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Procedures To Increase the Entry of Women in Mathematics-Related Careers. ERIC/SMEAC Mathematics Education Digest No. 3.

The underrepresentation of women in mathematics related careers, long an issue of equity and justice, has serious economic implications as the United States faces a shortage of scientists, engineers, and mathematically trained workers. In 1986 women constituted 49 percent of the nation's workforce, but only 15 percent of employed scientists and engineers and 24 percent of mathematicians. By the year 2000 the need for employees in quantitative fields will be 36 percent higher than in 1986; however, the traditional pool of white males, which supplies most scientists and engineers, will shrink to just 15 percent of the new entrants into the workforce (National Science Foundation, NSF, 1988).

Future demands for technological workers have prompted a national effort to encourage all sectors of the population to consider careers in mathematics and science (National Council of Teachers of Mathematics, NCTM, 1989; NSF, 1988; Task Force, 1989).

WHAT FACTORS AFFECT PARTICIPATION IN MATHEMATICS-RELATED CAREERS?

Ethington and Wolfle (1988) identified the number of advanced mathematics and science courses taken in high school as the strongest direct influence on choice of a quantitative undergraduate major. But women often avoid these advanced courses, reducing their career options.

Reasons for the underrepresentation of women in technical fields involve a complex interaction of factors. Kenschaft (in press) lists 58 societal, educational, and family customs affecting the participation of women in mathematics, while Boswell (in Chipman, Brush, and Wilson, 1985) identifies three sets of factors: external barriers, such as overt sex discrimination; social pressures from parents and peers; and internal barriers, such as negative attitudes toward mathematics. Lantz (in Chipman, Brush and Wilson, 1985) groups the variables by (1) cognitive beliefs (usefulness of mathematics to one's educational or career goals), (2) affect (confidence, anxiety, enjoyment), and (3) achievement (spatial ability, grades, test scores, problem-solving ability).

Males and females perform and participate equally in mathematics up to adolescence. Girls then begin to exhibit less confidence in their mathematical ability. Differential

enrollment patterns appear by the Algebra II level, when participation in mathematics first becomes optional. Performance differences favoring males on problem solving and higher level mathematical tasks are evident by high school age, although the differences are small and have declined over the last 20 years (Linn and Hyde, 1989).

Tracking has a detrimental effect on females' participation in mathematics. Students in lower tracks learn less mathematics and take fewer advanced courses. Teachers recommend high-ability girls less often than high-ability males for advanced placement (Oakes, 1990).

Attitudes toward mathematics, especially enjoyment, confidence, and perceived usefulness of mathematics, influence persistence in mathematics (Stage et al., in Klein, 1985). Males, more than females, classify mathematics as a male domain. Adolescent girls, experiencing conflict between interests in mathematics and science and desire for popularity, may forego mathematics achievement to avoid male disapproval or think a career would interfere with family responsibilities (Stallings, in Chipman, Brush, and Wilson, 1985). Research shows that women who choose professional careers tend to be less traditional in their view of sex roles than women in nonprofessional careers (Oakes, 1990).

Parental stereotyping of careers affects girls' perception of the usefulness of mathematics. Parents have lower expectations for daughters than sons and attribute their daughter's success in math and science more to effort than ability (Eccles, in Chipman, Brush, and Wilson, 1985).

Counselors sometimes discourage girls from selecting advanced math or science courses because of stereotypes of quantitative fields. Teachers' perceptions and beliefs can affect students' goals and perception of their own ability. Teacher encouragement has a positive influence on females' mathematics participation, but teachers tend to treat boys and girls differently, often to the detriment of girls' mathematics achievement (Fennema and Leder, 1990).

WHAT ARE SOME TYPES OF INTERVENTION PROGRAMS?

Intervention programs, both preventive and remedial, are necessary to increase participation in mathematics-related careers. Preventive strategies, stressing awareness of career opportunities, development of mathematical knowledge and skills, and the importance of continued enrollment in mathematics and science, can reach students, parents, teachers or counselors. Remedial intervention programs target students who did not pursue advanced math and science in high school.
Davis and Humphreys (1985) list five categories of intervention programs: (1) short-term interventions, including one-day career conferences, workshops, science fairs, or

speakers; (2) printed and audiovisual products and exhibits; (3) experiential learning, including internships and field placements; (4) long-term efforts involving courses and curricula, retraining programs, and support programs; and (5) teacher education programs, including inservice and summer institutes to modify teacher attitudes and increase their skills.

WHAT DOES RESEARCH SAY ABOUT INTERVENTION STRATEGIES?

Research on the participation of women in mathematics has focused on identification of variables influencing persistence. Systematic evaluation of the impact of intervention programs on these variables is less common (Oakes, 1990).
The most effective age for intervention activities is pre-adolescence, before negative attitudes appear. The number of students considering careers in technical fields increases very little after ninth grade (Berryman, in Oakes, 1990).

Research indicates that changes at the affective and achievement levels have more effect on enrollment than those aimed at cognitive beliefs. Training for spatial ability, which appears to have an experiential base, has been especially effective (Linn and Hyde, 1989). Cognitive intervention increases awareness but does not affect behavior (Lantz, in Chipman, Brush, and Wilson, 1985).

Long range programs are more effective in changing attitudes. One-day events often stress negative aspects, do not involve active participation and rarely address the reasons females do not take advanced courses (Lantz, in Chipman, Brush, and Wilson, 1985).

Peers and older students are effective communicators to young girls, as are adult males supportive of females' interest in mathematical careers. Students sometimes have difficulty identifying with women conference speakers; however, exposure to women in scientific careers over longer periods of time, as teachers or through internships, does develop role models and results in positive attitude changes (Tsuji and Ziegler, 1990).

Interventions aimed at students' parents, teachers, and counselors are effective in changing attitudes (Oakes, 1990). Instruction in creating gender-equitable classroom environments is an especially effective form of teacher education intervention.

There is some support in the literature for sex-segregated classes in mathematics and science, but Fox and colleagues (in Chipman, Brush, and Wilson, 1985) think programs that maintain a "critical mass" of female students effectively encourage participation.

Research indicates instructional techniques that reduce emphasis on competitiveness are conducive to female achievement in mathematics (Tsuji and Ziegler, 1990).

Damarin (1990) recommends curriculum intervention involving cooperative learning, hands-on activities, and solution of personally defined problems. She urges teachers to confront sex bias directly through classroom discussions.

WHAT ARE SOME RESOURCES FOR INTERVENTION PROGRAMS?

Intervention programs in various formats are described in Davis and Humphreys (1985), Malcolm (1984) and Task Force (1989). Davis and Humphreys also suggest ways to evaluate effectiveness of intervention programs.
Lists of speakers, career brochures, and annotated resource bibliographies are available from the Association for Women in Mathematics (AWM) or Women in Mathematics Education (WME).

The Math/Science Network offers programs, publications, videotapes, and other resources to encourage young girls to pursue interests in science.

Lawrence Hall of Science offers a variety of equity resources including EQUALS (a teacher education program) and Family Math.

"Multiplying Options and Subtracting Biases," a set of videotapes and facilitator's guide for use with students, teachers, parents, and counselors, can be purchased from the National Council of Teachers of Mathematics or rented through WME.

SELECTED RESOURCES

- Association for Women in Mathematics (AWM)
- Wellesley College
- Box 178
- Wellesley, MA 02181

(617) 237-7517

Lawrence Hall of Science

University of California

Berkeley, CA 94720

(415) 642-1823

Math/Science Network

2727 College Ave.

Berkeley, CA 94705

(415) 841-MATH

National Council of Teachers of Mathematics (NCTM)

1906 Association Dr.

Reston, VA 22091

(703) 620-9840 -----

Women in Mathematics Education (WME)

Mount Holyoke College

302 Shattuck Hall

South Hadley, MA 01075

(413) 538-2608

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