Sex Differences in Mathematical Ability: An Appraisal of Recent Research

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Introduction

It is a generally accepted belief that males are superior to females when it comes to mathematics. Throughout history mathematics has been a masculine pursuit; there have been very few famous women mathematicians. For example, Edith Luchins, a mathematician at Rensselaer Polytechnic Institute, and Abraham Luchins, a psychologist at the State University of New York at Albany, asked mathematicians to list five famous contemporary women mathematicians and found that many could not.[1] Usually they named Emmy Noether, a German mathematician, who was called "Der Noether" ("Der" being the masculine form of "the") by her colleagues because of her "manlike" talents.[2]

At the Invitational Conference of the Educational Testing Service in the fall of 1972, Eleanor Maccoby, a psychologist at Stanford University, presented a critical review of the research literature of the 1960's, highlighting the following findings regarding sex differences:

1. Males and females do not differ systematically on measures of total or composite abilities, i.e., IQ measures.
2. Females tend to be superior on verbal abilities; males, on math and spatial aptitudes.
3. These differences in aptitudes do not become significantly apparent until adolescence.

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[1] Gina Bari Kolata, "Math and Sex: Are Girls Born with Less Ability?" Science, 210, December 12, 1980, p. 1234.

[2] Sheila Tobias, "Sexist Equations," Psychology Today, 16, January, 1982, p. 14.

4. Studies of children's aptitudes prior to adolescence do not provide consistent results and do not demonstrate significant sex differences.
5. The only significant differences in aptitudes among younger children appear to exist in children of disadvantaged backgrounds. Studies with disadvantaged children show the females to excel on verbal as well as on mathematical aptitudes even prior to adolescence.
6. In general, of all three aptitudes (math, spatial, and verbal), spatial relations emerge as one of the most consistent and strongly differentiating aptitudes between the sexes.
7. There is no difference in variability within sex up to age eleven. However, after that age, the standard deviation for males tends to be between 5 and 6 percent higher than that for females.
8. Studies that have examined genetic components, hormonal influences, or differential brain development as possible determinants of differential cognitive functioning between the sexes are not yet conclusive.
9. There have been no definitive studies that can demonstrate the relationship(s) between social pressures or aspects of socialization and specific patterns of abilities.[3]

Since the 1960's, there has been much research regarding sex differences in mathematical achievement. This difference in mathematical achievement has been expounded by two opposing theories. One popular

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[3]Helen S. Astin, "Sex Differences in Mathematical and Scientific Precocity," in Mathematical Talent, Daniel P. Keating, ed., p. 71.

hypothesis attributes this difference to environmental factors. The other current theory states that these sex differences in mathematical ability are genetically based. The purpose of this paper is to look at both sides of this ongoing controversy. By describing the opposing theories, examining the existing research, and reviewing the opinions of experts, the reasonability of each hypothesis will be analyzed. Only after careful consideration of these contradictory theories can this issue be resolved.

Environmental Case: The Fennema-Sherman Study

Elizabeth Fennema, an educational researcher at the University of Wisconsin, and Julia Sherman, a psychologist at the University of Wisconsin, contend that the belief that males are superior in mathematics is based on studies that have not controlled for the previous study of mathematics, one of the most important variables in achievement in high school mathematics. In 1975, Fennema and Sherman conducted a study to gain new insight into the area of sex-related differences in mathematics achievement when this variable is controlled, and to collect information about other variables hypothesized to be associated with sex-related differences in mathematics achievement. This study investigated mathematics achievement of 644 male and 589 female, predominantly white, 9th-12th grade students enrolled in mathematics courses in four high schools in a Wisconsin city, controlling for mathematics background and general ability. The study also investigated relationships to mathematics achievement and to sex-related differences in mathematics achievement, of spatial visualization, eight attitudes measured by the Fennema-Sherman Mathematics Attitudes Scales, a measure of Mathematics

Activities outside of school, and the number of Mathematics Related Courses and Space Related Courses taken.[4]

Data were gathered for three cognitive variables (mathematics achievement, general and verbal ability, and spatial visualization), eight affective variables (attitude toward success in mathematics, stereotyping of mathematics as a male domain, perceived attitudes of mother, father, and teacher toward one as a learner of mathematics, effectance motivation in mathematics, confidence in learning mathematics, and usefulness of mathematics), and three other variables (number of mathematics related courses taken, amount of time spent outside of school in mathematics related activities, and the number of space related courses taken).[5]

Mathematics achievement, the major dependent variable studied, was measured by the Test of Academic Progress. One test, the Quick Word Test, was used as an indicator of both general and verbal ability. Spatial visualization, "the ability to understand and manipulate drawings of two-dimensional and three-dimensional figures,"[6] was measured by the Space Relations Test of the Differential Aptitude Test.[7]

All of the affective variables assessed by the Fennema-Sherman Mathematics Attitudes Scales have been hypothesized as factors affecting differences between the sexes either in mathematics achievement or in

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[4]Elizabeth Fennema and Julia Sherman, "Sex-Related Differences in Mathematics Achievement, Spatial Visualization and Affective Factors," American Educational Research Journal, 14, Winter, 1977, pp. 51-52.

[5]Ibid., p. 52.

[6]Sheila Tobias, Overcoming Math Anxiety, p. 101.

[7]Fennema and Sherman, op. cit., pp. 52-53.

the selection of mathematics courses. The hypothesis that females have a motive to avoid success in traditional male areas was measured by the Attitude toward Success in Mathematics Scale. Another hypothesis which claims that females have lower achievement motivation in academic areas not considered sex-appropriate was measured by the Mathematics as a Male Domain Scale.[8]

The Mother Scale, Father Scale, and Teacher Scale were used to measure the perceived attitudes of important others toward one as a learner of mathematics. To investigate the hypothesis that females are not as involved as males in problem solving behavior, effectance, based on R. W. White's definition of effectance as "inferred specifically from behavior that shows a lasting focalization and that has characteristics of exploration and experimentation,"[9] was measured by the Effectance Motivation in Mathematics Scale. Confidence in Learning Mathematics measured the subjects' confidence in their mathematics intellectual abilities. Because of the hypotheses that boys believe that mathematics is a more useful subject than do girls, and that girls who consider mathematics as useful are more likely to take advanced mathematics courses, perceived Usefulness of Mathematics was also measured.[10]

Three other variables, pertaining to indirect mathematical studies, were measured. One of these tests, Math Related Courses, measured the use of each student of mathematics in courses other than mathematics courses, such as chemistry, computing, and physics. Mathematics Activ-

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[8] Ibid., p. 53.

[9] R. W. White, "Motivation Reconsidered: The Concept of Competence Motivation," Psychological Review, 66, 1959, p. 321.

[10] Fennema and Sherman, loc. cit.

ities was the test used to measure the time spent by students outside of school on mathematics activities. To gather data on the number of courses taken by the students involving spatial perception, such as art, design, and drafting, the test of Space Related Courses was given.[11]

Although females tended to score higher on the Quick Word Test, at no school were significant sex effects found, indicating that the groups studied were of similar general and verbal ability. While males always scored higher on the mathematics achievement test, the differences were significant at only two schools. Also, males' scores tended to be higher on the spatial visualization test, but in only two schools was the difference significant. Mathematics was rated more of a male domain by boys than by girls, and this difference was significant in all four of the high schools. Males' scores were higher than females' scores in mathematics confidence, and the differences were significant at three of the high schools. Significantly less positive perceptions of their mothers' attitude (3 schools) and fathers' attitude (2 schools) toward them as learners of mathematics were reported by girls. However, significant sex effects were not found at any school for the Teacher Scale. Females reported that mathematics was less useful to them than did males at three high schools. In one high school, females indicated a significantly more favorable attitude toward success in mathematics than did males. Significant sex effects were not found at any school for the Effectance Motivation in Mathematics Scale.[12]

Boys tended to be involved in more mathematics activities outside

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[11] _Ibid._, p. 54.

[12] _Ibid._, pp. 58-61.

of school, and these differences were significant at two of the high schools. Also, males took more math related courses, and these differences were significant at two schools. Again, males took more space related courses than did females, and these differences were significant at two of the high schools.[13]

Sex-related differences in mathematics achievement and five attitude scales were found at School 1. In School 2, sex-related differences in spatial visualization and one attitude scale were found. In School 3, the only sex-related differences found were in three attitude scales. Sex-related differences in mathematics achievement, spatial visualization, and six attitude scales were found in School 4. Fennema and Sherman point out that in both of the schools in which there were significant sex-related differences in mathematics achievement, five or six significant sex-related differences in attitude were found.[14]

At the schools where significant sex-related differences in mathematics achievement were found, i.e., Schools 1 and 4, analyses of covariance were performed using as covariates those factors which had shown significant differences between the sexes at each school. Using as covariates Confidence, Mother, Father, Math as a Male Domain, and Usefulness, the difference between the sexes in mathematics achievement at School 1 became nonsignificant. Three analyses of covariance were performed at School 4. Using as covariates Confidence, Mother, Father, Math as a Male Domain, Attitude toward Success, and Usefulness, the difference between the sexes in mathematics achievement became nonsig-

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[13] Ibid., p. 61.

[14] Ibid., p. 63.

nificant. Using scores on spatial visualization as a covariate, the difference between the sexes in mathematics achievement again became nonsignificant. Also, the difference between the sexes in mathematical achievement became nonsignificant when the number of math related courses students had taken was used as a covariate.[15]

Fennema and Sherman suggest that the opinion that females have less aptitude for mathematics than males needs to be modified. In their study, which considered only students having similar mathematics backgrounds, the differences between the male and female groups in mathematics achievement were very small and were significant in only two of the four high schools. These differences occurred in a "matrix of interrelationships strongly suggesting the influence of socio-cultural factors."[16] In fact, the significant sex-related differences in mathematics achievement found at the two schools were eliminated by covarying out the differences in affective measures.[17]

The findings of this study support the belief that socio-cultural factors are highly important concomitants of sex-related differences in mathematics achievement. Besides the analyses of covariance, lending credence to this belief, is the finding that the two high schools with significant sex-related differences in mathematics achievement also show the highest number of sex-related differences in affective factors. Because of the observed variation from school to school in the occurrence of sex-related differences in mathematics achievement, it is

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[15] _Ibid._, pp. 64-65.

[16] _Ibid._, pp. 65-66.

[17] _Ibid._

unlikely that these differences can be attributed to sex per se.[18]

It is important to note that male and female groups with "the same apparent education"[19] cannot be assumed to have comparable backgrounds in mathematics. It was found that there was a steadily decreasing percentage of both males and females enrolled in mathematics courses, with the number of females enrolled decreasing more rapidly than the number of males. The fact that girls do not take as many advanced mathematics courses as boys explains why girls do not perform as well on mathematics achievement tests in the general population.[20]

The data of this study do not support the hypotheses that males are invariably superior in mathematics achievement and spatial visualization. Fennema and Sherman came to the following conclusion:

> The fact that half of the groups of students enrolled in mathematics did not show sex-related differences on these two variables can probably be attributed to better control of mathematics background in this study than in previous ones. The sex-related differences were small and score distributions overlapped considerably. The pattern of differences in mathematics achievement, spatial visualization and affective variables strongly suggests the influence of socio-cultural factors. This study suggests that long accepted beliefs about the validity and importance of 'sex differences' need re-examination in a variety of ways. These data certainly indicate that many females have as much mathematical potential as do many males. The generalized belief that females cannot do well in mathematics is not supported.[21]

Genetic Case: The Stanley-Benbow Study

In 1980, Camilla Persson Benbow and Julian C. Stanley, members of

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[18] *Ibid.*, p. 66.

[19] *Ibid.*, p. 67.

[20] *Ibid.*

[21] *Ibid.*, p. 69.

the Department of Psychology of Johns Hopkins University, put forth the hypothesis that "sex differences in achievement in and attitude toward mathematics result from superior male mathematical ability, which may in turn be related to greater male ability in spatial tasks."[22] They base this hypothesis on data which has been collected by the Study of Mathematically Precocious Youth (SMPY), a program at Johns Hopkins University which identifies, studies, and educationally assists mathematically precocious youths.[23] In six separate SMPY talent searches conducted from 1972 to 1979, 9927 students from schools in Maryland, Virginia, West Virginia, Delaware, Pennsylvania, and Washington, D.C. were tested.[24]

In 1972, the year of the first talent search, seventh, eighth, and accelerated ninth and tenth graders who scored in the upper 5 percent in mathematical ability on a standardized achievement test were eligible. To be eligible in the 1973 and 1974 searches, seventh, eighth, and accelerated ninth and tenth graders had to score in the upper 2 percent. For the 1976, 1978, and 1979 talent searches, only seventh graders and accelerated students of seventh grade age who scored in the top 3 percent were eligible. Of these 9927 participants, 43 percent were girls.[25]

These students, having been selected by equal criteria for high

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[22] Camilla Persson Benbow and Julian C. Stanley, "Sex Differences in Mathematical Ability: Fact or Artifact?" <u>Science</u>, 210, December 12, 1980, p. 1264.

[23] Julian C. Stanley, "Intellectual Precocity," in <u>Mathematical Talent</u>, Daniel P. Keating, ed., p. 17.

[24] "The Gender Factor in Math," <u>Time</u>, 116, December 15, 1980, p. 57.

[25] Benbow and Stanley, <u>op</u>. <u>cit</u>., p. 1262.

mathematical ability, were then invited to take both the mathematics (SAT-M) and the verbal (SAT-V) sections of the College Board's Scholastic Aptitude Test (SAT). The SAT is normally taken by high school juniors and seniors, who are, on the average, four to five years older than the talent search participants. Stanley and Benbow contend that the SAT-M scores of seventh and eighth grade students serve as a mathematical aptitude test, since until that time "all students had received essentially identical formal instruction in mathematics."[26] Thus, Benbow and Stanley use their data to contradict Fennema and Sherman's hypothesis that differential course-taking accounts for their observed sex differences in mathematical ability, and to support their own hypothesis that these sex differences "result from superior male mathematical ability."[27]

Data from the six SMPY talent searches are presented in Table 1. Most of the participants scored high on both sections of the SAT. The mean SAT-M scores for a random sample of high school juniors and seniors were 416 for males and 390 for females. Because the boys and girls performed equally well on the SAT-V, these results have been omitted.[28]

In every talent search, a large sex difference in mathematical ability in favor of boys was observed from the SAT-M scores. The mean differences in the six talent searches ranged from a high of 116 points in 1976 to a low of 32 points in 1979 in favor of boys. On the average, the boys scored about one-half of the girls' standard deviation (S.D.)

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[26] Ibid.

[27] Ibid.

[28] Ibid., p. 1263.

better than the girls in each talent search, even though all of the participants had been selected initially by the equal criteria of being in the upper 2 to 5 percent in mathematical reasoning ability according to a standardized achievement test.[29]

TABLE 1

PERFORMANCE OF STUDENTS ON THE SAT- M IN THE STUDY OF MATHEMATICALLY PRECOCIOUS YOUTH IN EACH TALENT SEARCH (N=9927)

Test date	Grade	Number		SAT-M scores $\bar{X} \pm$ S.D.		Highest score		Percentage scoring above 600	
		Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
March 1972	7	90	77	460±104	423± 75	740	590	7.8	0.0
	8+	133	96	528±105	458± 88	790	600	27.1	0.0
January 1973	7	135	88	495± 85	440± 66	800	620	8.1	1.1
	8+	286	158	551± 85	511± 63	800	650	22.7	8.2
January 1974	7	372	222	473± 85	440± 68	760	630	6.5	1.8
	8+	556	369	540± 82	503± 72	750	700	21.6	7.9
December 1976	7	495	356	455± 84	421± 64	780	610	5.5	0.6
	8+	12	10	598±126	482± 83	750	600	58.3	0.0
January 1978	7, 8+	1549	1249	448± 87	413± 71	790	760	5.3	0.8
January 1979	7, 8+	2046	1628	436± 87	404± 77	790	760	3.2	0.9

Moreover, the largest difference between the boys and girls is in the upper ranges of mathematical reasoning ability. Differences between the top-scoring boys and girls range from a high of 190 points in 1972 to a low of 30 points in 1978 and 1979 in favor of boys. Also, there is a great disparity in the percentage of boys and girls scoring above 600 of a possible 800 points on the SAT-M. Referring to Table 1, among the 1972 eighth graders, 27.1 percent of the boys scored higher than 600, whereas none of the girls did. Again in 1976, 58.3 percent of the

[29] Ibid.

eighth grade boys scored above 600, while not one of the girls did. In the six talent searches, boys scoring over 500 on the SAT-M outnumbered girls more than 2 to 1 (1817 boys versus 675 girls). The top SAT-M score was not earned by a girl in any of the talent searches. Benbow and Stanley state that much of the sex difference on the SAT-M can be explained by the lack of high-scoring girls.[30]

On the basis of these findings, Benbow and Stanley postulate that a genetic element enables boys to perform better in math than girls. However, they recognize that their data are conformable to numerous alternative hypotheses. Regarding these hypotheses, Benbow and Stanley state:

> Nonetheless, the hypothesis of differential course-taking was not supported. It also seems likely that putting one's faith in boy-versus-girl socialization processes as the only permissible explanation of the sex difference in mathematics is premature.[31]

Other Studies

Benbow and Stanley's hypothesis that males have superior mathematical ability gave rise to a myriad of opinions and new studies. One of these studies showed that high school boys and girls were equal at solving geometry proofs. According to University of Chicago researchers Zalman Usiskin and Sharon Senk, and Purdue University researcher Roberta Dees, there are no consistent differences between the sexes in the ability to learn math.[32]

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[30] Ibid.

[31] Ibid., p. 1264.

[32] "Chicago Researchers Find Boys Not Superior to Girls in Mathematical Ability," Phi Delta Kappan, 63, June, 1982, p. 710.

Usiskin, Senk, and Dees tested 1366 high school students on performing geometrical proofs, a subject requiring both abstract reasoning and spatial ability, two cognitive areas in which girls are presumed to be weaker than boys. According to Usiskin, this type of specialized mathematical problem is a powerful indicator of the ability to learn math because students rarely learn geometrical proofs on their own. As a result, testing proof solving ability minimizes the effects of experience, such as parental encouragement, on math performance. The conclusion reached by Usiskin, Senk, and Dees is that there are no sex differences in mathematical ability.[33]

Another study, conducted by Northwestern University sociologist David Maines, indicates that it may be women's sense of values that prohibits success in higher mathematics. This study of 84 male and 84 female mathematics majors at three Illinois universities revealed significant sex differences in the socialization of mathematicians. According to Maines, while males are very single-minded in their study of mathematics, females are much more sensitive to social obligations and pressures. It is this sense of social responsibility that effectively bars many women from the study of mathematics. Maines says that his findings contradict those of Benbow and Stanley, who have reported that socialization is not a significant cause of sex differences in mathematics.[34]

Many other researchers also believe that socialization is a significant cause of sex differences in mathematical achievement. For

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[33] W. Herbert, "Math Ability: Proof of Sexual Parity?" Science News, 121, March 20, 1982, p. 198.

[34] "Mathematical Values," Science News, 122, August 28, 1982, p. 136.

instance, Lynn Fox, Diane Tobin, and Linda Brody of Johns Hopkins University are looking into factors other than classroom training, such as what games the children played, what the expectations of their parents and teachers are, and whether the mother or father helped them with their math homework. They feel that boys' out-of-school activities have an effect on their performance on mathematical aptitude tests.[35] Anne C. Petersen, director of the Laboratory for the Study of Adolescence at the University of Chicago, cites studies of junior high school students showing that athletics (at least for boys) can develop spatial skills. Thus, many researchers feel that environmental and cultural factors play a large role in causing the sex differences in mathematical ability.[36]

A study by Lynn Fox and Sanford J. Cohn (who also participated in the Johns Hopkins study with Benbow and Stanley) on the percentage of boys who scored higher than the highest-scoring girls reveals some interesting findings. They present figures which were available to Benbow and Stanley, but not reported by them. It seems that Benbow and Stanley reported only the more dramatic results.[37]

In 1972, 19 percent of the boys scored higher than the highest-scoring girl, but in 1973, only 3 percent of the seventh-grade boys and 9.8 percent of the eighth-grade boys outperformed the highest-scoring girl. In 1978, only 0.1 percent of the boys scored higher than the highest-scoring girl. Only one boy outscored the highest-scoring girl

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[35] Kolata, op. cit., p. 1235.

[36] "Researchers Dispute Role of Genetics in Math Achievements by the Sexes," Phi Delta Kappan, 63, March, 1982, p. 436.

[37] Tobias, "Sexist Equations," p. 17.

in 1979, the year of the last talent search. Only 2 or 3 percent of the highest-scoring males consistently outscored the highest-scoring females. Fox and Cohn conclude that it is not likely that these differences in mathematical ability are genetic.[38]

One researcher's contention was that the type of test given to students can exaggerate sex differences in mathematical ability. Robert M. Hashway, director of the Developmental Skills Program of the Massachusetts State College System (MSCS), contends that all previous studies of sex differences in mathematical ability used norm-referenced achievement tests, which are designed to discriminate maximally between students. Hashway hypothesized that sex differences in mathematics achievement are artifacts of the types of tests that researchers have used. To test his hypothesis, he tested 4899 incoming freshmen in the MSCS in the fall of 1979, using the domain-referenced Mathematics Placement Test developed by MSCS.[39]

This test measures 148 mathematics skills that incoming freshmen are expected to have mastered. The mathematics skills are organized into eight learning units that correspond to eight behavior domains: whole number arithmetic; fractions; decimals; ratio, proportion, and percent; tables and graphs; integer arithmetic; elementary geometric principles; and elementary algebraic principles. Average test scores for males and females in each of the eight domains are shown in Table 2. One-way analyses of variance were used to detect achievement differences between the sexes.[40]

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[38] Ibid.

[39] Robert M. Hashway, "Sex Differences in Mathematics Achievement -- Are They Real?" Phi Delta Kappan, 63, October, 1981, p. 139.

[40] Ibid., pp. 139-40.

TABLE 2

AVERAGE PERCENT CORRECT ON MSCS MATHEMATICS PLACEMENT TEST BY SEX

Subject area	Males N=1929	Females N=2970	p	% of variance explained by between-group differences
Whole number arithmetic	79.36	79.89	p>.20	.03
Fractions	65.94	71.12	p<.01	.97
Decimals	82.17	81.94	p>.68	.00
Ratio, proportion, and percent	55.99	51.80	p<.01	.85
Tables and graphs	74.21	73.67	p>.42	.01
Integer arithmetic	71.87	71.62	p>.60	.01
Elementary geometry	67.07	61.71	p<.01	1.49
Elementary algebra	58.11	57.78	p>.60	.01

Hashway found that males and females did not differ significantly in their achievement in five of the eight domains. Referring to Table 2, males and females performed equally well in the subject areas of whole number arithmetic, decimals, tables and graphs, integer arithmetic, and elementary algebra. However, females showed a significantly higher ability to solve problems involving fractions than did males. On the other hand, males showed a significantly higher ability to solve problems involving ratio, proportion, and percent, and those involving elementary geometry.[41]

These findings suggest that sex differences in mathematical ability have been exaggerated. In the three domains for which significant sex differences were found, these differences account for less than 1.5 percent of the variation between individuals. Therefore, Hashway claims

[41] Ibid.

that "about 98 percent of the differences between individuals in mathematical achievement can apparently be attributed to some characteristic other than sex."[42]

Conclusions

In summary, there is indeed a difference in mathematical achievement between males and females. This sex difference has been accounted for by two diametrically opposite theories. One of these theories, studied by Fennema and Sherman, states that environmental factors give rise to the observed sex differences in mathematical achievement. The other major theory, examined by Benbow and Stanley, sees this sex difference in mathematical achievement as being the result of genetic differences. The majority of the other current studies support the case for environmental factors.

Fennema and Sherman's study involved high school students with a common background. Small sex differences in the mathematical ability of these students were found. However, the results of their study indicated that some or all of the following factors were influencing girls: the bias of parents; negative attitudes toward mathematics; little value for the usefulness of mathematics; and, perhaps most importantly, different course-taking behavior. When these factors were accounted for, the sex differences in mathematical achievement became nonsignificant. Thus, Fennema and Sherman came to the conclusion that sex differences in mathematical achievement are the result of environmental factors.

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[42] Ibid.

On the other side of the controversy, Benbow and Stanley are proponents of the genetic case for sex differences in mathematical achievement. Benbow and Stanley conducted a study of students having similar backgrounds in the previous study of mathematics. Because all students had received "essentially identical formal instruction in mathematics,"[43] the conclusion that sex differences in mathematical achievement are caused by genetic factors was reached. The main flaw with this argument is that if sex differences in mathematical ability were genetically based, wouldn't all boys outperform all girls? Since this is not the case, it seems unlikely that sex differences in mathematical achievement are genetically based. Also, all learning is not accomplished in the classroom. Many other current studies stress the importance of factors other than formal education in mathematics. For example, other factors, such as what the parents' expectations of their children are, and what toys the children played with, are being examined by Fox, Tobin, and Brody.

It seems that the current data do not support the hypothesis that males are superior to girls in mathematical ability. Rather, the results of these studies strongly indicate the influence of environmental factors on mathematical achievement. Since it is not possible to screen out all environmental factors, how can one say that sex differences are caused by genetic factors? This issue may never be resolved by the experts. However, in my own mind, it has already been resolved. As Diane Tobin of Johns Hopkins University says, "As a woman,

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[43] Benbow and Stanley, op. cit., p. 1262.

I don't want to think there is something about us that does not allow us to do math like the men do."[44]

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[44]Kolata, *loc. cit.*

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