical aptitude test (SAT-M) scores are presented.

Since significant correlations were found between eighth grade DAT Space Relations Test scores and eighth grade DAT Mechanical Reasoning Ability Test scores for both the men and the women ($\underline{r} = .658$; $\underline{p} < .001$, and $\underline{r} = .422$; $\underline{p} < .001$, respectively), the eighth grade DAT Mechanical Ability Test scores were eliminated from consideration in

further analyses. The eighth grade DAT Space Relations Test scores were retained because the spatial ability measure is one of the variables of major interest in the path analytic model posited a priori for factors predicting SAT-M scores and is also a variable of considerable interest in current research on factors predicting pattern of math course enrollment across the high school years.

As the data presented in Tables 12 and 13 indicate, strong interrelationships were also found between the majority of the variables measured in the study for both the men and the women. Perceptions of social support to study math was found to be very highly correlated with Attitude toward Mathematics for both the men and the women. Therefore, perceptions of social support to study math was eliminated from further consideration in the multiple regression analyses using a stepwise procedure to avoid multicollinearity among factors predicting pattern of mathematics course enrollment across the high school years and twelfth grade SAT-M scores. However, both perceptions of social support to study math and Attitude toward Mathematics were retained for the multiple regression analyses using a hierarchical procedure because both of these variables were included in the path analytic model posited a priori for factors predicting twelfth grade SAT-M scores (Spaeth, 1975, p. 70).

Table 12
Correlations for Men's Twelfth Grade Scores

	DAT MECHANICAL	SOCIAL SUPPORT	AGENTIC COMPETENCY	CAREER CHOICE	ATTITUDE TOWARD MATHEMATICS	PATTERN OF MATH COURSES	SAT-M SCORES
Spatial	.658***	.059	.119	-.169	.212*	.303**	.548***
Mechanical		.058	.031	-.112	.161	.412***	.691***
Social Support			.159	.172	.754***	.489***	.344***
Agentic Competency				.084	.258**	.203*	.204*
Career Choice					.129	.053	-.089
Attitude toward Math						.504***	.522***
Pattern of Math Courses							.752***
SAT-M Scores							

* $\bar{p} < .05$
 ** $\bar{p} < .01$
 *** $\bar{p} < .001$

Table 13

Correlations for Women's Twelfth Grade Scores

	DAT MECHANICAL	SOCIAL SUPPORT	AGENTIC COMPETENCY	CAREER CHOICE	ATTITUDE TOWARD MATHEMATICS	PATTERN OF MATH COURSES	SAT-M SCORES
Spatial	.422***	.412***	.010	.184	.394***	.431**	.545***
Mechanical		.314***	.001	.156	.253***	.401***	.466***
Social Support			.188*	.245*	.808***	.448***	.635***
Agentic Competency				-.009	.166	.005	.063
Career Choice					.245*	.347***	.415***
Attitude toward Math						.326**	.520***
Pattern of Math Courses							.725***
SAT-M Scores							

* $\bar{p} < .05$
 ** $\bar{p} < .01$
 *** $\bar{p} < .001$

For both the men and the women, Attitude toward Mathematics and Pattern of Math Courses taken across the high school years were found to be fairly highly correlated with twelfth grade SAT-M scores. However, these two variables were not found to be too highly intercorrelated to be used as potential predictions of SAT-M scores. Therefore, both of these variables were retained for consideration in all future analyses.

Factors Related to Pattern of Math Courses

Multiple Regression Analyses, using a forward stepwise procedure, were performed to isolate factors predicting men's and women's Pattern of Enrollment in Math Courses across the high school years. The variables that were considered for entry into the equations as potential predictors of Pattern of Enrollment in Math Courses were: eighth grade DAT Space Relations Test scores, Traditionality of Career Choice, Agentic Competency scores, Attitude toward Mathematics, and senior year SAT-M scores.

As inspection of the summary data presented in Table 14 reveals, over 60 percent of the total variation in men's Pattern of Enrollment in Math Courses was accounted for by the five independent variables operating jointly ($R^2 = .604$). When senior year SAT-M score was entered into the equation first, this variable accounted for approximately 56 percent of the total variance ($R^2 = .565$) in men's Pattern of Math

Table 14

Factors Predicting Pattern of Enrollment in Math Courses

	Men				
	Multiple R	R Square	Simple R	B	Beta
SAT-M	.752	.565	.752	.1996976	.76385
Attitude	.763	.582	.504	.1285033	.11035
Space Relations	.772	.596	.303	-.1517211	-.12865
Career Choice	.776	.602	-.053	-.4000982	-.08905
Agentic Competency	.777	.604	.204	.2261720	.04192
(Constant)				-6.686686	
	Women				
	Multiple R	R Square	Simple R	B	Beta
SAT-M	.725	.526	.725	.2090492	.73184
Attitude	.728	.530	.326	-.6952914	-.07331
Space Relations	.730	.532	.431	.7168671	.06142
Agentic Competency	.730	.533	.005	-.1620004	-.02985
Career Choice ^a	-	-	.167	-	-
(Constant)				-5.379225	

a. Variable not entered into equation due to insufficient F-level

Courses. Another two percent of the total variation accounted for was found to be attributable to men's Attitude toward Mathematics, when this variable was entered into the equation second ($R^2 = .582$). As eighth grade DAT Spatial Test score was added to the equation in third order, the total amount of variance accounted for in men's Pattern of Math Courses did not increase appreciably ($R^2 = .596$). The addition of the fourth variable, Traditionality of Career Choice, and the fifth variable, Agentic Competency, also contributed very little to the total amount accounted for (less than one percent).

As the data summarized for the analyses of factors predicting women's Pattern of Enrollment in Math Courses reveal, the five independent variables acting jointly accounted for 53 percent of the total variance in women's Patterns of Math Courses completed across the high school years ($R^2 = .533$). When SAT-M score was entered into the equations in first order, this variable accounted for almost the full 53 percent of the total variance in women's Pattern of Math Courses ($R^2 = .526$). As for the men, very little of the total variance accounted for was found to be attributable to the other four predictor variables in the order of entry used in this analysis. When Attitude toward Mathematics was entered in second position, R^2 increased by .004 to .530. The addition of eighth grade DAT Spatial Test score in third position

only changed $\underline{R}^2$ to .532. As Agentic Competency was entered into the equation fourth, the $\underline{R}^2$ change was small ($\underline{R}^2 = .533$). When Traditionality of Career Choice was entered into the equation last, the resultant $\underline{R}^2$ change was so minute that this variable was omitted from the equations.

Since all of the variables in the predictor set are intercorrelated to some extent, it should be noted that their relative contributions to the predictability of the criterion depend heavily on both the variables that are included in the equations and the order of their appearance in the regression equation (Linderman, Merenda & Gold, 1980). Therefore, caution is advised in interpreting these data. See Table 15 in Appendix B for a summary of Multiple Regression Analyses, using a hierarchical procedure to predict Pattern of Math Course, in which SAT-M score was omitted from the equations and Space Relations Test score accounted for nine percent of the total variance accounted for in men's pattern of math courses (34 percent) and 19 percent of the total variance accounted for in women's pattern of math courses (31 percent).

Summary. The results of the Multiple Regression Analysis, in which a forward stepwise procedure was used to isolate factors predicting pattern of enrollment in mathematics courses completed across the high school years, revealed that senior year SAT-M score was the most important correlate

of both men's and women's pattern of math courses when that variable was entered into the equations in first order. Eighth grade DAT Space Relations Test scores contributed very little to the total variation accounted for in both men's and women's pattern of math courses when that variable was entered into the equations in third order.

Factors Predicting Twelfth Grade SAT-M Scores

In this section, the results of analyses performed to test the path analytic model based on a causal theory for factors predicting senior year SAT-M scores of men and women are presented. First, the results of Multiple Regression Analyses in which a hierarchical procedure was used to assess the adequacy of the recursive model shown in Figure 1 are presented. Second, the results of separate Multiple Regression Analyses in which a hierarchical procedure was used to determine the strength of each separate path of causal influence are presented and discussed.

The diagram in Figure 1 shows the posited ordering among the variables hypothesized to predict SAT-M scores of men and women. Each arrow in the figure represents a presumed causal linkage or path of causal influence among the variables in the model. Since an ordering of potential predictors had been posited a priori based on a causal theory for factors predicting SAT-M scores of men and women, multiple regression techniques using a hierarchical procedure were used for the

MEN

WOMEN

Figure 1. Variables Determining Senior Year SAT-M Scores

path analyses discussed below. The path analyses involved several multiple regression analyses. In the first set of analyses, all of the independent variables in the model were entered into the equations to assess both the total amount of variance in men's and women's SAT-M scores accounted for by the effects of the independent variables acting jointly and the amount of variance attributable to each of the variables acting separately.

Then, several separate multiple regression analyses using a hierarchical procedure were performed to determine the magnitude of direct and indirect influence that each variable has on other variables that follow it in the presumed causal order (i.e., to estimate the strength of each separate path which the arrows and path coefficients in Figure 1 represent). For these analyses, adjustments were made for only those variables that precede a given variable in a hierarchical order. For example, perception of social support to study math was a dependent variable for the analyses of the spatial ability-perception of social support to study math relationship, traditionality of career choice was a dependent variable with regard to the spatial ability-perception of social support to study math-traditionality of career choice relationship, etc. The Pearson correlation coefficients found for the relationship between each of the

variables in the model are shown in parentheses next to each path coefficient for which the two values differ.

As can be seen from examination of the diagram presented in Figure 1, the variables that were entered into the equations as potential predictors of twelfth grade SAT-M scores of men and women, in order of entry, were: eighth grade DAT Space Relations Test scores, perception of encouragement to study math, traditionality of career choice, Agentic Competency, Attitude toward Mathematics, and pattern of math courses completed across the high school years.

The result of the Multiple Regression Analyses in which a hierarchical procedure was used to assess the adequacy of the recursive model revealed that 30 percent of the total variation in men's SAT-M scores which was accounted for by all of the independent variables in the model acting jointly (71 percent) is explained by the linear regression of their eighth grade DAT Space Relations Test scores without the effects of the other correlated variables in the model controlled. When entered into the equations in second order, almost 10 percent of the variations in men's SAT-M scores is explained by perceptions of encouragement to study math from parents and teachers. When traditionality of career choice and Agentic Competency were entered as a block in third order, only one percent of the variations in men's SAT-M scores were explained by these variables. As Attitude

toward Mathematics was entered in fourth position, seven percent of the variation in men's SAT-M scores is explained by this variable. When entered in last position, pattern of math courses taken across the high school years accounted for 24 percent of the total variation explained in men's SAT-M scores with the effects of the other correlated variables controlled.

As found for the men, almost 30 percent of the total explained variation in women's SAT-M scores (69 percent) is also explained by the linear regression of their eighth grade DAT Space Relations Test scores without the effects of the other correlated variables controlled. When entered into the equation in second order, perception of social support to study math accounted for 20 percent of the total variation in women's SAT-M scores. When traditionality of career choice and Agentic Competency were entered as a block in third order, these variables accounted for 5.8 percent of the explained variation in women's SAT-M scores. When entered into the equation fourth, Attitude toward Mathematics only explained .17 percent of the total variation accounted for in women's SAT-M scores. When entered in last position, pattern of mathematics courses taken across the high school years explained only 13.4 percent of the total variation accounted for in women's SAT-M scores with the effects of the other correlated variables controlled.

As can be seen by examination of the path coefficients presented in Figure 1, the results of the separate analyses to determine the strength of each separate path of causal influence revealed that pattern of mathematics courses taken across the high school years was the most important determinant of men's SAT-M scores ($p = .60$), whereas eighth grade DAT Space Relations Test score was the most important determinant of women's SAT-M scores ($p = .545$). Thus, it appears that all other things being equal, one standard deviation unit change in pattern of enrollment in math courses would introduce the greatest change in SAT-M score for men, and one unit change in eighth grade DAT Space Relations Test score would introduce the greatest change in SAT-M score for women. It also appears that one unit change in traditionality of career choice would introduce the least change in SAT-M scores for men ($p = -.03$), whereas one unit change in Agentive Competency would introduce the least change in SAT-M scores for women ($p = .02$). The difference between the path coefficients for men and women for the links between eighth grade spatial ability test score and perceived encouragement to study math and between attitude toward mathematics and pattern of math courses were found to be significant ($p < .02$). It should be noted, however, that the relative magnitude of the path coefficients presented in

Figure 1 are dependent on the order of entry of the independent variables into the equations since all of the variables are intercorrelated to some extent.

For example, perceived encouragement to study math from parents and teachers was found to be very highly correlated with Attitude toward Mathematics for men ($r = .75$) and for women ($r = .81$). Since the former variable precedes Attitude toward Mathematics in the causal model posited a priori, perception of encouragement to study math accounted for much of the effect that would be attributed to Attitude toward Mathematics if perception of encouragement was omitted from the model. Thus, interpretation of data on the relative importance of Attitude toward Mathematics for men and women must proceed cautiously (See Table 16 in Appendix B for a summary of Multiple Regression Analyses, using a forward stepwise procedure to predict SAT-M scores, in which perception of encouragement to study math was omitted from the equations, and Attitude toward Mathematics contributed nine percent of the total variation accounted for (67 percent) in women's SAT-M scores).

Likewise, perception of encouragement or social support to study math from parents and teachers was also found to be correlated with eighth grade DAT Space Relations Test scores, pattern of mathematics courses taken across the high school years, and twelfth grade SAT-M scores for women ($r = .41$,

$\underline{r} = .45$, and $\underline{r} = .64$, respectively). Since perception of encouragement to study math also preceded pattern of mathematics courses taken across the high school years in the causal model, the direct effect of women's pattern of math courses on their twelfth grade SAT-M scores was diminished to some extent.

Although the Pearson correlations between DAT Space Relations Test scores and SAT-M scores were almost the same for the men ($\underline{r} = .548$) and the women ($\underline{r} = .545$), and the Pearson correlations between pattern of math courses and SAT-M were almost the same for the men ($\underline{r} = .752$) and the women ($\underline{r} = .725$), the relative strength of the direct paths between pattern of math courses and SAT-M score for the men ($\underline{p} = .60$) and the women ($\underline{p} = .47$) were found to be somewhat different due to the different pattern of intercorrelations between the independent variables and the criterion variable for the men and the women.

Examination of the path coefficients estimated from latent variables (i.e., all residual causes) associated with specific variables in the model reveals that the variables in the model account for a great deal of the variance in SAT-M scores for both the men ($\underline{e} = .53$) and the women ($\underline{e} = .55$). However, inspection of the specific path coefficients suggest that it might be possible for the model to be made more parsimonious by elimination of redundant and/or

meaningless links such as the one for career plan for men ($p = -.03$) and for women ($p = -.04$). Further analysis is needed, however, to test this prediction.

Summary. The results of the Multiple Regression Analyses to test the path analytic model posited a priori revealed that all of the independent variables in the model accounted for 71 percent of the total variance in men's SAT-M scores and 69 percent of the total variance in women's SAT-M scores. For men, pattern of mathematics courses completed across the high school years was the strongest determinant of twelfth grade SAT-M scores. For women, the path coefficient for the direct path between eighth grade DAT Space Relations Test score and twelfth grade SAT-M score was of greater magnitude than any of the other path coefficients for the model. For men, the path coefficient for the direct path between eighth grade DAT Space Relations Test score and twelfth grade SAT-M score was the one of second greatest magnitude. For women, pattern of mathematics courses taken across the high school years was the second strongest determinant of twelfth grade SAT-M scores. The Pearson correlation coefficients between both Space Relations Test scores and SAT-M scores and between pattern of math courses and SAT-M scores were almost the same for the men and the women. The difference in the relative importance of the paths between these independent variables and the criterion variable were attributed, therefore, to

sex-related differences found in the pattern of intercorrelations of some of the other variables in the model.

Findings Relevant to Hypotheses

Sex-Related Differences

Based on previous research on sex-related differences in visual-spatial ability, mathematical ability, attitudes toward mathematics, and factors predicting pattern of enrollment in mathematics courses across the high school years, several hypotheses concerning expected sex-related differences in the present study were formulated. Prior to data collection, it was hypothesized that sex-related differences in favor of men would be found for Perception of Encouragement to Study Math, Attitude toward Mathematics, Pattern of Mathematics Courses Completed across the High School Years, and twelfth grade mathematical aptitude test (SAT-M) scores.

Perception of Encouragement to Study Math. As expected, sex-related differences in favor of the men were found in the present study for perception of encouragement to study math. Further examination of the data revealed that there were significant sex-related differences in favor of the men for perception of encouragement to study math from both mother and teacher.

Attitude toward Mathematics. Consistent with previous research, the senior men were found to hold significantly

more positive attitudes toward mathematics than the senior women. As expected, the senior men perceived mathematics to be significantly more useful to their future occupations and career goals than the women, and the men also expressed more confidence in their ability to succeed in math courses than the women. In addition, the men scored significantly higher than the women on the Effectance Motivation in Math scale which purports to measure attitude toward problem-solving tasks. However, no significant sex-related difference was found for the Attitude toward Success in Math subscale, the "fear of success" measure used in the present study.

Pattern of Math Courses. As expected, a statistically significant sex-related difference in favor of the men was found for Pattern of Math Courses completed across the high school years. In the present study, there was a steadily decreasing percentage of both men and women found to enroll in advanced mathematics courses beyond geometry, but the observed decline was found to be sharper for women than men.

Scholastic Aptitude Test (SAT-M). In contrast to expectations based on previous research, no statistically significant sex-related difference was found for twelfth grade mathematical aptitude test (SAT-M) scores in the present study.

Factors Related to Pattern of Enrollment in Math Courses

In addition to the hypotheses concerning sex-related differences in certain variables of considerable current research interest, several hypotheses concerning the inter-relationship between men's and women's pattern of advanced mathematics course participation and some of the cognitive and affective variables discussed above were also formulated a priori. Based on a review of the relevant literature, it was predicted that, for both the men and the women, Pattern of Enrollment in Math Courses would be positively related to Perception of Encouragement to Study Math, Career Choice, Agentic Competency score, Attitude toward Mathematics, and twelfth grade SAT-M score.

As expected, for both the men and the women, significant positive relationships were found between Pattern of Mathematics Courses and Perception of Encouragement to Study Math, Attitude toward Mathematics, and twelfth grade SAT-M scores. A significant positive correlation was also found between Pattern of Math Courses and career choice for the women, but not for the men. The hypothesis concerning the direction of relationships between pattern of math courses and men's and women's Agentic Competency scores was also not supported. In the present study, a small, but statistically significant

positive relationship was found between Pattern of Enrollment in Math Courses and Agentic Competency scores for the men, but not for the women.

Factors Related to Twelfth Grade SAT-M Scores. In light of the current controversy surrounding the issue of sex-related differences in SAT-M scores among high school seniors, correlational analyses were also completed to assess the strength and direction of relationship between pre-college SAT-M scores and several variables of present research interest. Prior to data collection, it was hypothesized that for both the men and the women, twelfth grade SAT-M scores would be positively related to Perception of Encouragement to Study Math, Career Choice, Agentic Competency Scores, Attitude toward Mathematics, and Pattern of Enrollment in Math Courses Across the High School Years. As expected, significant positive relationships were found between twelfth grade SAT-M scores and Perception of Encouragement to Study Math from Parents and Teachers, Attitude toward Mathematics, and Pattern of Enrollment in Math Courses Across the High School Years for both the men and the women. However the hypotheses concerning the relationship between twelfth grade SAT-M scores and both Career Choice and Agentic Competency scores were not supported. In the present research, SAT-M scores and career choice were found to be significantly correlated for the women, but not for the men.

A significant positive relationship was found between SAT-M scores and Agentic Competency scores for the men, but not for the women.

In light of the present debate concerning the relative importance of the relationship between pre-college mathematical aptitude test scores and certain cognitive and social variables, a path analytic model was posited a priori to test the two rival hypotheses of Benbow and Stanley (1980) and Fennema and Sherman (1977) concerning mathematical aptitude. Based on a review of the relevant literature, several hypotheses were formulated prior to data collection concerning the relative importance of the cognitive and social variables for twelfth grade SAT-M scores. It was predicted that sex-related differences would be found in the relative importance of the cognitive and social variables used as predictors of SAT-M scores in the present study. It was also predicted that variables other than level of spatial ability prior to math course-taking in high school would also be found to be important determinants of SAT-M scores for men and women.

As expected, both level of spatial ability prior to math coursework in high school and certain social variables were found to be important determinants of SAT-M scores of men and women. For the men, pattern of math courses completed across

the high school years was the most important direct determinant of twelfth grade SAT-M scores, whereas eighth grade Space Relations Test score was the most important direct determinant of the twelfth grade SAT-M scores for the women. For the men, eighth grade Space Relations Test score was the second most important direct determinant of twelfth grade SAT-M scores, whereas pattern of math courses completed across the high school years was the second most important direct determinant of twelfth grade SAT-M scores for the women. The link between eighth grade spatial ability test score and Perception of Encouragement to Study Math was found to be important for the women, but not for the men. For both the men and the women, the relative magnitude of the other paths of causal influence in the model were found to be quite weak.

Summary of Findings Relevant to Hypotheses. Consistent with expectation based on previous research, sex-related differences in favor of the men were found for perception of encouragement to study math, attitudes toward mathematics, and pattern of mathematics courses completed across the high school years. However, the hypotheses concerning sex-related differences for twelfth grade mathematical aptitude scores was not supported. No statistically significant differences was found between the men's and women's twelfth grade SAT-M scores in the present study.

Several predictions concerning the direction of relationship between the cognitive and social variables were supported. For both the men and the women, perception of encouragement to study math, attitude toward mathematics, pattern of mathematics courses completed across the high school years, and twelfth grade SAT-M scores were all found to be positively related. However, the hypotheses concerning the strength and direction of relationship between both pattern of math courses and SAT-M scores and career choice and Agentic Competency scores were not supported. In contrast to expectations, sex-related differences were found for these last two variables. Both pattern of math courses and SAT-M scores were found to be significantly related to career choice for women, but not for men. Both pattern of math courses and SAT-M scores were found to be significantly related to Agentic Competency scores for the men, but not for the women.

CHAPTER 4

DISCUSSION AND CONCLUSION

The main purpose of the present study was to assess the magnitude of sex-related differences in visual-spatial ability, perception of social support to study math, attitudes toward mathematics, pattern of mathematics courses completed across the high school years, and pre-college mathematical aptitude among high school students. Among the students, no sex-related differences were found for the cognitive variables. Few sex-related differences of practical significance were found for the social variables. These data support the conclusion of Fennema and Sherman (1977) that the existing opinion that women are generally poorer in visual-spatial ability and have less aptitude for mathematics than men needs to be seriously modified.

Cognitive Variables

Visual-Spatial Ability. No statistically significant sex-related difference was found for eighth grade DAT Space Relations Test scores in the present study. This finding is of theoretical importance for several reasons. First, it is inconsistent with expectations based on Stafford's (1961) X-linked hypothesis regarding sex-related differences in visual-spatial ability. Second, it is contrary to expectations based on the long-standing conclusion that sex-related

differences in visual-spatial ability are "well-established" (Maccoby & Jacklin, 1974). Third, it is supportive of recent research in which no consistent sex-related differences in visual-spatial ability were found (e.g., see reviews by Vandenberg & Kuse, 1979; also, Brush, 1980; de Wolf, 1977; Fennema & Sherman, 1977; Nash, 1979; Schratz, 1978; Sherman, 1979). Fourth, it is consistent with the growing skepticism about the magnitude and nature of sex-related differences in visual-spatial ability found in past research (e.g., see Fennema, 1974; Fennema & Sherman, 1977; Hyde, 1981; Sherman, 1975; 1978). Fifth, it is inconsistent with the widely publicized hypothesis of Benbow and Stanley (1980) concerning the "natural superiority of males" in spatial ability prior to differential course-taking in mathematics across the high school years.

Scholastic Aptitude Test (SAT-M). In contrast to expectations based on previous research, no statistically significant sex-related difference was found for twelfth grade mathematical aptitude test (SAT-M) scores in the present study. This finding is of theoretical importance for several reasons. First, as with the lack of differences in eighth grade scores, the data is not consistent with expectations based on Stafford's (1972) X-linked hypothesis regarding sex-differences in mathematical aptitude. Second, it is not consistent with expectations based on a widely publicized

and popularized research report purporting to show genetic basis for sex-differentiated spatial ability (Benbow & Stanley, 1980). Third, it is consistent with the growing skepticism regarding the magnitude and nature of sex-related differences in mathematical aptitude (e.g., see Hyde, 1981; also Note 2, Rossi, 1982).

In light of the current controversy surrounding the issue of sex-related differences in SAT-M scores, it seems important to note that there was a sex-related difference observed in the range of SAT-M scores found in the present study that is consistent with previous research for high school seniors (e.g., see reviews by Fox, 1980; also, Benbow & Stanley, 1980). The SAT-M scores of the senior men ranged from 260 to 750, whereas the SAT-M scores for the senior women ranged from 250 to 700. Thus, there was a 50-point difference found between the highest scoring man and the highest scoring woman in the present study. Despite the 50-point difference in maximum SAT-M score between the men and the women, however, these data do not support Benbow's and Stanley's (1980) hypothesis concerning the "natural superiority of males" in spatial ability and mathematical aptitude. No significant sex-related difference was found for visual-spatial ability prior to differential coursework in high school, as noted earlier, and no sex-related difference was observed for maximum eighth grade DAT Space

Relations Test scores. For both the men and the women, the maximum eighth grade Space Relations Test score was 99. Thus, the observed difference in range of pre-college SAT-M score did not reflect a sex-related difference in initial level of visual-spatial ability prior to differential math course-taking in high school.

Upon close examination of the data, it was noted that only two of the senior men scored over 700 points on the SAT-M, the highest score for a woman. Inspection of their background data revealed that these two men were the only students who had completed the highest patterns of math courses (Patterns 10 and 11) and both were planning to pursue careers in applied mathematics and science.

The discussion of the findings concerning a sex-related difference in ranges of SAT-M scores is of theoretical importance for several reasons. First, the findings that the two men who out-scored the highest scoring woman had completed the highest patterns of math courses and were planning to pursue careers related to applied mathematics and science (i.e., Biomedical Engineering) appears to underscore the importance of the interrelationship between career choice, perceived usefulness of math to future education and career goals, pattern of math courses completed across the high school years, and pre-college SAT-M scores. Second, the discussion of the observed sex-related difference in range

of SAT-M scores in the absence of a significant sex-related difference in these scores demonstrates how interpretations of sex-related differences based on observed differences in range of scores rather than assessment of the statistical and practical significance of group-related differences can serve to exaggerate sex-related differences as Rossi (Note 3, 1983) has pointed out. Third, the finding of a sex-related difference in range of SAT-M scores in the absence of a sex-related difference in Space Relations Test scores highlights the importance of actually controlling for level of spatial ability prior to differential coursework in math across the high school years in research of this nature. In studies in which interpretation is based on the relationship of these two variables, relying solely on references to the body of literature which purports to have found that sex-related differences in visual-spatial ability are "well-established", as was done by Benbow and Stanley (1980), is not an adequate control technique.

Social Variables

Perception of Encouragement to Study Math. The finding that men perceived significantly more encouragement to study math than the women from mothers, but not fathers is consistent with previous research (Fennema & Sherman, 1977). The finding that the men also perceived significantly more encouragement to study math than the women from their teachers

is inconsistent with the results of Fennema's and Sherman's research in which no significant sex-related difference was found for the variable among high school students. It seems important to note that this apparent differential encouragement of men and women to study math appears to be independent of the students' level of spatial ability prior to math coursework in high school since no sex-related difference was found for either eighth grade Space Relations Test scores or twelfth grade SAT-M scores, as noted earlier.

Attitude toward Mathematics. The finding that the men perceived mathematics to be more useful to their future education and career goals than the women is consistent with previous research (e.g., Brush, 1980; Ernest, 1976; Haven, 1971; Hilton & Berglund, 1974; Keeves, 1973) as is the finding that the men were more confident about their ability to succeed in math courses than the women (e.g., see reviews by Fox, 1980; Tobias, 1978; also, Brush, 1980; Fennema & Sherman, 1977). The finding of a significant sex-related difference in favor of the men for Effectance Motivation in Math, or attitude toward problem-solving tasks, is not consistent with evidence provided in previous research (Fennema & Sherman, 1977) for high school students.

Since the sample for the present study was drawn from a high school enrolling high socio-economic class students, the finding of no sex-related difference in favor of males

on the Attitude toward Success in Math subscale is not consistent with expectations based on the "Fear of Success" literature and on previous research (Fennema & Sherman, 1977) in which women enrolled in high schools located in high socio-economic class neighborhoods held "somewhat less positive attitudes toward success in math" than their male counterparts. This finding is of theoretical importance because it shows that the problem of women's less positive attitude toward mathematics is not due to a "fear of success" as hypothesized by others.

Pattern of Math Courses. The finding of a statistically significant sex-related difference in pattern of enrollment in math courses across the high school years is in agreement with previous research (e.g., Brush, 1980; de Wolf, 1977; Fennema & Sherman, 1977). Examination of the actual patterns of math courses completed by the men and the women, however, revealed that 73.8 percent of the men and 53.9 percent of the women had completed at least one course beyond Geometry. Of these students, 18.7 percent of the men and 19.1 percent of the women had completed Pre-Calculus (Analysis) and another 26.1 percent of the men and 15.7 percent of the women had completed Calculus. Thus, the sex-related differences found for pattern of math courses completed across the high school years was not as great as one would expect based on previous research (e.g., see reviews by Tobias, 1978).

Assessment of the practical significance of the statistically significant sex-related difference in pattern of math courses completed across the high school years revealed that this sex-related difference was small. More than 98 percent of the variance in pattern of math courses completed across the high school years is accounted for by factors other than sex. This finding is of theoretical importance because it illustrates the value of assessing the practical significance of sex-related differences when found prior to interpretation of data, as Hyde (1981) and others (e.g., Rossi, Note 2, 1982), have pointed out. Examining the actual patterns of math courses completed by men and women across the high school years is also important in research on achievement in mathematics because, as the present findings indicate, more men and women may be presently completing higher patterns of math courses than was found in past research.

Longitudinal Change in Attitude toward Mathematics.

The longitudinal analyses for the 44 students (22 men and 22 women) who participated in pilot research in 1981 and who also participated in the present research revealed a significant increase in the men's attitude toward mathematics between the junior and senior years, and a non-significant decrease in women's attitude toward mathematics during that period of time. The same pattern of results was also found for the men and women for perception of

encouragement to study math, but the differences did not reach significant levels.

The findings of an increase in men's attitude toward mathematics and of a slight decrease in women's attitude toward mathematics between the junior and senior years is not consistent with previous cross-sectional findings in which a significant decrease was found for both men and women high school students or with longitudinal findings of no change (Brush, 1980). The present findings are of importance for several reasons, however. First, they appear to support the contention of Fennema and Sherman (1977) that attitude toward mathematics and perception of encouragement to study math from parents and teachers are related in an important manner. Second, they underscore the necessity of collecting longitudinal data in research on attitudes toward mathematics among a variety of populations. Third, they suggest that collecting longitudinal data for perception of encouragement to study math from parents and teachers among a variety of populations may be useful for determining the grade level at which differential encouragement of men and women first occurs.

Factors Related to Pattern of Enrollment in Math Courses. The findings of significant positive relationships between pattern of enrollment in math courses and both perception of encouragement to study math and attitude toward

mathematics is supportive of previous research (e.g., see reviews by Fox, 1980; also, Fennema & Sherman, 1977). The finding that career choice was significantly related to women's pattern of math courses completed across the high school years is supportive of research reviewed by Fox (1980) in which students who were either planning to pursue careers which were considered to be "traditionally masculine" ones in the past or students who were undecided about their future career plans enrolled in more math courses in high school than students who were planning to pursue careers which were considered to be "traditionally feminine" ones in the past. The finding of no significant relationship between pattern of enrollment in math classes and career choices for men is inconsistent with findings of previous research discussed above. It should be noted, however, that there was less variability in the men's data for career choice than in the data for women's career choice. Even though no difference was found between the percentage of men and women who were undecided about their future career plans (15 percent and 14.6 percent, respectively), a significant difference was found between the percentages of men and women planning to pursue "traditionally masculine" careers (85 percent and 47.2 percent respectively) and "traditionally feminine" careers (0 percent and 38.2 percent, respectively).

In addition to the correlational analyses discussed above, Multiple Regression Analyses were also performed to isolate factors determining men's and women's pattern of mathematics course enrollment across the high school years. Following the correlational analyses to determine the best set of potential predictors, the variables that were finally entered into the equations as potential predictors of pattern of enrollment in math courses in the analysis using the stepwise procedures were: eighth grade DAT Space Relations Test scores, Career Choice, Agentic Competency, Attitude toward Mathematics, and senior year SAT-M scores. The results of these analyses revealed that senior year SAT-M score was an important correlate of both men's and women's Pattern of Math Courses Completed Across the High School Years. When SAT-M score was entered into the equations in first order, this variable accounted for 56 percent of the total variance accounted for in men's pattern of math courses (60 percent) and almost 53 percent of the total variance accounted for in women's pattern of math courses (53 percent). The remaining variables contributed very little to the total variation accounted for in both men's and women's pattern of math courses when entered into the equations in the order selected for these stepwise analyses. The results of the analyses using a hierarchical procedure in which SAT-M score was omitted from the equations revealed that Space Relations Test score

accounted for nine percent of the total variance accounted for in pattern of math courses (34 percent) and 19 percent of the total variance accounted for in women's pattern of math courses (31 percent).

The present findings appear to be inconsistent with Sherman's (1981) findings that initial level of spatial ability was the most important factor postdicting years of enrollment in theoretical math courses for high school women and the least important factor for men. However, since some variables included in Sherman's analyses were different from those included in the present study, it is difficult to compare the results of these analyses with those of Sherman.

It should be noted that, in the present study, a significant positive relationship was found between pattern of mathematics courses completed across the high school years and eighth grade spatial visualization test scores for both the men ($\underline{r} = .3031$; $\underline{p} < .01$) and the women ($\underline{r} = .4311$; $\underline{p} < .01$). The finding of a significant positive relationship between pattern of mathematics courses completed across the high school years and eighth grade spatial visualization test scores appears to be supportive of Benbow's and Stanley's (1980) hypotheses concerning the direction of relationship between these variables and is also consistent with results of previous research for high school students (e.g., Brush, 1980; Fennema & Sherman, 1977). However, the results

of the present study clearly do not support Benbow's and Stanley's contention concerning the importance of the relationship between initial level of spatial ability and pattern of math course enrollment in high school. Since some social variables (e.g., perception of social support to study math and twelfth grade SAT-M scores) were found to be important as well as prior ability, the results of these analyses support the hypothesis of Fennema and Sherman (1977) concerning the importance of the interrelationship between these variables and experience in math courses for both men and women. The high prediction of twelfth grade SAT-M score to pattern of math courses completed across the high school years found in the Multiple Regression Analyses is of theoretical importance because it is not supportive of Benbow's and Stanley's contention that the relationship between these variables is not important. The fact that SAT-M score accounted for 56 percent of the total variation accounted for in men's pattern of math courses and almost 53 percent of the total variation accounted for in women's pattern of math courses in the present study is significant. The results of the present study also demonstrate the importance of controlling for initial level of spatial ability and actual pattern of math courses completed across the high school years in research on later mathematical aptitude.

Factors Related to Twelfth Grade SAT-M Scores. The finding of positive relationships between SAT-M scores and both perceptions of encouragement to study math and attitude toward mathematics is supportive of previous research (Fennema & Sherman, 1977) in which the same pattern of relationship was found between perceptions of encouragement to study math, attitude toward mathematics, and achievement test scores among high schools students. The finding of no relationship between SAT-M score and Agentic Competency score for women appears to be inconsistent with previous research in which a positive relationship had been found between achievement in mathematics and self-attribution of traits related to intellectual functioning (e.g., logical, competent) for high school women (e.g., Potter, 1974). The finding of a strong positive relationship between SAT-M scores and pattern of mathematics courses completed across the high school years is of theoretical importance for several reasons. First, it is consistent with previous research in which pattern of math courses completed across the high school years was found to be related to achievement in mathematics (see reviews by Fox, 1980; also de Wolf, 1979; Fennema & Sherman, 1977). Second, it is supportive of Fennema's and Sherman's (1977) hypothesis which posits that experience in math courses is importantly related to later achievement in mathematics.

The findings of the present study concerning factors predicting SAT-M scores are of theoretical importance for several reasons. First, the finding of a strong, positive relationship between men's and women's senior year SAT-M scores and their eighth grade spatial visualization test scores is consistent with previous research in which initial level of spatial ability was found to be important for achievement in mathematics (e.g., Bishop, 1973; Hills, 1957; McCallum, Smith & Eliot, 1979). Second, the finding of a strong positive relationship between men's and women's senior year SAT-M scores and their eighth grade spatial visualization test scores is supportive of the hypotheses of both Fennema and Sherman (1977) and Benbow and Stanley (1980) concerning the direction of relationship for these variables. Third, the finding concerning the importance of the relationship between SAT-M scores and pattern of math courses completed across the high school years for both men and women clearly demonstrates that both cognitive and social variables are important determinants of pre-college SAT-M scores, as Fennema and Sherman (1977) have pointed out. Fourth, the finding of a large sex-related difference in the relative magnitude of the path of causal influence between eighth grade spatial ability level and perception of encouragement to study math from parents and teachers suggests that encouragement of women to pursue advanced study in math may be

more dependent on ability level than is such encouragement of men. It appears that the strength of the causal link between women's initial level of visual-spatial ability and mathematical aptitude test scores (e.g., Sherman, 1981) may have been exaggerated by social variables such as perception of encouragement to study math, whereas the link between men's initial level of spatial ability and mathematical aptitude test scores is masked due to the non-discriminative encouragement of men to study math.

Social variables played a large role in both men's and women's selection of math courses and senior year SAT-M scores. However, social variables other than perceived support, such as attitude toward mathematics, distinguished men from women in the predictive models. Further analyses of the evolution of positive attitudes toward mathematics among men and women should be an important future direction.

Limitations and Implications of Present Research

In the present research, the variables of race and socio-economic class were not investigated since the students who participated were currently enrolled in a suburban high school located in a predominantly white, high socio-economic class community in New England. Participation in this study was further limited to students who a) volunteered to participate, b) signed student consent forms, c) had eighth grade DAT Space Space Relations Test scores in their student

records, and d) had twelfth grade Scholastic Aptitude Test scores (SAT-M) in their student records. Therefore, the results of the present study may only be generalizable to white, middle-to-upper middle class, college-bound high school students. Generalizability of the present findings for factors predicting both pattern of mathematics courses completed across the high school years and SAT-M scores are further restricted since complete data was available for fewer students than would be considered the optimum number for such multivariate analyses. Therefore, replications of these findings are needed before widespread generalizations of these results may be made.

However, the present research made a considerable contribution to the literature because it was the first in which factors predicting twelfth grade SAT-M scores of men and women were isolated. Also, because both eighth grade spatial ability level and pattern of math courses completed across the high school years were controlled, considerable light was shed on the importance of both cognitive and social variables in research on mathematical aptitude. In addition, this research was also apparently the first in which a path analytic model for SAT-M scores of men and women was posited a priori and tested.

The present data indicates that, for both men and women, there is an important interrelationship between level of

visual-spatial ability prior to math coursework in high school, pattern of math courses completed across the high school years, and twelfth grade mathematical aptitude test scores. Since eighth grade spatial visualization test score was found to be an important determinant of pre-college SAT-M score, further research on cognitive and affective factors predicting spatial ability test scores among middle school students seems warranted since there appear to be few such studies to date. For example, Fennema's and Sherman's hypothesis concerning the importance of the relationship between spatial ability level and experience in math- and space-related in-school courses and out-of-school activities could be tested. In the present study, no sex-related difference was found for initial spatial ability level while significant sex-related differences were found for both current participation in math- and space-related in-school courses and participation in math- and space-related out-of-school activities among high school seniors. Perhaps longitudinal data for these variables would be useful for interpreting sex-related differences, when found. It appears that future research on the relationship between initial level of visual-spatial ability of boys and girls and perception of encouragement to study math from parents and teachers is also needed since eighth grade spatial ability level was found to be a strong predictor of encouragement

to study math for senior girls, but not senior boys, in the present study. The senior men and women were found to be equal in both eighth grade visual-spatial ability test scores and twelfth grade mathematical aptitude test (SAT-M) scores. Even so, the men and women perceived differential encouragement to study math from parents and teachers. The men also held more positive attitudes toward mathematics than the women and enrolled in higher patterns of math courses across the high school years.

Additional research on factors predicting both pattern of enrollment in math courses across the high school years and SAT-M scores is also needed, since the present study is the only one to date to assess both criterion variables. The few studies conducted on factors predicting pattern of enrollment in math courses across the high school years have used different measures and yield inconsistent and/or uncomparable results. Therefore, replication of these studies is needed. Also, certain variables of considerable interest, such as eighth grade mathematical ability test scores, have not been controlled in any study to date. Since the sample for this present study was a restricted one, isolation of factors predicting pre-college SAT-M scores among students of varying ability level, race, and social class levels is indicated prior to widespread generalization of these

results. Sufficient sample descriptions should be included in reports of such research to enhance comparison of the findings.

In light of the results of the longitudinal analyses included in the present study which indicates that both attitude toward mathematics and perception of encouragement to study math change over time, there is a need to extend this research to students of varying grade levels, since both of these variables have been found to be strongly related to completed pattern of mathematics courses and twelfth grade SAT-M scores. For example, it appears that examination of attitude toward mathematics and perception of encouragement to study math among college students would be useful to determine if there are sex-related differences in these variables that might inhibit achievement in mathematics in college for men or women of varying levels of mathematical ability. In the present study, the scores for the men for these social variables were found to increase between the junior and senior years, whereas the scores for the women decreased slightly. It seems possible, then, that men and women might experience differential encouragement to pursue advanced study in math beyond the junior year in high school despite the fact that there may be no sex-related difference in mathematical aptitude.

Strategies for Social Change

In light of the present findings and growing list of recent research in which no sex-related difference was found for either spatial visualization test scores or mathematical aptitude test scores, social change in attitude toward the mathematical ability of men and women seems indicated. Several proposed strategies for implementing changes are outlined below.

1. Direct public attention toward the growing body of scientific research in which no sex-related differences in cognitive abilities are being found since a great deal of publicity has been devoted to studies purporting to support the concept of "natural male superiority" in such abilities (e.g., Benbow & Stanley, 1980; Stafford, 1961).

2. Re-evaluate the presumed current practice of rejecting for publication studies in which no significant sex-related differences in cognitive measures are found since this practice appears to lead to exaggeration of sex-related differences and to foster the notion that sex-related differences in cognitive abilities are innate (Greenwald, 1975).

3. Consider requiring researchers to report both the statistical and practical significance of sex-related differences when found, as Hyde (1981) and others have suggested.

4. Direct public attention toward recent research in which important interrelationships have been found between

mathematical aptitude test scores and social variables such as pattern of math course enrollment in high school and perception of encouragement to study math from parents and teachers.

5. Direct public attention toward cross-cultural data which indicate that the direction of sex-related differences in spatial visualization test scores, attitudes toward mathematics, enrollment in math courses, and mathematical aptitude test scores is culture bound (e.g., see review by Tobias, 1978).

6. Direct public attention toward recent research in which spatial visualization test scores of boys and girls improved with training in spatial-related tasks (e.g., see review by Meece, Parsons, Kaczala, Goff & Futterman, 1982).

7. Challenge the motives of those who are continuing to publicize the notion of "natural male superiority" in cognitive ability both in textbooks and the press in the absence of research evidence to support such a contention. As Fennema and Sherman have pointed out, the ease with which hypotheses such as the X-linked hypotheses concerning spatial ability and mathematical ability (Stafford, 1961; 1972) are accepted should serve as a reminder of the readiness of society to accept biological explanations that serve to justify the status quo.

Reference Notes

1. Wittig, M.A. Personal communication. November 1981.
2. Rossi, J.S. Sex and Mathematical Ability: A note on the magnitude of experimental effects. Manuscript submitted for publication, 1982.
3. Rossi, J.S. Ratios Exaggerate Gender Differences in Mathematical Ability. Manuscript submitted for publication, 1983.

References

- Aiken, L.R. Attitudes toward mathematics. Review of Educational Research, 1970, 40, 551-596.
- Aiken, L.R. Intellective variables and mathematics achievement: Directions for research. Journal of School Psychology, 1971, 9, 201-212.
- Aiken, L.R. Update on attitudes and other affective variables in learning mathematics. Review of Educational Research, 1976, 46, 293-311.
- Anastasi, A. Differential Psychology: Individual and Group Differences in Behavior, New York: The MacMillan Company, 1958.
- Armstrong J.A. A national assessment of participation and performance of women in mathematics. Paper presented at Society for Research in Child Development meetings in San Francisco, California, March 1979.
- Benbow, C.P. & Stanley, J.C. Sex Differences in mathematical ability: Fact or artifact? Science, 1980, 210. 1263-1264.
- Bennett, G., Seashore, H. & Wessmen, A. Manual for the Differential Aptitude Test. New York: Psychological Corporation, ed. 5, 1974, forms S and T.
- Betz, N.E. Prevalence, distribution, and correlates of math anxiety in college students. Journal of Counseling Psychology, 1978, 25, 441-448.
- Bishop, A.S. Use of structured apparatus and spatial ability. Research in Education, 1973, 9, 43-49.

- Block, J.H. Conception of sex role: Some cross cultural and longitudinal perspectives. American Psychologist, 1973, 28, 512-526.
- Bock, R.D. A family study of spatial visualizing ability. American Psychologist, 1967, 22, 571.
- Bock, R.D. A study of familial effects in certain cognitive and perceptual variables. Final Report of the Illinois Psychiatric Training and Research Grant No. 17-137 to the University of Chicago, 1970.
- Broverman, S.M., Klaiber, E.L., Kobayaski, Y. & Vogel, W. Roles of activation and inhibition in sex differences in cognitive abilities. Psychological Review, 1968, 75, 23-50.
- Brush, L. Encouraging girls in mathematics: The problem and the Solution. Cambridge, MA: Abt Books, 1980.
- Cassery, P.L. Factors affecting female participation in advanced programs in mathematics, chemistry, and physics. In L.H. Fox, L. Brody & D. Tobin (Eds.), Women and the Mathematical Mystiques. Baltimore: The Johns Hopkins University Press, 1980, pp. 136-263.
- Dawson, J.L.M. Effects of sex hormones on cognitive styles in rats and men. Behavior Genetics. 1972, 2, 21-42.
- de Wolf, V.A. High school mathematics preparation and sex differences in quantitative abilities. Report presented to Educational Assessment Center, Seattle, June, 1977.
- Dornbusch, S.M. To try or not to try. The Stanford Magazine, 1974, 2, 50-54.
- Ernest, J. Mathematics and Sex; American Mathematical Monthly, 1976, 83, (8), 595-614.
- Feinberg, L.B. & Halperin, S. Affective and cognitive correlates of course performance in introductory statistics, Journal of Experimental Education, 1976, 11-18.
- Fennema, E. Mathematics learning and the sexes: A review. Journal for Research in Mathematics Education, 1974, 5, 126-139.

- Fennema, E. Influences of selected cognitive, affective, and educational variables on sex-related differences in mathematics learning and studying. (National Institute of Education paper on Education and Work. No. 8 U.S. Department of Health, Education & Welfare). Washington, DC: U.S. Government Printing Office, 1977.
- Fennema, E. Sex-related differences in mathematics achievement, spatial visualization and affective factors. American Educational Research Journal, 1977, 14, (1), 5-71.
- Fennema, E. Sex-related differences in mathematics achievement and related factors: A further study, Journal of Research in Mathematics Education, 1978, 9, (3), 188-203.
- Fennema, E. & Sherman, J.A. Fennema-Sherman mathematics attitude scales: Instruments designed to measure attitudes toward learning of mathematics by females and males. American Psychological Association. Document MS1225. Journal Supplement Abstract Service, American Psychological Association, Washington, DC 20036, 1976
- Fox, L.H. The problem of women and mathematics. A report to the Ford Foundation, March 1980.
- Greenwald, A.G. Consequences of prejudice against the null hypothesis. Psychological Bulletin, 1915, 82, 1-20.
- Guttman, R. Genetic analysis of analytical spatial ability. Raven's Progressive Matrices, Behavior Genetics, 1974, 4, 273-284.
- Hartlage, L.C. Sex-linked inheritance of spatial ability. Perceptual and Motor Skills, 1970, 31, 610.
- Haven, E. Selected community, school, teacher, and personal factors associated with girls electing to take advanced mathematics courses in high school. Unpublished dissertation, University of Pennsylvania, 1971.
- Hendel, D.D. Correlates of mathematics anxiety of adult women participants in a math anxiety program. Psychology of Women Quarterly, 1980, 5, (2), 219-230.
- Hills, J.A. Factor-analyzed abilities and success in college mathematics. Educational and Psychological Measurement, 1957, 17, 615-622.

- Hilton, T.L. & Berglund, G.W. Sex differences in mathematics achievement - a longitudinal study. Journal of Educational Research, 1974, 67, 231-237.
- Hoffman, L.W. Fear of success in males and females: 1965 and 1971. Journal of Consulting and Clinical Psychology, 1974, 42, 353-358.
- Horner, M. Achievement-related conflicts in women. In Mednick, M. & Tangri, S. (Eds.) New perspectives on women, Journal of Social Issues, 1972, 28, 157-175.
- Horner, M. Why bright women fear success. In C. Tavis (Ed.) The female experience. Del Mar. California: Communications Research Machines, 1973, 55-57.
- Hoyenga, K.B. & Hoyenga, K.T. The question of sex differences. Boston: Little, Brown and Company, 1979.
- Husen, T. (Ed.) International study of achievement in mathematics, a comparison of twelve countries. New York: Wiley, 1967.
- Hyde, J.S. How large are cognitive gender differences? American Psychologist, 1981, 36, (18), 892-901.
- Kagan, J. Aquisition and significance of sex typing and sex roles identity. From Hoffman, M.L. and Hoffman, L.W. (Eds.) Review of Child Development Research, Russell Sage Foundation, 1964, 137-167.
- Kagan, J. & Kogan, N. Individual variation in cognitive processes. In P.H. Musen (Ed.) Charmichael's Manual of Child Psychology, New York: Wiley, 1970, 1273-1365.
- Klaiber, E.L., Broverman, D.M., Vogel, W. and Kobayashi, Y. Rhythms in plasma MAO activity, EEG, and behavior during the menstrual cycle. In M. Ferin, F. Halberg, R.M. Richart, and R.L. Vande Wiele (Eds.), Biorhythms and human reproduction. New York: Wiley, 1974, 353-367.
- Klaiber, E.L., Kobayashi, Y. and Broverman, D.M. The automatization cognitive style, androgens, and monoamine oxidase. Psychopharmacologia, 1967, 11, 320-336.
- Keeves, J.P. Differences between the sexes in mathematics and science courses. International Review of Education, 1973, 19, 47-63.

- Koff, E. & Makros, J.R. Sex-stereotyping of children's judgments of academic success. Psychological Reports, 1978 43, 802.
- Kolata, G.B. Math and sex: Are girls born with less ability? Science, 1980, 210, 1234-1235.
- Lazrus, M. Mathophobia: Some personal speculations. The Principal, Jan/Feb, 1974, 18.
- Lemkau, J.P. Personality and background characteristics of women in asexotypical occupations. Unpublished dissertation, University of Rhode Island, 1978.
- Lindeman, R.H., Merenda, P.F. & Gold, R.T. Introduction to bivariate and multivariate analysis, Illinois: Scott, Foresman & Co., 1980.
- Lott, B. Becoming a woman. The socialization of gender. Springfield, Ill.: Charles C. Thomas, 1981.
- Luchins, E.H. & Luchins, A.S. Female mathematicians: A contemporary appraisal. in L.H. Fox, L. Brody, & D. Tobin (Eds.) Women and the mathematical mystique. Baltimore: The Johns Hopkins University Press, 1980.
- Maccoby, E.E. (Ed.) The development of sex differences. Stanford, Stanford University Press, 1966.
- Maccoby, E.E. & Jacklin, C.N. Psychology of sex differences. Stanford, Stanford University Press, 1974.
- Makros, J.R. & Koff, E. Sex-stereotyping of children's success in mathematics and reading. Psychological Reports, 1978, 42, 1287-1293.
- Meracek, Jeanne. Power and women's psychological disorders: preliminary observations. Mimeo, 1977. Swarthmore College, Swarthmore, Pa.
- McCallum, D.I., Smith, I.M. & Eliot, J. Further investigation of components of mathematical ability. Psychological Reports, 1979, 44, 1127-1133.
- McGee, M.G. Interfamilial correlations and heritability estimates for human spatial abilities in a Minnesota sample. Behavioral Genetics, 1978, 8, 77-80.

- Meece, J.L., Parsons, J.E., Kaczala, C.M., Goff, S.D. & Futterman, R. Sex differences in math achievement: Toward a model of academic choice. Psychological Bulletin, 1982, No. 91 (2), 324-345.
- Nash, S.C. The relationship among sex-role stereotyping, sex-role preference, and the sex difference in spatial visualization. Sex Roles, 1975, 1, (1), 15-32.
- Nash, S.C. Sex role as a mediator in intellectual functioning. In M.A. Wittig & A.C. Peterson (Eds.), Sex-related differences in cognitive functioning. New York: Academic Press, 1979, 263-293.
- O'Connor, J. Structural visualization. Boston: Human Engineering Labs, 1943.
- Peterson, A.C. Physical androgyny and cognitive functioning in adolescence. Developmental Psychology, 1976, 12, 524-533.
- Petro, C.S. & Putnam, B.S. Sex role stereotypes: Issues of attitudinal changes. Sex Roles, 1979, 5, 29-39.
- Potter, N. Mathematical and verbal ability patterns in women. In: Tobias, S. Overcoming math anxiety, New York: W.W. Norton & Co., 1978, 90.
- Reinisch, J.M. Prenatal exposure of human fetuses to synthetic progestin and oestrogen affects personality. Nature, 1977, 266, 561-562.
- Rounds, J.B. & Hendel, D.D. Measurement and dimensionality of mathematics anxiety. Journal of Counseling Psychology, 1980, 27, (2), 138-149.
- Scannel, D.P. Test of Academic Progress, Manual, Form S. Boston, MA: Houghton Mifflin, 1972.
- Schratz, M. Developmental investigation of sex differences in spatial (Visual-Analytic) and mathematical skills in three ethnic groups. Developmental Psychology, 1978, 14, (3), 263-267.
- Schildkamp-Kuendiger, E. Die Frauenrolle und die mathematische leistung. In: Tobias, S. Overcoming math anxiety, New York: W.W. Norton & Co., 1978, 89.
- Sells, L. Mathematics - a critical filter. The Science Teacher, 45, (2), Feb. 1978.

- Seepie, A.C. & Keeling, B. The relationship between type of anxiety and under-achievement in mathematics. Journal of Educational Research. 1978, 72, (1), 15-19.
- Sherman, J. Problem of sex-differences in space perception and aspects of intellectual functioning. Psychological Review, 1967, 74, 290-298.
- Sherman, J. On the psychology of women: A survey of empirical studies, Springfield, Illinois: Charles C. Thomas, 1971.
- Sherman, J. Field articulation, sex, spatial visualization, dependency, practice, laterality of the brain and birth order. Perceptual and Motor Skills, 1974, 38, 1223-1235.
- Sherman, J. Review of the psychology of sex differences by E.E. Maccoby & C.N. Jacklin. Sex Roles, 1975, 1, 197-301.
- Sherman, J. Sex-related cognitive differences: An essay on theory and evidence. Springfield: Charles C. Thomas, 1978.
- Sherman, J. Women and mathematics: Summary of research from 1977-1979. N.I.E. Grant. Partially summarized in J. Sherman: Prediction: mathematics performance in high school girls and boys. Journal of Educational Psychology, 1979, 71, 242-249.
- Sherman, J. Girls' and boys' enrollments in theoretical math courses: A longitudinal study. Psychology of Women Quarterly, 1981, 5 (5), 681-689.
- Sherman J. & Fennema, E. The study of mathematics by high school girls and boys: Related variables. American Educational Research Journal. 1977, 14, 159-168.
- Sherman, J. & Fennema, E. Distribution of spatial visualization and mathematical problem solving scores: A test of Stafford's X-linked hypotheses. Psychology of Women Quarterly, 1978, 3 (2), 157-167.
- Spaeth, J. Path Analysis. In D.J. Amick & H.J. Walbergs (Eds.) Introductory Multi-variate Analysis for Educational, Psychological, and Social Research, New York: McCutchan Publishing Corp., 1975. 53-59.
- Stafford, R.E. Sex differences in spatial visualization as evidence of sex-linked inheritance. Perceptual and Motor Skills, 1961, 13, 428.

- Stafford, R.E. An investigation of similarities in parent-child test scores for evidence of hereditary components. Princeton Educational Testing Service. 1963. In: Hoyenga, K.B. & Hoyenga, K.T. The questions of sex differences. Boston: Little, Brown and Company, 1979.
- Stafford, R.E. Heredity and environmental components of quantitative reasoning. Review of Educational Research, 1972, 42, 183-201.
- Stage, E.K. Commentary on women in math. Project on the Status of and Education of Women, No. 29, Winter, 1981, 2, 15.
- Starr, B.S. Sex differences among personality correlates of mathematical ability in high school seniors. Psychology of Women Quarterly, 1979, 4, 212-220.
- Stein, A.H. & Smithells, J. Age and sex differences in children's sex role standards about achievement. Developmental Psychology, 1969, 1, 252-259.
- Tobias, S. Overcoming math anxiety. New York: W.W. Norton & Co., 1978.
- Vandenberg, S.C. & Kuse, A.R. Spatial ability: A critical review of the sex-linked major-gene hypothesis. In M.W. Wittig & A.C. Peterson (Eds.), Sex-related differences in cognitive functioning: Developmental issues. New York: Academic Press, 1979.
- Weigers, R.M. & Frieze, I.H. Gender, females traditionality, achievement level, and cognitions of success and failure. Psychology of Women Quarterly. 1977, 2, 125-137.
- Wexler, H. Women in mathematics: An overview. American Education, June, 1980, 38.
- White, M.S. Measuring androgyny in adulthood. Psychology of Women Quarterly, 1979, 3, 293-307.
- Whitely, R.H. Internal-external locus of control, subjective probability of success, decision consequence, and other selected variables as factors in pre-decision information acquisition (Doctoral Abstracts, International, 1970, 30, 2865A-2866A (University Microfilms No. 69-15, 024).

- Wilhelm, S. & Brooks, D.M. The relationship between pupil attitudes toward mathematics and parental attitudes toward mathematics. Educational Research Quarterly, 1980, 5, (2), 8-16.
- Winer, B.J. Statistical principles in experimental design; Second Ed. New York: McGraw-Hill Book Company, 1971.
- Wise, L.L., Steel, L., & MacDonald, C. Origins and career-consequences of sex differences in high school mathematics achievement. Report to the National Institute of Education on its grant No. NIE-G88-001. Palo Alto, Calif.: The American Institute for Research, 1979.
- Wittig, M.A. Sex differences in intellectual functioning: how much of a sex difference do genes make? Sex Roles, 1976, 2, 63-74.
- Wittig, M.A. Letter to the Editor. Sex Roles, 1978, 4, 331-332.
- Yen, W.M. Sex-linked major gene influences on selected types of spatial performance. Behavior Genetics, 1975, 5, 281-298.

APPENDIX A

STUDENT CONSENT FORM

You are being asked to participate in a survey about mathematics. This study is being done in order to help us understand how students feel about this subject. We are only interested in how students in general feel. We will not use your individual answers or your name in our report. No one will be told how you answer any questions in this survey.

On the following pages there is a series of statements. There are no correct answers for these statements. They have been set up in a way which permits you to indicate the extent to which you agree or disagree with the ideas expressed. As you read each statement, you will know whether you agree or disagree. Circle the appropriate number to indicate your response.

Please answer each statement, but do not spend much time on any of them. Remember, there are no "right" or "wrong" answers. The only correct responses are those that are true for you. Whenever possible, let the things that have happened to you help you make your choice. THIS SURVEY IS BEING USED FOR EDUCATIONAL RESEARCH PURPOSES ONLY, AND NO ONE WILL KNOW WHAT YOUR RESPONSES ARE. Please sign this form so we will know that you understand that you are taking part in a confidential research project designed to study how students feel about math. Thank you.

(sign your name here)

After signing your name, please turn the page and begin. Continue until you have completed every statement in this survey.

ATTITUDES TOWARD MATHEMATICS SCALES

Fennema-Sherman (1975)

Confidence in Learning Mathematics Scale (C)Weight

1.	+	Generally I have felt secure about attempting mathematics.
2.	+	I am sure I could do advanced work in mathematics.
3.	+	I am sure that I can learn mathematics.
4.	+	I think I could handle more difficult mathematics.
5.	+	I can get good grades in mathematics.
6.	+	I have a lot of self-confidence when it comes to math.
7.	-	I am no good in math.
8.	-	I don't think I could do advanced mathematics.
9.	-	I am not the type to do well in math.
10.	-	For some reason even though I study, math seems unusually hard for me.
11.	-	Most subjects I can handle O.K., but I have a knack for flubbing math.
12.	-	Math has been my worst subject.

Mother Scale (M)Weight

1.	+	My mother thinks I'm the kind of person who could do well in mathematics.
2.	+	My mother thinks I could be good in math.
3.	+	My mother has always been interested in my progress in mathematics.
4.	+	My mother has strongly encouraged me to do well in mathematics.
5.	+	My mother thinks that mathematics is one of the most important subjects I have studied.
6.	+	My mother thinks I'll need mathematics for what I want to do after I graduate from high school.
7.	-	My mother thinks advanced math is a waste of time for me.
8.	-	As long as I have passed, my mother hasn't cared how I have done in math.
9.	-	My mother wouldn't encourage me to plan a career which involves math.
10.	-	My mother has shown no interest in whether or not I take more math courses.
11.	-	My mother thinks I need to know just a minimum amount of math.
12.	-	My mother hates to do math.

Father Scale (F)Weight

1. + My father thinks that mathematics is one of
 the most important subjects I have studied.
2. + My father has strongly encouraged me to do well
 in mathematics.
3. + My father has always been interested in my
 progress in mathematics.
4. + My father thinks I'll need mathematics for what
 I want to do after I graduate from high school.
5. + My father thinks I'm the kind of person who
 could do well in mathematics.
6. + My father thinks I could be good in math.
7. - My father wouldn't encourage me to plan a
 career which involves math.
8. - My father hates to do math.
9. - As long as I have passed, my father hasn't
 cared how I have done in math.
10. - My father thinks advanced math is a waste of
 time for me.
11. - My father thinks I need to know just a minimum
 amount of math.
12. - My father has shown no interest in whether or
 not I take more math courses.

Attitude Toward Success in Mathematics Scale (AS)

Weight

1. + It would make me happy to be recognized as an excellent student in mathematics.
2. + I'd be proud to be the outstanding student in math.
3. + I'd be happy to get top grades in mathematics.
4. + It would be really great to win a prize in mathematics.
5. + Being first in a mathematics competition would make me pleased.
6. + Being regarded as smart in mathematics would be a great thing.
7. - Winning a prize in mathematics would make me feel unpleasantly conspicuous.
8. - People would think I was some kind of a grind if I got A's in math.
9. - If I had good grades in math, I would try to hide it.
10. - If I got the highest grade in math I'd prefer no one knew.
11. - It would make people like me less if I were a really good math student.
12. - I don't like people to think I'm smart in math.

Teacher Scale (T)Weight

1. + My teachers have encouraged me to study more mathematics.
2. + My teachers think I'm the kind of person who could do well in mathematics.
3. + Math teachers have made me feel I have the ability to go on in mathematics.
4. + My math teachers would encourage me to take all the math I can.
5. + My math teachers have been interested in my progress in mathematics.
6. + I would talk to my math teachers about a career which uses math.
7. - When it comes to anything serious I have felt ignored when talking to math teachers.
8. - I have found it hard to win the respect of math teachers.
9. - My teachers think advanced math is a waste of time for me.
10. - Getting a mathematics teacher to take me seriously has usually been a problem.
11. - My teachers would think I wasn't serious if I told them I was interested in a career in science and mathematics.

Weight

12. - I have had a hard time getting teachers to talk to me seriously about mathematics.

Mathematics as a Male Domain (MD)

1. + Females are as good as males in geometry.
2. + Mathematics is just as important for women as for men.
3. + I would trust a women just as much as I would trust a man to figure out important calculations.
4. + Girls can do just as well as boys in mathematics.
5. + Males are not naturally better than females in mathematics.
6. + Women certainly are logical enough to do well in mathematics.
7. - It's hard to believe a female could be a genius in mathematics.
8. - When a woman has to solve a math problem, it is feminine to ask a man for help.
9. - I would have more faith in the answer for a math problem solved by a man than a women.
10. - Girls who enjoy studying math are a bit peculiar.
11. - Mathematics is for men; arithmetic is for women.

Weight

12. - A woman who is good in math is a masculine type of person.

Usefulness of Mathematics Scale (U)

1. + I'll need mathematics for my future work.
2. + I study mathematics because I know how useful it is.
3. + Knowing mathematics will help me earn a living.
4. + Mathematics is a worthwhile and necessary subject.
5. + I'll need a firm mastery of mathematics for my future work.
6. + I will use mathematics in many ways as an adult.
7. - Mathematics is of no relevance to my life.
8. - Mathematics will not be important to me in my life's work.
9. - I see mathematics as a subject I will rarely use in my daily life as an adult.
10. - Taking mathematics is a waste of time.
11. - In terms of my adult life, it is not important for me to do well in mathematics in high school.
12. - I expect to have little use for mathematics when I get out of school.

Mathematics Anxiety Scale (A)Weight

1. + Math doesn't scare me at all.
2. + It wouldn't bother me at all to take more math courses.
3. + I haven't usually worried about being able to solve math problems.
4. + I almost never have gotten shook up during a math test.
5. + I usually have been at ease during math tests.
6. + I usually have been at ease in math classes.
7. - Mathematics usually makes me feel uncomfortable and nervous.
8. - Mathematics makes me feel uncomfortable, restless, irritable, and impatient.
9. - I get a sinking feeling when I think of trying hard math problems.
10. - My mind goes blank and I am unable to think clearly when working mathematics.
11. - A math test would scare me.
12. - Mathematics makes me feel uneasy and confused.

Effectance Motivation in Mathematics Scale (E)Weight

1. + I like math puzzles.
2. + Mathematics is enjoyable and stimulating to me.
3. + When a math problem arises that I can't immediately solve, I stick with it until I have the solution.
4. + Once I start trying to work on a math puzzle, I find it hard to stop.
5. + When a question is left unanswered in math class, I continue to think about it afterward.
6. + I am challenged by math problems I can't understand immediately.
7. - Figuring out mathematical problems does not appeal to me.
8. - The challenge of math problems does not appeal to me.
9. - Math puzzles are boring.
10. - I don't understand how some people can spend so much time on math and seem to enjoy it.
11. - I would rather have someone give me the solution to a difficult math problem than have to work it out for myself.
12. - I do as little work in math as possible.

Agency and Communion Competency Scales

Agency

ambitious
adventurous
curious
persevering
clear-thinking
determined
individualistic
industrious
energetic
independent
intelligent
outspoken
assertive
self-confident
calm
active
capable
forceful
courageous
efficient
enterprising
rational
initiative
organized
sharp-witted

Communion

dependable
tactful
sensitive
conscientious
affectionate
understanding
kind
appreciative
adaptable
warm
responsible
cooperative
helpful
imaginative
original
considerate
discreet
fair-minded
reasonable
thoughtful
friendly
praising
good-natured
sympathetic
reliable

BACKGROUND QUESTIONNAIRE

Please circle the number next to each of the following statements that best describes you.

1. Your sex is:

- 1. male
- 2. female

2. Your age is:

- 1. 10
- 2. 11
- 3. 12
- 4. 13
- 5. 14
- 6. 15
- 7. 16
- 8. 17
- 9. 18
- 10. 19

3. Which grade are you in?

- 1. 7th
- 2. 8th
- 3. 9th
- 4. 10th
- 5. 11th
- 6. 12th

4. Circle the number next to all the math classes you have already taken.

- 1. Mathematics (7th grade)
- 2. Algebra I
- 3. Algebra II
- 4. Geometry
- 5. College Algebra
- 6. Trigonometry
- 7. Analysis
- 8. Calculus
- 9. Analytical Geometry
- 10. Other (please specify) _____

5. Fill in the name of the math class you are taking this semester.

6. Fill in the name of the occupation you are planning to do in the future.

7. Do you think that your math background is sufficient to enable you to go on to study more math?

1. yes

2. no

8. Do you plan to study more math in the future?

1. Yes

2. No

9. Do you think you will use mathematics in the occupation you are planning to do in the future?

1. Yes

2. No

10. When you were in elementary school, did your father work outside the home?

1. Yes

2. No

11. When you were in elementary school, did your mother work outside the home?

1. Yes

2. No

12. Does your father work outside the home at the present time?
1. Yes
 2. No
13. Does your mother work outside the home at the present time?
1. Yes
 2. No
14. Please indicate your birth order and number of siblings:
1. Firstborn	1. Only child
2. Secondborn	2. Brothers only
3. Thirdborn	3. Sisters only
4. Fourthborn or later	4. Brothers and sisters
15. Please circle the number next to all of the courses listed below that you have taken in high school.
1. Art
 2. Drafting
 3. Woodworking
 4. Mechanical Drawing
 5. Physics
 6. Chemistry
16. Please circle the number next to all the activities and hobbies listed below that you participate in and fill in the amount of years that you have done so.

<u>ACTIVITY</u>	<u>NUMBER OF YEARS</u>
1. Drawing	_____
2. Woodworking	_____
3. Model Building	_____

- 4. Sailing _____
- 5. Sports _____
- 6. Scouting _____

(Girls or Boys scouts)

Thank you for completing this questionnaire.

APPENDIX B

Table 15

Factors Predicting Pattern of Math Courses with Hierarchical Procedure

	Men			
	Multiple R	R Square	Simple R	Beta
Space Relations	.303	.092	.303	.28007
Social Support	.561	.315	.489	.51631
Career Choice	.561	.315	-.053	-.96196
Agentic Competency	.570	.325	.204	.41351
Attitude	.583	.340	.504	.22990
(Constant)				-9.09367
	Women			
	Multiple R	R Square	Simple R	Beta
Space Relations	.431	.186	.431	.36177
Social Support	.524	.274	.448	.64574
Career Choice	.540	.292	-.167	-.63225
Agentic Competency	.545	.297	.005	-.38562
Attitude	.554	.307	.326	-.15965
(Constant)				-2.87220

Table 16

Factors Predicting SAT-M Score with Stepwise Procedure

Men				
	Multiple R	R Square	Simple R	Beta
Pattern	.752	.565	.752	21.7402
Space Relations	.823	.678	.548	1.4568
Attitude	.835	.698	.522	.7953
Career Choice	.840	.705	-.089	-30.2104
(Constant)				244.8455
Women				
	Multiple R	R Square	Simple R	Beta
Pattern	.725	.526	.725	17.84622
Attitude	.785	.616	.520	.79011
Space Relations	.804	.647	.545	.8394
Career Choice	.815	.664	.415	16.7799
(Constant)				182.8791

Bibliography

- Aiken, L.R. Attitudes toward mathematics. Review of Educational Research, 1970, 40, 551-596.
- Aiken, L.R. Intellective variables and mathematics achievement: Directions for research. Journal of School Psychology, 1971, 9, 201-212.
- Aiken, L.R. Update on attitudes and other affective variables in learning mathematics. Review of Educational Research, 1976, 46, 293-311.
- Anastasi, A. Differential Psychology: Individual and Group Differences in Behavior, New York: The MacMillan Company, 1958.
- Armstrong J.A. A national assessment of participation and performance of women in mathematics. Paper presented at Society for Research in Child Development meetings in San Francisco, California, March 1979.
- Benbow, C.P. & Stanley, J.C. Sex Differences in mathematical ability: Fact or artifact? Science, 1980, 210. 1263-1264.
- Bennett, G., Seashore, H. & Wessmen, A. Manual for the Differential Aptitude Test. New York: Psychological Corporation, ed. 5, 1974, forms S and T.
- Betz, N.E. Prevalence, distribution, and correlates of math anxiety in college students. Journal of Counseling Psychology, 1978, 25, 441-448.
- Bishop, A.S. Use of structured apparatus and spatial ability. Research in Education, 1973, 9, 43-49.
- Block, J.H. Conception of sex role: Some cross cultural and longitudinal perspectives. American Psychologist, 1973, 28, 512-526.
- Bock, R.D. A family study of spatial visualizing ability. American Psychologist, 1967, 22, 571.
- Bock, R.D. A study of familial effects in certain cognitive and perceptual variables. Final Report of the Illinois Psychiatric Training and Research Grant No. 17-137 to the University of Chicago, 1970.

Broverman, S.M., Klaiber, E.L., Kobayaski, Y. & Vogel, W. Roles of activation and inhibition in sex differences in cognitive abilities. Psychological Review, 1968, 75, 23-50.

Brush, L. Encouraging girls in mathematics: The problem and the Solution. Cambridge, MA: Abt Books, 1980.

Casserly, P.L. Factors affecting female participation in advanced programs in mathematics, chemistry, and physics. In L.H. Fox, L. Brody & D. Tobin (Eds.), Women and the Mathematical Mystiques. Baltimore: The Johns Hopkins University Press, 1980, pp. 136-263.

Dawson, J.L.M. Effects of sex hormones on cognitive styles in rats and men. Behavior Genetics. 1972, 2, 21-42.

de Wolf, V.A. High school mathematics preparation and sex differences in quantitative abilities. Report presented to Educational Assessment Center, Seattle, June, 1977.

Dornbusch, S.M. To try or not to try. The Stanford Magazine, 1974, 2, 50-54.

Ernest, J. Mathematics and Sex; American Mathematical Monthly, 1976, 83, (8), 595-614.

Feinberg, L.B. & Halperin, S. Affective and cognitive correlates of course performance in introductory statistics, Journal of Experimental Education, 1976, 11-18.

Fennema, E. Mathematics learning and the sexes: A review. Journal for Research in Mathematics Education, 1974, 5, 126-139.

Fennema, E. Influences of selected cognitive, affective, and educational variables on sex-related differences in mathematics learning and studying. (National Institute of Education paper on Education and Work. No. 8 U.S. Department of Health, Education & Welfare). Washington, DC: U.S. Government Printing Office, 1977.

Fennema, E. Sex-related differences in mathematics achievement, spatial visualization and affective factors. American Educational Research Journal, 1977, 14, (1), 5-71.

Fennema, E. Sex-related differences in mathematics achievement and related factors: A further study, Journal of Research in Mathematics Education, 1978, 9, (3), 188-203.

Fennema, E. & Sherman, J.A. Fennema-Sherman mathematics attitude scales: Instruments designed to measure attitudes toward learning of mathematics by females and males. American Psychological Association. Document MS1225. Journal Supplement Abstract Service, American Psychological Association, Washington, DC 20036, 1976

Fox, L.H. The problem of women and mathematics. A report to the Ford Foundation, March 1980.

Greenwald, A.G. Consequences of prejudice against the null hypothesis. Psychological Bulletin, 1915, 82, 1-20.

Guttman, R. Genetic analysis of analytical spatial ability. Raven's Progressive Matrices, Behavior Genetics, 1974, 4, 273-284.

Hartlage, L.C. Sex-linked inheritance of spatial ability. Perceptual and Motor Skills, 1970, 31, 610.

Haven, E. Selected community, school, teacher, and personal factors associated with girls electing to take advanced mathematics courses in high school. Unpublished dissertation, University of Pennsylvania, 1971.

Hendel, D.D. Correlates of mathematics anxiety of adult women participants in a math anxiety program. Psychology of Women Quarterly, 1980, 5, (2), 219-230.

Hills, J.A. Factor-analyzed abilities and success in college mathematics. Educational and Psychological Measurement, 1957, 17, 615-622.

Hilton, T.L. & Berglund, G.W. Sex differences in mathematics achievement - a longitudinal study. Journal of Educational Research, 1974, 67, 231-237.

Hoffman, L.W. Fear of success in males and females: 1965 and 1971. Journal of Consulting and Clinical Psychology, 1974, 42, 353-358.

Horner, M. Achievement-related conflicts in women. In Mednick, M. & Tangri, S. (Eds.) New perspectives on women, Journal of Social Issues, 1972, 28, 157-175.

Horner, M. Why bright women fear success. In C. Tavis (Ed.) The female experience. Del Mar. California: Communications Research Machines, 1973, 55-57.

- Hoyenga, K.B. & Hoyenga, K.T. The question of sex differences. Boston: Little, Brown and Company, 1979.
- Husen, T. (Ed.) International study of achievement in mathematics, a comparison of twelve countries. New York: Wiley, 1967.
- Hyde, J.S. How large are cognitive gender differences? American Psychologist, 1981, 36, (18), 892-901.
- Kagan, J. Aquisition and significance of sex typing and sex roles identity. From Hoffman, M.L. and Hoffman, L.W. (Eds.) Review of Child Development Research, Russell Sage Foundation, 1964, 137-167.
- Kagan, J. & Kogan, N. Individual variation in cognitive processes. In P.H. Musen (Ed.) Charmichael's Manual of Child Psychology, New York: Wiley, 1970, 1273-1365.
- Klaiber, E.L., Broverman, D.M., Vogel, W. and Kobayashi, Y. Rhythms in plasma MAO activity, EEG, and behavior during the menstrual cycle. In M. Ferin, F. Halberg, R.M. Richart, and R.L. Vande Wiele (Eds.), Biorhythms and human reproduction. New York: Wiley, 1974, 353-367.
- Klaiber, E.L., Kobayashi, Y. and Broverman, D.M. The automatization cognitive style, androgens, and monoamine oxidase. Psychopharmacologia, 1967, 11, 320-336.
- Keeves, J.P. Differences between the sexes in mathematics and science courses. International Review of Education, 1973, 19, 47-63.
- Koff, E. & Makros, J.R. Sex-stereotyping of children's judgments of academic success. Psychological Reports, 1978 43, 802.
- Kolata, G.B. Math and sex: Are girls born with less ability? Science, 1980, 210, 1234-1235.
- Lazrus, M. Mathophobia: Some personal speculations. The Principal, Jan/Feb, 1974, 18.
- Lemkau, J.P. Personality and background characteristics of women in asextypical occupations. Unpublished dissertation, University of Rhode Island, 1978.
- Lindeman, R.H., Merenda, P.F. & Gold, R.T. Introduction to bivariate and multivariate analysis, Illinois: Scott, Foresman & Co., 1980.

Lott, B. Becoming a woman. The socialization of gender. Springfield, Ill.: Charles C. Thomas, 1981.

Luchins, E.H. & Luchins, A.S. Female mathematicians: A contemporary appraisal. in L.H. Fox, L. Brody, & D. Tobin (Eds.) Women and the mathematical mystique. Baltimore: The Johns Hopkins University Press, 1980.

Maccoby, E.E. (Ed.) The development of sex differences. Stanford, Stanford University Press, 1966.

Maccoby, E.E. & Jacklin, C.N. Psychology of sex differences. Stanford, Stanford University Press, 1974.

Makros, J.R. & Koff, E. Sex-stereotyping of children's success in mathematics and reading. Psychological Reports, 1978, 42, 1287-1293.

Meracek, Jeanne. Power and women's psychological disorders: preliminary observations. Mimeo, 1977. Swarthmore College, Swarthmore, Pa.

McCallum, D.I., Smith, I.M. & Eliot, J. Further investigation of components of mathematical ability. Psychological Reports, 1979, 44, 1127-1133.

McGee, M.G. Interfamilial correlations and heritability estimates for human spatial abilities in a Minnesota sample. Behavioral Genetics, 1978, 8, 77-80.

Meece, J.L., Parsons, J.E., Kaczala, C.M., Goff, S.D. & Futterman, R. Sex differences in math achievement: Toward a model of academic choice. Psychological Bulletin, 1982, No. 91 (2), 324-345.

Nash, S.C. The relationship among sex-role stereotyping, sex-role preference, and the sex difference in spatial visualization. Sex Roles, 1975, 1, (1), 15-32.

Nash, S.C. Sex role as a mediator in intellectual functioning. In M.A. Wittig & A.C. Peterson (Eds.), Sex-related differences in cognitive functioning. New York: Academic Press, 1979, 263-293.

O'Connor, J. Structural visualization. Boston: Human Engineering Labs, 1943.

Peterson, A.C. Physical androgyny and cognitive functioning in adolescence. Developmental Psychology, 1976, 12, 524-533.

- Petro, C.S. & Putnam, B.S. Sex role stereotypes: Issues of attitudinal changes. Sex Roles, 1979, 5, 29-39.
- Potter, N. Mathematical and verbal ability patterns in women. In: Tobias, S. Overcoming math anxiety, New York: W.W. Norton & Co., 1978, 90.
- Reinisch, J.M. Prenatal exposure of human foetuses to synthetic progestin and oestrogen affects personality. Nature, 1977, 266, 561-562.
- Rounds, J.B. & Hendel, D.D. Measurement and dimensionality of mathematics anxiety. Journal of Counseling Psychology, 1980, 27, (2), 138-149.
- Scannel, D.P. Test of Academic Progress, Manual, Form S. Boston, MA: Houghton Mifflin, 1972.
- Schratz, M. Developmental investigation of sex differences in spatial (Visual-Analytic) and mathematical skills in three ethnic groups. Developmental Psychology, 1978, 14, (3), 263-267.
- Schildkamp-Kuendiger, E. Die Frauenrolle und die mathematikleistung. In: Tobias, S. Overcoming math anxiety, New York: W.W. Norton & Co., 1978, 89.
- Sells, L. Mathematics - a critical filter. The Science Teacher, 45, (2), Feb. 1978.
- Seepie, A.C. & Keeling, B. The relationship between type of anxiety and under-achievement in mathematics. Journal of Educational Research. 1978, 72, (1), 15-19.
- Sherman, J. Problem of sex-differences in space perception and aspects of intellectual functioning. Psychological Review, 1967, 74, 290-298.
- Sherman, J. On the psychology of women: A survey of empirical studies, Springfield, Illinois: Charles C. Thomas, 1971.
- Sherman, J. Field articulation, sex, spatial visualization, dependency, practice, laterality of the brain and birth order. Perceptual and Motor Skills, 1974, 38, 1223-1235.
- Sherman, J. Review of the psychology of sex differences by E.E. Maccoby & C.N. Jacklin. Sex Roles, 1975, 1, 197-301.

- Sherman, J. Sex-related cognitive differences: An essay on theory and evidence. Springfield: Charles C. Thomas, 1978.
- Sherman, J. Women and mathematics: Summary of research from 1977-1979. N.I.E. Grant. Partially summarized in J. Sherman: Prediction: mathematics performance in high school girls and boys. Journal of Educational Psychology, 1979, 71, 242-249.
- Sherman, J. Girls' and boys' enrollments in theoretical math courses: A longitudinal study. Psychology of Women Quarterly, 1981, 5 (5), 681-689.
- Sherman J. & Fennema, E. The study of mathematics by high school girls and boys: Related variables. American Educational Research Journal. 1977, 14, 159-168.
- Sherman, J. & Fennema, E. Distribution of spatial visualization and mathematical problem solving scores: A test of Stafford's X-linked hypotheses. Psychology of Women Quarterly, 1978, 3 (2), 157-167.
- Spaeth, J. Path Analysis. In D.J. Amick & H.J. Walbergs (Eds.) Introductory Multi-variate Analysis for Educational, Psychological, and Social Research, New York: McCutchan Publishing Corp., 1975. 53-59.
- Stafford, R.E. Sex differences in spatial visualization as evidence of sex-linked inheritance. Perceptual and Motor Skills, 1961, 13, 428.
- Stafford, R.E. An investigation of similarities in parent-child test scores for evidence of hereditary components. Princeton Educational Testing Service. 1963. In: Hoyenga, K.B. & Hoyenga, K.T. The questions of sex differences. Boston: Little, Brown and Company, 1979.
- Stafford, R.E. Heredity and environmental components of quantitative reasoning. Review of Educational Research, 1972, 42, 183-201.
- Stage, E.K. Commentary on women in math. Project on the Status of and Education of Women, No. 29, Winter, 1981, 2, 15.
- Starr, B.S. Sex differences among personality correlates of mathematical ability in high school seniors. Psychology of Women Quarterly, 1979, 4, 212-220.

Stein, A.H. & Smithells, J. Age and sex differences in children's sex role standards about achievement. Developmental Psychology, 1969, 1, 252-259.

Tobias, S. Overcoming math anxiety. New York: W.W. Norton & Co., 1978.

Vandenberg, S.C. & Kuse, A.R. Spatial ability: A critical review of the sex-linked major-gene hypothesis. In M.W. Wittig & A.C. Peterson (Eds.), Sex-related differences in cognitive functioning: Developmental issues. New York: Academic Press, 1979.

Weigers, R.M. & Frieze, I.H. Gender, females traditionality, achievement level, and cognitions of success and failure. Psychology of Women Quarterly. 1977, 2, 125-137.

Wexler, H. Women in mathematics: An overview. American Education, June, 1980, 38.

White, M.S. Measuring androgyny in adulthood. Psychology of Women Quarterly, 1979, 3, 293-307.

Whitely, R.H. Internal-external locus of control, subjective probability of success, decision consequence, and other selected variables as factors in pre-decision information acquisition (Doctoral Abstracts, International, 1970, 30, 2865A-2866A (University Microfilms No. 69-15, 024)).

Wilhelm, S. & Brooks, D.M. The relationship between pupil attitudes toward mathematics and parental attitudes toward mathematics. Educational Research Quarterly, 1980, 5, (2), 8-16.

Winer, B.J. Statistical principles in experimental design; Second Ed. New York: McGraw-Hill Book Company, 1971.

Wise, L.L., Steel, L., & MacDonald, C. Origins and career-consequences of sex differences in high school mathematics achievement. Report to the National Institute of Education on its grant No. NIE-G88-001. Palo Alto, Calif.: The American Institute for Research, 1979.

Wittig, M.A. Sex differences in intellectual functioning: how much of a sex difference do genes make? Sex Roles, 1976, 2, 63-74.

Wittig, M.A. Letter to the Editor. Sex Roles, 1978, 4, 331-332.

Yen, W.M. Sex-linked major gene influences on selected types of spatial performance. Behavior Genetics, 1975, 5, 281-298.