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ABSTRACT

The under-representation of females in mathematical careers persists despite the fact that in recent years, gender differences in mathematics achievement and participation in mathematics coursework at the high school level have virtually disappeared. This bulletin presents research findings and discusses gender differences in mathematics coursework, mathematics achievement, and choice of careers; reasons for female under-participation in mathematics; how to encourage females toward mathematics-related careers; and new questions and directions. Contains 43 references. (MKR)

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The Mathematics Outlook

Promoting Interest in Mathematical Careers Among Girls and Women

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Promoting Interest in Mathematical Careers Among Girls and Women

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The extent to which females are underrepresented in mathematics- and science-related careers has been well documented. The underrepresentation of females in mathematical careers persists despite the fact that in recent years, gender differences in mathematics achievement and participation in mathematics coursework at the high school level have virtually disappeared. Research examining gender differences in mathematics and science has not produced a definitive explanation for why so few women enter professions that call for substantial backgrounds in mathematics and science, but the changing trends in female achievement and coursework participation suggest that sociocultural factors must be at play

Gender Differences in Mathematics Coursework

Recent data show that females are enrolling in higher level mathematics coursework in increasing numbers, and in some cases at levels that exceed those of their male peers. Still, at the very highest levels of college mathematics, males continue to participate in significantly greater numbers.

For instance, a recent study of high school transcripts (National Center for Education Statistics, 1993a) showed that for 1990 high school graduates, 79% of the females had taken Algebra I, 65% had taken Geometry, and 51% had taken Algebra II. This compares to 76% of the males taking Algebra I, 64% taking Geometry, and 48% taking Algebra II. Participation rates in Trigonometry courses were equal for males and females at 18%, but slight differences favoring males emerge for participation in analysis/precalculus and calculus courses. Here, 13% of the females compared to 14% of the males had taken analysis/precalculus, and 6% of the females compared to 8% of the males had taken high school calculus.

Trends at the college level show females participating in mathematics coursework in greater numbers than in previous years, although still not at the rate of their male peers. According to the National Research Council of the National Academy of Sciences (1989), women now enter college nearly as well prepared mathematically as men, and 46% of the mathematics baccalaureates go to women. But once beyond the baccalaureate level, larger gender differences emerge, with women receiving only 35% of the master's degrees and 17% of the Ph.D. degrees in the mathematical sciences.

Gender Differences in Mathematics Achievement

Gender differences in mathematics achievement parallel those of course participation. That is, achievement differences between males and females in mathematics have, in recent years, become negligible (Ethington, 1990: Friedman, 1989; Hyde, Fennema, & Lamon, 1990; Linn & Hyde, 1989; Sadker, Sadker, & Klein, 1991).

For example, recent results from the National Assessment of Educational Progress (NAEP) show gender differences in mathematics achievement to be minimal at ages 9 and 13, and only slightly larger, favoring males, at age 17 (National Center for Education Statistics, 1993b). The difference at age 17 may be due to the slight differences in mathematics course participation, which show a somewhat larger number of males taking precalculus and calculus.

It is more difficult to ascertain what is happening to gender differences in mathematics achievement at the postsecondary level, as mathematics achievement is not routinely assessed using standardized measures. However, females consistently earn higher grades in their mathematics courses than their male peers (Linn, 1992).

Gender Differences in Choice of Careers

It is ironic that, given the apparent success of efforts to increase female participation in mathematics coursework and to raise the level of female achievement in mathematics, so few women choose careers in mathematics. Linn and Hyde (1989) note that female participation in mathematical and scientific careers has gone from 8.6% in 1975 to a mere 13.4% in 1986. The good news is that the proportion of women in these fields has increased by more than 50%; the bad news is that an increase of only 4.8 percentage points can sound like impressive progress because the representation of women in these fields is so low.

Linn and Hyde suggest that the "glass ceiling" that many women encounter in traditionally male professions, coupled with the fact that earning power for women compared to men has not changed overall during this period of time, may imply that the increases indicated by these figures actually reflect increased participation primarily in lower-paying careers related to mathematics and science. Disheartening figures such as these have prompted at least one evaluator of programs to encourage girls in mathematics and science to wonder if these programs really work in the long run (Campbell, 1994).

Reasons for Female Underparticipation in Mathematics

Research on female underparticipation in mathematics has centered on two general areas: gender differences in cognitive domains and gender differences in psychosocial domains. Research in the cognitive domain has centered on the extent to which innate gender differences may exist in quantitative abilities, particularly in mathematically talented children (e.g., Benbow & Stanley, 1980) or in spatial abilities (e.g., Fennema & Sherman, 1977). As gender differences in mathematics achievement have diminished in recent years, arguments for innate differences have grown less convincing.

Research in the psychosocial domain, however, has explored a rich variety of factors that may contribute to female underparticipation in mathematics. Some of these factors include gender differences in aggression, confidence, interest, susceptibility to social influence, and tendency to help others (see Linn & Hyde, 1989, for a review). There is speculation that, despite diminishing gender differences in mathematics course participation and mathematics achievement, these psychosocial factors may significantly influence the extent to which women choose careers in mathematics and science.

The fact that, at the college level, even women who are well prepared in mathematics and science choose careers in other fields suggests the importance of examining factors that influence career choice itself. For instance, Eccles (1986) found that women perceive male-stereotyped occupations as more difficult, but not more important, than female-stereotyped occupations, and that they expect to be less successful in mathematics, regardless of their actual abilities. Both of these findings were confirmed by Ethington (1992), who also found that females tend to value mathematics- and science-related careers less than female-stereotyped occupations.

Dick and Rallis (1991) found that social influences play a subtle yet powerful role in attracting females to mathematics- and science-related careers, with even women who are academically well prepared in mathematics not choosing such careers unless specifically encouraged to do so by parents or teachers. It should also be noted that the hierarchical nature of mathematics and science coursework can make it difficult for women to re-enter mathematical and scientific career paths once they have opted out of these courses (Rayman & Brett, 1993).

In addition to examining the beliefs and values that females may bring with them to the domain of mathematics, some research has examined the actual processes and behaviors of male and female students, and their teachers, during mathematics instruction. For example, a difference in preference for autonomous learning behaviors, which include working independently and persistently on high-level tasks, has been suggested as a possible explanation for gender differences in mathematics (Fennema, Walberg, & Marrett, 1985), although a recent study of 8th-grade students found no gender differences in these kinds of behaviors (Caporrimo, 1990). It has been further speculated that a lack of confidence in their own abilities may lead female students to rely more heavily on the algorithmic procedures emphasized in school and thus be less likely to explore creative, alternative strategies that allow them to grapple with underlying mathematical ideas (Linn, 1992).

A related body of research reports differential patterns of student-teacher interactions during mathematics instruction (e.g., Becker, 1981; Jungwirth, 1991; Leder, 1987, 1990). This research documents the nature of these patterns, which largely but subtly tend to favor males and seem to communicate important messages of mathematical competence (or lack of it) to both males and females. The devastating cumulative effect of these kinds of differential patterns of interaction on girls throughout their education in a range of content areas has recently been highlighted in *Failing at Fairness: How America's Schools Cheat Girls* (Sadker & Sadker, 1994). For young women studying mathematics or science at the postsecondary level, these patterns are particularly marked, especially at the graduate level (Peterson & Dubas, 1992; Rayman & Brett, 1993). Given the widespread nature of the differential patterns of interaction that these reports suggest, it is quite remarkable that young women persist in the study of mathematics and mathematics-related fields to the extent that they do!

Encouraging Females Toward Mathematics-Related Careers

Most efforts to encourage girls in mathematics have focused on (1) increasing their awareness of the importance of mathematics, (2) exposing them to high-level mathematics and developing confidence in their ability to do mathematics, (3) providing opportunities to learn about careers in mathematics, if possible from women working in those careers, or if not, through examples portraying such women, and (4) developing support systems to encourage girls in mathematics, both in the family and in the classroom. These efforts were begun in the late 1970s and early 1980s and were very deliberately built on research from that period suggesting that the attitudes and beliefs that girls brought to the study of mathematics kept them from going on to mathematics- and science-related careers (Fennema, 1980; Fennema & Carpenter, 1981).

Many of these efforts targeted interested teachers and included workshops as well as resources. For example, the EQUALS program developed at the Lawrence Hall of Science developed workshops on strategies for raising awareness of the problem of female underrepresentation in mathematics- and science-related careers, developing problem-solving skills in mathematics, and encouraging career aspirations (Kaseberg, Kreinberg, & Downie, 1980). These workshops have reached large numbers of high school mathematics teachers and, more recently, middle school and elementary school teachers.

For teachers seeking additional support, other resources were developed, such as *SPACES: Solving Problems of Access to Careers in Engineering and Science* (Fraser, 1982), containing mathematics and career activities for elementary and secondary students; *Math for Girls and Other Problem Solvers* (Downie, Slesnick, & Stenmark, 1981), the curriculum for a course that brought girls together to solve interesting and relevant mathematical problems; and *Family Math* (Stenmark, Thompson, & Cossey, 1986), a set of activities to be used in workshops where girls and their parents could explore mathematical problem solving together in a positive and supportive fashion. Other resources of a similar nature, such as *How to Encourage Girls in Math and Science: Strategies for Parents and Educators* (Skolnick, Langbort, & Day, 1982) and *Math Equals: Biographies of Women Mathematicians + Related Activities* (Perl, 1978), also appeared during this period of time.

While these efforts addressed the beliefs and values that seemed to contribute to female underrepresentation in mathematics- and science-related careers, much less attention was paid to research findings on differences in behavior of male and female students during mathematics instruction, or differential patterns of interaction between teachers and their male and female students. It may have been assumed that, once beliefs and values began to change, girls' behavior during mathematics instruction would reflect more of the problem-solving orientation of their male peers. Or, it may have been presumed that teachers who were actively working to encourage girls in mathematics would naturally interact in ways that conveyed support and encouragement to their female students as well as to their male students.

Indeed, only one resource from this period (Skolnick, et al., 1982) refers to intervention in the area of behavior, such as how to promote independence and risk taking in problem solving, and how to group children during activities to maximize learning and minimize negative peer pressure. However, with the very recent publicity about the widespread nature of differential patterns of interaction, many efforts are currently underway to help teachers look critically at their interaction with students and find ways to equalize the opportunities they provide for their male and female students in all content areas. For example, workshops are now available in which teachers learn to recognize subtle instances of sexism through videotapes of classroom interactions, role playing of classroom situations, and critical examination of their own classroom practice (Sadker & Sadker, 1994). These teachers develop a range of strategies for attending to and addressing interactions which disadvantage their female students.

Efforts at the postsecondary level to encourage women in mathematics- and science-related careers have featured mentoring programs (Rayman & Brett, 1993) and special programs such as the Women in Science Project at Dartmouth College (1993), that also includes such components as research internships, industrial site visits, career seminars, and an electronic newsletter. However, like many similar efforts at earlier grade levels, these intervention programs rarely address the nature of the mathematics and science instruction itself and rarely involve faculty who teach those content area courses. A rare exception is the mathematics program at the State University of New York College at Potsdam, which produces a large number of female mathematics majors, and where instruction deliberately invokes inquiry, discussion, and collaboration (Rogers, 1990).

New Questions and Directions

Efforts to promote interest in mathematical careers among girls and women have focused largely on changing their beliefs and values about the field of mathematics and their relationship to it. These efforts have included raising awareness of the importance of mathematics, teaching about career opportunities in mathematics and science and the activities of women in those fields, and building support networks for girls. Judging from the closing gap between males and females in mathematics course participation and mathematics achievement, these strategies appear to be working. However, at the postsecondary level, and particularly at the graduate level, the effects of these efforts appear to be washing out, and women are choosing careers other than those in mathematics and science. These findings raise questions about the extent to which women can ultimately see themselves as members of the mathematics and science community.

Recent discussions about women in mathematics and science question whether mathematics and science, as they are often taught, are compatible with "women's ways of knowing" (Belenky, Clinchy, Goldberger, & Tarule, 1986). Some mathematics educators are calling for dramatic changes in the way mathematics is experienced and studied (e.g., Becker, 1994; Borasi, 1990, 1992; Damarin, 1990, 1994; Isaacson, 1989). This new kind of mathematics instruction, often referred to as teaching mathematics from a feminist perspective, strives to provide opportunities to explore more humanized and contextualized aspects of mathematics rather than the "pure" mathematics that has been traditionally taught. If it is true that there is something intrinsically incompatible with the way girls and young women have been experiencing mathematics in the past, then it may be that they are persisting in mathematics only long enough to serve their purposes and are later choosing career alternatives that they perceive as better suiting their needs and interests.

Mathematics education is currently undergoing a reform in which fundamentally new ways of thinking about mathematics teaching, mathematics learning, and mathematics itself are being explored (NCTM, 1989, 1991). Much of the research on factors contributing to female underparticipation in mathematics was undertaken within an older paradigm in which mathematics teachers gave explanations and students listened, remembered, and provided correct answers. We do not yet know very much about the ways in which gender issues might unfold in this new paradigm for mathematics education, where there is strong emphasis on problem solving, reasoning, communication, and connections, with many parallels to "women's ways of knowing" as mentioned earlier.

In some ways, the efforts to encourage girls and women in mathematics initiated in the early 1980s helped change the culture of the mathematical experience by stressing problem solving and collaboration, and by placing at least some mathematics in the context of careers, although much of the latter took place outside of formal mathematics instruction. At the college level, mathematics education reform has made much less headway, but the Potsdam example of an instructional program that is compatible with reform recommendations appears to be making a marked difference in the extent to which women can view themselves as a part of the larger mathematics community. Thus, current initiatives are beginning to address postsecondary mathematics education reform, and it is critical that these efforts be supported.

However, the culture of the mathematics- and science-related workplace remains an issue yet to be addressed. Just as it is important that girls and women be encouraged to prepare for mathematics- and science-related careers through educational environments that recognize and support their abilities, it is equally important that, once in the workplace, they encounter an environment that nurtures their talents and rewards their contributions.

References

Becker, J. R. (1981, January). Differential treatment of females and males in mathematics class. *Journal for Research in Mathematics Education, 12*(1), 40-53.

Becker, J. R. (1994, April). *Research on gender and mathematics: Perspectives and new directions.* Paper presented at the Annual Meeting of the American Educational Research Association, New Orleans, LA.

Belenky, M. F., Clinchy, B. M., Goldberger, N. R., & Tarule, J. M. (1986). *Women's ways of knowing.* New York: Basic Books.

Benbow, C. P., & Stanley, J. C. (1980, 12 December). Sex differences in mathematical ability: Fact or artifact? *Science, 210*(4475), 1262-1264.

Borasi, R. (1990). The invisible hand operating in mathematics instruction: Students' conceptions and expectations. In T. J. Cooney & C. R. Hirsch, (Eds.), *Teaching and learning mathematics in the 1990s* (1990 Yearbook). Reston, VA: National Council of Teachers of Mathematics.

Borasi, R. (1992). *Learning mathematics through inquiry.* Portsmouth, NH: Heinemann.

Campell, P. B. (1994, April). *Gender equity in mathematics: Moving forward, backward, or going nowhere fast.* Paper presented at the Annual Meeting of the American Educational Research Association, New Orleans, LA.

Caporrimo, R. (1990). *Gender, confidence, math: Why aren't the girls "Where the Boys Are"?* Paper presented at the Annual Meeting of the American Psychological Association, Boston, MA.

Damarin, S. K. (1990). Teaching mathematics: A feminist perspective. In T. J. Cooney & C. R. Hirsch (Eds.), *Teaching and learning mathematics in the 1990s* (1990 Yearbook). Reston, VA: National Council of Teachers of Mathematics.

Damarin, S. K. (1994, April). *Genders, mathematics, and feminisms.* Paper presented at the Annual Meeting of the American Educational Research Association, New Orleans, LA.

Dartmouth College. (1993). The Women in Science Project: A Bold New Initiative in Education. In *Dartmouth College 1992-1993 Annual Report.* Hanover, NH: Author.

Dick, T. P., & Rallis, S. F. (1991, July). Factors and influences on high school students' career choices. *Journal for Research in Mathematics Education, 22*(4), 281-292.

Downie, D., Slesnick, T., & Stenmark, J. (1981). *Math for girls and other problem solvers.* Palo Alto, CA: Dale Seymour.

Eccles, J. S. (1986, June/July). Gender roles and women's achievement. *Educational Researcher, 15*(6), 15-19.

Ethington, C. A. (1990, March). Gender differences in mathematics: An international perspective. *Journal for Research in Mathematics Education, 23*(2), 166-181.

Ethington, C. A. (1992, January). Gender differences in a psychological model of mathematics achievement. *Journal for Research in Mathematics Education, 21*(1), 74-80.

Fennema, E. (1980). Sex-related differences in mathematics achievement: Where and why. In L. H. Fox, L. Brody, & D. Tobin (Eds.), *Women and the mathematical mystique*. Baltimore, MD: Johns Hopkins University Press.

Fennema, E., & Carpenter, T. (1981, October). Sex-related differences in mathematics: Results from national assessment. *Mathematics Teacher, 74*(7), 554-559.

Fennema, E., & Sherman, J. (1977, Spring). Sex-related differences in mathematics achievement, spatial visualization, and socio-cultural factors. *American Educational Research Journal, 14*(1), 51-71.

Fennema, E., Walberg, H., & Marrett, C. (1985, August). Explaining sex-related differences in mathematics: Theoretical models. *Educational Studies in Mathematics, 16*(3), 303-320.

Fraser, S. (1982). SPACES: Solving Problems of Access to Careers in Engineering and Science. Palo Alto, CA: Dale Seymour.

Friedman, L. (1989). Mathematics and the gender gap: A meta-analysis of recent studies on sex differences in mathematical tasks. *Review of Educational Research, 59*, 185-213.

Hyde, J. S., Fennema, E., & Lamon, S. J. (1990). Gender differences in mathematics performance: A meta-analysis. *Psychological Bulletin, 107*, 139-155.

Isaacson, Z. (1989). Of course you *could* be an engineer, dear, but wouldn't you *rather* be a nurse or teacher or secretary? In P. Ernest (Ed.), *Mathematics teaching: The state of the art*. New York: Falmer Press.

Jungwirth, H. (1991, June). Interaction and gender: Findings of a microethnographical approach to classroom discourse. *Educational Studies in Mathematics, 22*(3), 263-284.

Kaseberg, A., Kreinberg, N., & Downie, D. (1980). *Use EQUALS to promote the participation of women in mathematics*. Berkeley, CA: Lawrence Hall of Science.

Leder, G. C. (1987, August). Teacher student interaction: A case study. *Educational Studies in Mathematics, 18*(3), 255-271.

Leder, G. C. (1990). Gender and classroom practice. In L. Burton (Ed.), *Gender and mathematics: An international perspective*. London: Cassell Educational.

Linn, M. C. (1992). Gender differences in educational achievement. In *Proceedings of the 1991 ETS Invitational Conference on Sex Equity in Educational Opportunity, Achievement, and Testing*. Princeton, NJ: Educational Testing Service.

Linn, M. C., & Hyde, J. S. (1989, November). Gender, mathematics, and science. *Educational Researcher, 18*(8), 17-19, 22-27.

National Center for Education Statistics. (1993a). *The 1990 high school transcript study tabulations: Comparative data on credits earned and demographics for 1990, 1987, and 1982 high school graduates*. Washington, DC: U S. Department of Education.

National Center for Education Statistics. (1993b). *The NAEP 1992 mathematics report card for the nation and the states*. Washington, DC: U.S. Department of Education.

National Council of Teachers of Mathematics. (1989). *Curriculum and evaluation standards for school mathematics*. Reston, VA: Author.

National Council of Teachers of Mathematics. (1991). *Professional standards for teaching mathematics*. Reston, VA: Author.

National Research Council. (1989). *Everybody counts: A report to the nation on the future of mathematics education*. Washington, DC: National Academy Press.

Perl, T. (1978). *Math equals: Biographies of women mathematicians + related activities*. Menlo Park, CA: Addison Wesley.

Peterson, A. C., & Dubas, J. S. (1992). Strategies for achieving sex equity in postsecondary education. In *Proceedings of the 1991 ETS Invitational Conference on Sex Equity in Educational Opportunity, Achievement, and Testing*. Princeton, NJ: Educational Testing Service.

Rayman, P., & Brett, B. (1993). *Pathways for women in the sciences*. Wellesley, MA: Wellesley College Center for Research on Women.

Rogers, P. (1990). Thoughts on power and pedagogy. In L. Burton (Ed.), *Gender and mathematics: An international perspective*. London: Cassell Educational.

Sadker, M., & Sadker, D. (1994). *Failing at fairness: How America's schools cheat girls*. New York: Charles Scribner's Sons.

Sadker, M., Sadker, D., & Klein, S. (1991). The issue of gender in elementary and secondary education. *Review of Research in Education, 17*, 269-334.

Skolnick, J., Langbort, C., & Day, L. (1982). *How to encourage girls in math and science. Strategies for parents and educators*. Englewood Cliffs, NJ: Prentice-Hall.

Stenmark, J., Thompson, V., & Cossey, R. (1986). *Family math*. Berkeley, CA: Lawrence Hall of Science.

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