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ABSTRACT

Influences on sex equity in mathematics achievement are discussed in this summary of research and recommendations. Information on the following topics is presented, with each finding referenced to a source or sources in the bibliography provided at the end of the report: mathematics enrollment, influences on mathematics participation, predicting mathematics achievement, sex differences in attitudes toward mathematics and in mathematics achievement, visual/spatial skills, parents, peers and significant others, teachers, classroom environment, school structure, testing, advanced placement girls, career aspirations and educational goals, and recommendations to parents, teachers, and school personnel. Forty-four references are included in the bibliography. (MNS)

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Sex Equity and Math Achievement



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A Summary of Research and Recommendations



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P R E F A C E

Math is the critical filter in the job market -- perhaps more so today than ever before. Students in today's schools will face a workplace where technology is a critical component of many different professions, requiring a strong background in math. Statistics show that 9 out of 10 girls today will work for 25-45 years, while 2 out of 5 will be sole supporters of families. Yet, there still exist very strong attitudes and biases about a girl's need for and ability to perform in the mathematical arena.

This document was prepared by Kathleen Beauvais, Roslyn Mickelson and Patricia Pokay, who were participants in the Bush Program in Child Development and Social Policy at the University of Michigan during 1984-85. The Bush Program trains pre-and post-doctoral students in the interface between research and social policy and provides forums for discussing the many important issues related to child development and social policy. Each year, major working groups are formed to pursue topics of special interest. For the 1984-85 academic year, one work group focused on the topic of "Sex and Race Equity in Public Schools." The work group was led by Jacquelynne Eccles and Allan Wigfield, Department of Psychology, University of Michigan. Their interest in addressing the needs and concerns of educators and policymakers with regard to sex equity in the public schools have made this research summary most timely.

If you would like more information about sex equity in education, please call or write to the Office for Sex Equity in Education, Michigan Department of Education, P.O. Box 30008, Lansing, MI 48909, (517) 373-3497.

INFLUENCES ON SEX EQUITY IN MATH ACHIEVEMENT: SUMMARY OF RESEARCH AND RECOMMENDATIONS

INTRODUCTION

Beliefs concerning women and math that pervade our culture include the idea that math is not useful to women, women are naturally less competent in math and women prefer social to theoretical areas. However, there has been a growing concern over the small number of women pursuing careers in scientific, mathematical, and technical fields. In 1975-76, women received only 3.2 percent of undergraduate degrees in engineering, 20 percent in computer science, physical sciences, business and management. Most of the research has focused on students in seventh grade and above since that is when sex differences begin to emerge(6, 17). The purpose of this document is to review current research and recommendations in this area. The information reported here is meant to be representative rather than inclusive. While there may be individual studies that disagree with the results presented here, this paper summarizes results that have been reported by the majority of studies. Numbered bibliographic citations are noted parenthetically following each statement. Information is presented on the following topics relating to sex equity and math achievement:

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MATH ENROLLMENT

1. Only 46 percent of students take three or more years of math and 30 percent take three or more years of science. Few students take higher level math - 48 percent Geometry; 31 percent Algebra II; 8 percent Advanced Algebra; 6 percent Calculus. The average high school student in 1982 took 2.7 years of math(37).
2. The amount of math taken varies by race, sex, and SES. Generally, Asian Americans and Caucasian students take more math than do Black, Indian or Hispanic students. Boys take more than girls, and higher SES students take more than lower SES students(37).
3. Boys take more higher level math than do girls although the situation for girls is improving. Forty percent of those with a standard math preparation are women; Forty percent of women entering college are well prepared in math, having had four years of high school math(8, 10).
4. Enrollment in math courses is a major determining factor in eliminating sex differences in math knowledge and skill. When females enroll in math courses, their grades are as high as males(11, 21).

INFLUENCES ON MATH PARTICIPATION

1. Two significant background predictors for course plans are ability and SES; high ability students and high SES students plan to take more math although SES affects boys less than girls(8).
2. Boys and girls of equal ability, equal SES, and equivalent attitudes toward math do not take the same number of math courses. Boys take more(8).
3. Individual decisions of whether or not to continue with math are based on past achievement, the perceived utility value of math for future life goals, liking for math, level of self-confidence as a math learner, and the influence of parents, teachers, and counselors(1, 11, 19).

PREDICTING MATH ACHIEVEMENT

1. The evidence suggests that previous math achievement is the most consistent predictor of future math performance(11, 43).
2. Other factors which heavily influence math achievement are knowledge of basic math concepts and general academic skills, the availability of and participation in an appropriate math curriculum and interest in math and

math related careers; in other words--ability, participation and motivation(11, 43).

3. Math course selection and participation are so crucial to achievement that they account for all sex differences in math achievement which emerge by the end of high school and all sex differences demonstrated on standardized tests in math(2, 11, 43).

SEX DIFFERENCES IN ATTITUDES TOWARD MATH

1. As early as seventh grade, boys show a greater preference for math courses and plan to study more math than do girls(8).
2. Girls who continue with math are more likely to be less anxious, perceive higher utility value, and have parental support than girls not continuing(41).
3. Girls continue to enroll in math courses when they are in classes that are both interactive and instructive while interactive classes do not seem to be as important for boys(41).
4. Both sexes see math as an appropriate area of study for both boys and girls but girls are much more adamant in that opinion. When math is stereotyped as a male domain it does not necessarily have an adverse effect on the course plans or math attitudes of girls although when girls see math as appropriate they are more likely to enroll in advanced math courses(1, 8, 19, 23).
5. Confidence in one's ability is related to math achievement and course taking. Both boys' and girls' confidence decreases with age with girls' confidence decreasing before boys. Girls have less confidence than do boys even when their achievement is the same(11, 19, 21, 26, 36).
6. Perceived difficulty is related to math achievement and course taking. Both sexes perceive math to be increasingly more difficult. Girls perceive math to be harder than do boys. Parents also believe it is harder for girls. Girls are more likely to believe that their success is due to hard work while boys perceive success as due to ability. Thus, girls may be more likely to think continued math participation would require too much effort. This pattern is especially true of high ability girls(8, 15, 18, 19, 44).
7. Students who think math will be useful to them in their future careers are more likely to continue with math courses, have higher expectancies for success, and more positive self-concepts of math ability. Perceived usefulness of math decreases with age, with girls' attitudes decreasing

earlier and to a greater extent than boys. Both sexes see math as more useful for boys(17, 18, 19, 22).

8. Students become more negative in their attitudes toward and liking of math as they get older with girls' attitudes changing before boys(8, 18).

SEX DIFFERENCES IN MATH ACHIEVEMENT

1. During the elementary school years there are no sex differences in total math achievement scores(6, 10, 21, 23, 32, 35).
2. Differences in verbal and quantitative skills emerge during junior high. These differences are the equivalent of one or two test items on an exam. Boys score better on higher level conceptual math skills and girls score better on lower level computational skills(1, 16, 21, 22, 23, 35, 40).
3. Significant sex differences in math develop during high school, increasing after tenth grade when math courses generally become elective. On the average, male scores are 40 to 50 points higher than female scores on the math section of the SAT examination and male students are overrepresented in the extremely high math achievement group(1, 3, 4, 10, 12, 42).

VISUAL-SPATIAL SKILLS AND MATH ACHIEVEMENT

1. Some research studies have concluded that sex differences may exist in measures of visual-spatial abilities and that when these differences are demonstrated they favor males(33, 35, 42).
2. The weight of evidence suggests some relationship between aspects of visual-spatial ability and math achievement, although the exact nature of the relationship has not been established(12, 41, 42).
3. Visual-spatial skills may play a different role in math achievement for males and females. Verbal skills, which have also been correlated with math achievement, may more often be used by females in problem-solving(12, 22).
4. Several researchers caution that sex differences in visual-spatial skills are not consistent and that these skills, along with verbal and quantitative skills, may be significantly influenced by test conditions, testing measures used and prior learning experiences(12, 22).
5. Training programs to improve visual-spatial abilities have been successful(12).

PARENTS

1. Parents' beliefs are extremely important to students' self-concepts. A student's perception of their parents' beliefs has more influence on that student's self-concept, plans and expectations than their own past math performance. Parents' judgements affect both the student's perception of their own ability and their actual grades in math(16, 19).
2. Studies suggest that fathers are generally more positive about math than mothers and have more sex-role stereotyped attitudes toward math. Male students' attitudes correlate with their fathers' beliefs and females' attitudes correlate with their mothers'(6).
3. Sons and daughters receive different treatment from parents with respect to math. First, parents have different expectations for boys and girls. Second, parents believe it is more important for boys to continue in math. Third, boys receive more parental encouragement than girls to take math and excel. Fourth, while parents may rate their son's and daughter's abilities the same, they tend to believe that girls need to try harder than boys in math to achieve at similar levels. Consequently, daughters perceive lower expectations from parents(18, 19, 22, 25, 26, 29).
4. Several parental factors influence girls' participation in math. Encouragement from parents, especially from fathers, has been found to be important in girls' decisions to take math. Parents' expectations about college and the prestige and math level required in the father's occupation are also factors in girls continuing to take math(22, 26, 43).
5. Research studies indicate that exposure to public information which reinforces stereotypic beliefs about gender and math, such as media reports, affects parental math attitudes. Those parents most affected are mothers of daughters and fathers of sons, both becoming more stereotyped in their beliefs(30).

PEERS AND SIGNIFICANT OTHERS

1. The level of both male and female student's educational aspirations in math is heavily influenced by their peers(9).
2. While both males and females report feelings of support in studying math from peers, parents and teachers, only boys indicate receiving encouragement from counselors as well(8, 19).
3. Counselor encouragement, parental encouragement and parental

educational expectations are the best predictors of twelfth grade boys' math participation(1).

4. The best predictors for girls' math participation are teacher encouragement and fathers' educational expectations. Encouragement from adults in the school, other than the math teacher, influences girls' math aspirations and career goals(1, 9).

TEACHERS

1. Recent research studies indicate that teachers can be an important influence on student math confidence. Teacher expectations have been found to strongly predict student expectations, especially student's expectations of the difficulty of math and their own math abilities(11, 18).
2. Teacher encouragement is a strong factor in math persistence(11).
3. Teachers do not indicate any bias in their own beliefs regarding whether or not males and females are equally capable in math. However, studies of teacher behavior suggest that there is often unintentional sex bias operating within the classroom(7, 16, 21, 34).
4. The significance of teacher influence varies with each student depending on the subjective value students assign to it(18).

CLASSROOM ENVIRONMENT

1. The classroom environments of boys and girls can be unequal even when formal education is similar(21).
2. Differential teacher treatment of students varies by classroom, sex, subject and ability level. Observations in math and other classrooms indicate a trend of different treatment by sex with males being spoken to more often, asking more questions and being asked more often to respond by the teacher. Boys receive more sustained feedback and volunteer more often. Overall, girls receive less work related criticisms than boys on both the quality and form of their work(2, 7, 19, 27, 32, 36, 41).
3. Evidence suggests that teachers do treat males and females differently, but that this difference can be due to precipitating student behaviors(34).
4. Females have higher personal expectations for success and interact more often during class when they are members of cooperative and not publicly critical classrooms(19).

5. Classrooms where students are treated differently by sex are most beneficial to bright boys and least beneficial to bright girls. In such classrooms boys receive more praise and criticism than girls for both work and form. When students are treated equally, girls' classroom interactions increase and they receive more praise and criticism(19).

SCHOOL STRUCTURE

1. Neither the male/female ratio in the classroom nor the sex of the teacher have been found to be important factors in determining math enrollment(31).
2. Per pupil expenditure, the training and experience of teachers and the percentage of students in college prep classes all correlate with twelfth grade math participation and achievement(43).
3. Ability tracking, the frequency of standardized testing, the presence of Advanced Placement math and science courses and the percentage of parental PTA participation all have been found to predict higher female math participation(43).

TESTING

1. Sex-bias occurs in intelligence tests, aptitude tests and interest inventories. For example, until recently, interest inventories have been based on the responses of the white male occupational incumbents. Cautious interpretations of such test results are warranted especially when they are being used for course selection, ability tracking or vocational counseling(20).
2. Differences in math performance on tests has been shown to be related to the number of years of coursework taken by a student(13, 14).
3. Tests assume that students have had an equal opportunity to learn the processes and contents being assessed. Research indicates that this is sometimes an erroneous assumption(14).

ADVANCED PLACEMENT GIRLS

1. Schools with high female participation in advanced placement math have certain trends in curricula and teachers. These include teachers who are available for individual help, teachers who take a departmental view of

their responsibilities, teachers who share their own experiences regarding math anxiety, and teachers who stress the utility and beauty of math in a variety of contexts(9).

2. Many advanced placement girls were identified as being math-able in elementary school and were generally placed in accelerated math programs by the sixth grade(9).
3. Advanced placement girls stressed the importance of former teachers, usually in grades four through seven, in developing their sense of self-worth, persisting in math and establishing initial career aspirations. These girls also saw teachers and counselors as mentors; their educational goals were strongly influenced by their feelings concerning women's roles in the world(9).
4. Math gifted girls who participated in a special program, including career awareness and female role models, had higher educational aspirations than either math gifted boys or girls who did not have the same treatment(24).

CAREER ASPIRATIONS AND GOALS

1. Math is one of the least sex-typed college majors with between 38 and 42 percent of BAs in math being awarded to women (as of 1976). Some research suggests that the field of math is both more attractive and receptive to women than are math related careers such as engineering and physical science. It is not clear that math requirements are significant factors in women's choices of college majors and careers(10).
2. Gender differences in verbal and spatial abilities are too small to account for the enormous differences in occupational distributions of females and males in engineering and comparable fields. Researchers express concern about the tendency of many counselors to give undue weight to these differences in the vocational counseling of women(14).
3. Early selection factors which screen out many students, especially women, make later path changes into math careers very difficult(43).
4. Role models influence career aspirations based on the power and attractiveness of the model. By eighth grade students recognize the link between education, work, money and social class(20, 28).

RECOMMENDATIONS/PARENTS

1. Parents should be made aware of their own sex bias regarding their sons'

- and daughters' math abilities and expectations(30).
2. The significance of parental influence on student career choices and decisions regarding enrollment in advanced math should be stressed(41).
 3. Parents should be given information regarding the value of math for future jobs and careers(8, 19).
 4. Parents should be cautioned against stressing the difficulty of math in discussions with their children(19).
 5. Parents attributing academic success to ability and interest rather than exclusively to hard work is very important, especially for girls(19).

RECOMMENDATIONS/ TEACHERS

1. Teachers should discuss the importance of math for future careers at all grade levels, encouraging students to continue taking math and to consider a math-related career(19).
2. Classroom activities which capitalize and build on the math enjoyment expressed by younger children will increase the intrinsic interest value of math(1, 19).
3. Teachers should utilize a variety of instructional techniques in their math classrooms. Specific suggestions include the discovery teaching method, using real-world problems to illustrate math concepts, conducting exercises to increase spatial skills and "verbalizing" math concepts(1, 19, 31).
4. The classroom atmosphere should be relaxed and non-threatening, with teachers giving appropriate work praise and criticism and calling on specific students rather than waiting for volunteers(8, 19, 31).
5. Teachers should model and reinforce positive attributions for high ability females and work with the parents of math-able females to increase parental encouragement and support(19).

RECOMMENDATIONS/ SCHOOL PERSONNEL

1. Possible sex bias in aptitude tests and vocational interest inventories should be carefully assessed. Such instruments should not be used in guiding future math course selections or in career discussions(20).
2. Low teacher to student ratios are important in math courses(31).
3. School systems should provide an array of new math courses and require four years of math for high school graduation(8).

4. Programs which help develop study skills and which provide tutorial assistance are beneficial(31).
5. Programs should be presented which provide accurate career and vocational information. Such programs should include career math requirements, "hands on" activities such as role playing and simulations and the promoting of equal educational/career aspirations as well as the diligence with which they must be pursued(8, 19, 31).
6. School systems should encourage active problem assessment in the area of equity in math achievement and have an equally active math curriculum. Textbooks and materials should present and promote females as math-able and as participating successfully in a variety of nontraditional occupations(5, 6, 31).

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