Why Women Succeed in Mathematics

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Contemporary educational research has suggested several factors that increase women's success in mathematics, and historical investigations support the validity of these recent observations. Most women in the history of mathematics shared three characteristics: a supportive family background, early exposure to significant mathematics, and available female role models in mathematics.

Historical Evidence

Ada Byron Lovelace
1815–1852

The first computer scientist, Ada Byron Lovelace (1815–1852), was the daughter of Annabella Milbanke, an avid amateur mathematician, and Lord Byron, who referred to his wife as "the Princess of Parallelograms'' (Perl 1978, 103). When Ada Byron was a young woman, her mentor was the leading nineteenth-century mathematician Mary Somerville (1780–1872), who introduced Ada Byron to Charles Babbage (Perl 1978, 101). Not only did Ada Byron learn the logic of Babbage's analytic engine, write programs for it, and develop the logic of loops and branching in programming, but she saw, remarkably ahead of her time, that the computer could manipulate and output symbols as well as numbers.

Hypatia
370–415

Over a millennium earlier, one of Plutarch's daughters tutored Hypatia (370–415), who subsequently wrote several mathematical commentaries, including "On the Conic Sections of Apollonius,'' which helped to popularize the work done by Apollonius approximately five hundred years earlier. Her main interest was to continue the work of Diophantus, and she wrote a number of treatises on Diophantine equations. Hypatia's father, Theon, was a professor of mathematics at the University of Alexandria and later became its director. Her father was believed to have been determined to produce a "perfect human being.''

Consequently, her childhood was immersed in an atmosphere of learning, questioning, and exploration. Eventually Theon's daughter's reputation eclipsed his own, and it was said that letters in the ancient world addressed to "The Muse'' were delivered to her (Osen 1974, 29).

In the sixth century B.C., Pythagoras (569 B.C.–c. 500 B.C.) led an active mathematical school that included women who supported each other. Among them were his wife, Theano, and two of their daughters. Theano wrote a biography of her husband, now lost (Turnbull 1956, 82), and one can speculate that she and her daughters were responsible for attaching his name to a theorem that was well known at least two millennia before his time and that his activities as a "feminist philosopher'' (Osen 1974, 15) were an underlying reason that posterity honors his name.

Emmy Noether
1882–1935

In our own century the founder of modern algebra, Emmy Noether (1882–1935), was the daughter of an outstanding nineteenth-century German mathematician, Max Noether (Kimberling 1982, 248). That he infused his home with the subject he loved is indicated by the fact that Emmy's younger brother was also a mathematician. However, at the age of eighteen she passed examinations to certify her as a teacher of two foreign languages, French and English. Why, then, did she become a mathematics student at her father's university the following fall, the only woman in a student body of over nine hundred? Possibly Emmy Noether was inspired by Charlotte Scott's address at the International Congress of Mathematics in Paris in the summer of 1900 (Kenschaft 1983, 19). Charlotte Scott (1858–1931), a mathematician from Bryn Mawr, was an official United States delegate to the International Congress. In turn, Emmy Noether served as a mentor for several female mathematicians who studied at Bryn Mawr, including Olga Taussky-Todd, Ruth Stauffer McKee, Marie Weiss, and Grace Shover Quinn (Dick 1981, 84–85).

One of the first two black women to receive a doctorate in mathematics in the United States, Marjorie Lee Browne (1914–1979, Ph.D., University of Michigan, 1949), had a father who was a “whiz’’ at mental arithmetic. Having first stimulated her interest in mathematics as a child, he later learned mathematics from her as her studies advanced. All of the twenty-two black women with doctorates in mathematics interviewed by Kenschaft (1981, 603) reported that they had both a highly supportive member of their family in the older generation, who was willing to sacrifice for their education, and a secondary school teacher who told them they were gifted in mathematics and that it would be worth the struggle to attain a career in mathematics.

Family influence continues to be an important factor for female mathematicians in the twentieth century. Cathleen Morawetz (1923–), the first American woman to head a mathematics institute (Courant Institute of Mathematics) is the daughter of John Synge, an applied mathematician (Patterson 1987, 152). Maria Goeppert Mayer (1906–1972), a joint winner of the 1963 Nobel Prize in physics for her work concerning nuclear shell structure, came from a family of six generations of professors (Sicherman and Green 1980, 466–68). Rear Admiral Grace Murray Hopper (1906–), the “Mother of COBOL,’’ who led the team at Eckart-Mauchly that designed the first compiler, attributes her success to her father’s belief in equal educational opportunities for his son and his daughters (King 1987, 67).

Early exposure to mathematical ideas is crucial.

These and many other historical figures indicate that parents’ occupations and direct involvement in their daughters’ education, early exposure to mathematical ideas, and the influence of female mentors strongly affect the success of women in mathematics. This statement does not denigrate the importance of other observed factors influencing women’s participation in mathematics, such as parental expectations, societal stereotypes, peer pressure, attitudes of teachers, successful experiences in mathematics, and an understanding of the probable usefulness of mathematics in their future. Still, these three factors are sufficiently important to merit continued examination of their implications.

Contemporary Research

It is unrealistic in modern times to depend on families’ socialization to provide enough prospective mathematicians to fill the personnel needs of a technology-based economy. Educators and writers can, of course, suggest to parents that they encourage and stimulate their daughters’ innate inquisitiveness about mathematics as much as they do their sons’. But as schools and preschools more and more share the family’s function of encouraging, counseling, and setting expectations for young people, teachers are also able to directly affect students’ interests and abilities.

Ideally, learning and achievement in mathematics should be encouraged and nurtured for both sexes starting in preschool, and experiences involving independent thinking and problem solving should allow girls the same freedom as boys. In reality, studies have shown that teachers generally allow boys more freedom to deviate from rules and algorithms and to discover alternative solutions to problems, whereas they require girls to follow rules more closely (Fennema and Peterson 1985, 27). Other studies (e.g., Nash 1979, 316) have shown that teachers treat gifted female students more negatively than gifted male students, finding that they tend to criticize female students' work more than that of their male counterparts. Also, Thomas and Stewart found that all too often counselors discourage girls from pursuing mathematics (Armstrong 1985, 64).

When the number of girls in nonrequired advanced mathematics classes becomes very small, the remaining girls tend to drop out (Nash 1979, 318). In one study Casserly (1984, 16) reported that female students did better in mathematics classes in which teachers set high goals for them and made it difficult for them to drop out. Another study found that if girls are required to participate in a particular skill, their achievement in that skill is likely to be increased (Eccles 1984, 98). Similar conclusions have motivated Nash (1979, 317), Chasek (1986, 3), and others to suggest that all students should be required to take four years of high school mathematics.

A number of studies have found that girls achieve better in same-sex classes. In a course on basic skills for women only at the University of Missouri–Kansas City, participants earned higher grades, had a more positive attitude toward mathematics, and were more likely to continue their mathematics education than women in coeducational classes (MacDonald 1980, 115–37). When left to their own devices in coeducational science-laboratory teams, girls tend to assume the passive role of recorder and boys the active role of experimenter, according to a report by the American Federation of Teachers (AFT) (*AFT Bulletin* 1987, 2). However, girls did better in same-sex teams or in coeducational teams in which roles were assigned.

Some studies show that one barrier to females' mathematics achievement on standardized examinations is that test questions are male oriented (e.g., AWM/ICM-86 Report 1986, 9). In particular, a study of Scholastic Aptitude Tests found that men were more frequently mentioned in the reading passages and that the tests, especially in the mathematics sections, were male oriented (Hildebrand 1987, 1). Indeed, the fact that in some countries female students' achievements on standardized tests is equal to or superior to males' (Gray 1981, 4; Hanna 1989, 225–32) points to the conclusion that women's underrepresentation in mathematical fields is a cultural phenomenon.

Female role models strongly affect the success of women.

Career education in schools is another factor to be considered. Armstrong concluded that for both sexes, the most important factors in deciding whether to take more mathematics was its perceived usefulness, followed by confidence in, and enjoyment of, mathematics (Chipman 1985, 78). In three separate studies, Fennema and Peterson (1985, 24), Nash (1979, 318), and Eccles (1984, 106) confirmed that the perception of mathematics as a necessary skill for her future career is crucial in a high school girl's choice to take advanced mathematics courses.

Providing girls with appropriate role models in mathematics has been explored by a number of different programs. EQUALS, which may be the oldest of these programs, is based at the University of California at Berkeley and furnishes books and information on methods for helping girls achieve success in mathematics. The Futures Unlimited Project, developed at Rutgers University, supplies information on giving workshops in which female junior high school students can meet women working in mathematics and related fields. Keep Your Options Open, a Rhode Island-based project, offers female speakers for junior high school classes on careers for women in mathematics and science. The Women and Mathematics (WAM) program of the Mathematical Association of America, which is active in over a dozen metropolitan areas nationwide, sends female mathematicians to speak in high schools and junior high schools.

Recommendations

Actions can be implemented now to increase females' participation in mathematics and mathematics-based fields. Both the family and the school can directly encourage girls to take mathematics seriously, offer experiences designed to develop their spatial abilities, stimulate independent thinking and problem solving as early as possible, promote assertive participation in classroom discussions, and ensure high-quality mathematics education beginning in preschool. Schools should also furnish information about the role of mathematics in many careers and stress the crucial nature of mathematics for adult life in modern times.

Female mathematics teachers serve as important role models for girls. In addition, appropriate materials should demonstrate applications of mathematics to fields currently of great interest to women, and textbooks should include biographies of female mathematicians. Intervention programs, such as Futures Unlimited, EQUALS, and WAM, and organizations like the Association for Women in Mathematics (AWM), which help young people meet female mathematicians and read about their contributions to mathematics and in general show that women can succeed in mathematics, should be supported and expanded. Sources of funding and financial aid for women studying and doing research in mathematics need to be increased in both size and number.

Let us lose no time in implementing current knowledge to correct our country's sexual imbalance in mathematical fields. Both our children and our society will benefit from the increased contributions of women to the future of scientific advances in our nation.

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