Equity in Mathematics Education: The Educational Leader's Role

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Informed by research findings, educators can follow these suggestions for encouraging females to study mathematics.

One of the most serious problems facing educational leaders concerned with equity in education is ensuring that females and minority students continue their study of mathematics beyond the level of minimum requirements. Recent research funded by the National Institute of Education and the National Science Foundation, among others, has focused on identifying the causes of this pervasive problem. A substantial body of research shows that female students drop out of the study of mathematics as soon as it becomes optional. A 1977 study presents data to support the fact that minority students also drop out of mathematics study at the point of choice.[1] The mathematics education community recognizes the importance of this problem and the National Council of Teachers of Mathematics has appointed a task force to investigate and suggest appropriate actions.

Researchers have focused their efforts in two directions. One has been to investigate any sex-related differences in mathematical achievement and/or ability; the other has been to examine the differences in the amount of mathematics study pursued by males and females, and to establish the causes of any observed differences.

Fennema states the following conclusions about sex-related differences in mathematics learning in the United States in 1978:

> . . . 1) There are no sex-related differences evident in elementary school years. This is at all cognitive levels from computation to problem solving. This conclusion has been accepted for a number of years. 2) After elementary school years, differences do not always appear. 3) Starting at about seventh grade, if differences do appear, they tend to be in the male's favor, particularly on tasks involving higher level cognitive skills. . . . 5) Conclusions reached about male superiority have often been gathered from old studies or studies in which the number of mathematics courses taken was not controlled. Therefore, a better mathematically educated group of males was being compared to a group of females who had participated in less mathematics education. In reality what was being compared were not females and males but students who had studied mathematics 1-3 years with students who had studied mathematics 2-4 years in high school.[2]

If we investigate the research about the relationship of the effect of differential ability in spatial visualization on the mathematics learning of males and females we discover that even less is known. Fennema and Sherman have concluded:

> Existing evidence suggests that the sex-related differences in studying and learning math cannot be explained fully by any difference in cognitive abilities between the sexes. Even the small differences in performance on spatial visualization tasks cannot account for the very large (numerical) discrepancy between males and females who study math. Therefore attention must be given to that wide range of variables identified as socioculture or affective factors.[3]

Several studies suggest other relevant findings: the development of spatial visualization skills may be closely related to sexual stereotypes and therefore related to sex role

[1] L. W. Sells, "Mathematics: A Critical Filter," *Science Teacher* 45 (1978): 28-29; J. Ernest, *Mathematics and Sex* (Goleta, Calif.: Triple R Press, 1976); J. E. Jacobs, ed., *Perspectives on Women and Mathematics* (Columbus, Ohio: ERIC/SMEAC Clearinghouse for Science, Mathematics and Environmental Education, Ohio State University, 1978).

[2] E. Fennema, "Sex Related Differences in Mathematics Achievement: Where & Why?" in *Perspectives on Women and Mathematics*, J. E. Jacobs, p. 1-17.

[3] E. Fennema and J. Sherman, "Sex-Related Differences in Mathematical Learning: Myths, Realities and Related Factors," paper presented to the American Association for the Advancement of Science, Boston, 1976.

socialization practices; this difference between males and females is due to differential training; and practice produces significant differences in female performance on spatial visualization tasks. DeFries and others demonstrated that spatial ability is not genetically controlled.[4] Thus the difference in male and female achievement in mathematics appears to be largely a cultural phenomenon.

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Why Fewer Females Choose Mathematics

Investigation of differences in the amount of mathematics study and the causes of this difference has produced much less ambiguous results. Definite differences *do* exist in the study of mathematics, and these differences are sex-related. For a variety of reasons, fewer females enroll in mathematics courses in high school. This leads to underrepresentation of females in university level mathematics courses and by extension contributes to many females' nonparticipation in mathematics - related occupations. The one variable that can be positively identified as causing sex-related differences in mathematics learning is the differential number of years females and males spend formally studying and using mathematics.[5] Other studies suggest the situation for minority students may be much the same.[6] One could infer that it is even worse for minority women as they encounter both racist and sexist bias in educational institutions. Thus, the study of mathematics in high school acts as a critical filter for female students. Failure to study mathematics in high school prevents females from meeting the requirements of universities for continued mathematics study, and leads to few females being admitted to occupations that require mathematics.

A considerable body of literature generated during the 1970s has indicated that sex-role expectations and sex-role stereotyping contribute to this situation. In the United States sex-role stereotyping begins early and stays late. Parents, the educational system, peers, and the larger society hold attitudes that convey a clear message regarding the relative competence and ability of men and women in mathematics and mathematics-related areas. The assumption that girls are neither good in mathematics nor interested in the subject is one of the more damaging examples. It creates a situation in which girls and young women behave in ways to confirm this set of expectations. Studies have confirmed that a substantial portion of young women have a variety of negative attitudes (that is, lack of interest and lack of self-confidence) toward mathematics.[7]

Math Avoidance

Another widely mentioned factor is "math avoidance." While the avoidance of mathematics study is by no means an exclusively feminine trait, females, beginning in adolescence, have less confidence in their ability to do mathematics and therefore avoid it much more than males. Other more specific factors have been identified as contributing to the difference in male-female mathematics study. One of the more widely known is the concept of "math anxiety," which is considered by some to be an irrational dread of mathematics. This issue must be kept in perspective and considered along with other factors if educational leaders are to avoid the perpetuation of stereotypes. Fennema suggests that since people tend to choose to do the things in which they feel confident of their ability and to avoid actions that arouse anxiety, an examination of differential amounts of anxiety about or confidence in mathematical ability is a more productive path for research.[8] She reports evidence

[4] J. Sherman, "Effects of Biological Factors on Sex-Related Differences in Mathematics Achievement," in *Women and Mathematics: Research Perspectives for Change*, NIE Papers in Education and Work, No. 8 (Washington, D.C.: NIE, 1977); S. Johnson, J. Flinn, and Z. Tyer, "The Effect of Practice and Training of Spatial Skills in Males and Females," *Perceptual and Motor Skills* (in press, 1979); J. C. DeFries, G. C. Ashton, R. C. Johnson, A. R. Kuse, G. E. McClearn, M. P. Mi, M. N. Rashad, S. E. Vandenberg, and J. R. Wilson, "Parent-Offspring Resemblance for Specific Cognitive Abilities in Two Cognitive Groups," *Nature* 201 (1976): 131-133.

[5] E. Fennema, in *Perspectives on Women and Mathematics*, p. 7.

[6] L. Sells, in "Mathematics . . . ," p. 137.

[7] P. L. Casserly, "An Assessment of Factors Affecting Female Participation in Advanced Placement Programs in Mathematics, Chemistry and Physics," report to the National Science Foundation, Grant No. GY-11325 (July 1975); E. W. Havens, *Factors Associated with the Selection of Advanced Mathematics Courses by Girls in High School* (Princeton, N.J.: Educational Testing Service, March 1972); B. A. Kirk, *Factors Affecting Young Women's Direction Toward Science-Technology-Mathematics* (Berkeley: Management Technology Career Projects, September 1975); M. Levine, "Identifications of Reasons Why Qualified Women Do Not Pursue Mathematical Careers," report to the National Science Foundation, Grant No. GY 11411 (August 1976).

[8] E. Fennema, in *Perspectives on Women and Mathematics*, pp. 1-17.

to confirm that high anxiety is associated with lower achievement in mathematics and that girls show higher anxiety levels than boys in mathematics study.

Others have found that many people believe the study of mathematics is a masculine domain and that it is unfeminine to study mathematics. Research findings in this area provide evidence that this belief becomes a self-fulfilling prophecy. Stein and Smithells found that mathematics is not considered as masculine until adolescent years. They also suggest that the view of mathematics as masculine is held more strongly by males than by females in adolescence.[9]

Ernest and Kirk found that students turn to their fathers, not their mothers, for help in mathematics, particularly in adolescence.[10] This is a two-edged sword, for it tends to confirm the image of mathematics as being a male domain and to perpetuate the stereotype of male superiority in mathematics. This perception of mathematics as a male domain has been shown by Fox to cause career conflict for female students at a time when they are already under considerable developmental stress around identity and career *vs.* family-marriage issues.[11] Related to this factor are studies that demonstrate that many women do not see mathematics study as useful to their future roles.[12] The failure to take sufficient mathematics in high school will at the least delay the entrance of young women into most college majors and at worst permanently discourage them from taking the courses that could gain them entrance into careers that offer more promise, in terms of financial reward, than positions in education and the social sciences.

What Makes Some Schools Different?

Other research has focused on educational environment to discover factors there that account for the differential rate of male-female mathematics study. Casserly studied secondary schools that were outstanding in their success in attracting and holding young women in strong, sustained programs in mathematics, physics, and chemistry, to identify some reasons for their success.[13] One was the homogenous grouping of students according to ability as soon as practical. This provides girls from elementary school years on with both a challenging learning environment and a support group of other girls who are engaged in the study of mathematics. This demands that students of high mathematics ability be identified as early as possible. Another factor was encouragement for girls to keep their college major and career options open by taking the full mathematics sequence. Secondary school personnel gave calm, kind, and firm support to girls who wanted to "give up" when frustrated by skill gaps.

Casserly found other factors that made these schools successful.

1. Older girls were used to counsel, encourage, and tutor younger girls. The role models identified by adults as relevant to young women were rarely identified as such by young women themselves. Young women tended to emulate teachers and counselors who were seen as trusted older friends, respected mentors, and informed, assertive counselors, whatever their sex, age, or marital status.

2. Teachers of advanced placement students tended to thrive on teaching students, even female ones, who may have been brighter than they were. This quality set them apart from their teacher colleagues. This was seen as crucial to the young women they taught, especially in light of evidence that gifted young female students are not the delight to their teachers that gifted young men are.

3. Teachers of the advanced placement classes had direct access to the parents of their students and used it when girls appeared to be having trouble or were falling behind.

What Leaders Can Do

What can educational leaders derive from this research that will enable them to work for equal educational opportunity for women and minority students in mathematics education? One can begin by acknowledging that the differential mathematics achievement of males and females is almost all accounted for by environmental factors, not innate biological sex-related differences. This will allow educational leaders to frame the problems in a way that will permit solutions that they have the resources and power to implement. It will prevent them from falling into the trap of blaming the victim when confronted with the apparent

[9] A. H. Stein, "The Effects of Sex Role Standards for Achievement and Sex Role Preference on Three Determinants of Achievement Motivation," *Developmental Psychology* 4 (1971): 219-231; A. H. Stein and J. Smithells, "Age and Sex Differences in Children's Sex Role Standards about Achievement," *Developmental Psychology* 1 (1969): 252-259.

[10] J. Ernest, *Mathematics and Sex.*

[11] L. H. Fox, "Sex Differences in Mathematical Precocity: Bridging the Gap" in *Intellectual Talent: Research and Development*, ed. D. P. Keating (Baltimore: Johns Hopkins University Press, 1976).

[12] J. Ernest, *Mathematics and Sex;* L. H. Fox, "The Effects of Sex Role Socialization on Mathematics Participation and Achievement," *Women and Mathematics: Research Perspectives for Change*, NIE Working Papers in Education and Work, No. 8 (Washington, D.C.: NIE, 1977); T. Hilton and G. Berglund, "Sex Difference in Mathematics Achievement a Longitudinal Study," *Journal of Educational Research* 67 (1974): 231-237.

[13] P. Casserly, "Factors Leading to Success—Present and Future," in *Perspectives on Women and Mathematics*, pp. 119-125.

lack of interest of young women for mathematics study. Educational leaders must acknowledge that the study of mathematics and the acquisition of mathematical competence is essential for full participation in tomorrow's society. They will regard continued study in mathematics as essential as the study of English.

Some ways you may be able to help:

1. *Remember, anxiety about mathematical study has its roots in the early years of schooling.* It is important to develop positive attitudes toward the study of mathematics and its usefulness and importance. Elementary school leaders have an important role in helping parents and teachers capitalize on the enthusiasm of girls for mathematics before these students reach adolescence. Early identification of high ability students in mathematics is critical, as is some variety of ability grouping. Females need the support of same sex peers in order to maintain interest and commitment to mathematics.

2. *Identify and guide the "math anxious" teacher.* Educational leaders need to do more than just identify these individuals, they need to provide staff development programs designed to help these "math anxious" teachers overcome their problem. The Oregon Mathematics Education Council has conducted a highly successful project in this area.[14] Inservice training could focus on ways to make mathematics more interesting rather than sessions on how to teach long division.

3. *Develop a variety of support systems:*

a. Try sharing success. The shared practices technique, which involves educators sharing, on a regular basis, classroom and/or administrative practices that have been successful for them, has been shown to be effective in promoting support, disseminating innovative ideas, and encouraging change.

b. Identify women with leadership potential. Become their mentors and see to it that they receive both the formal education necessary for assuming these roles and the opportunities for experience in leadership roles. It is in the area of developing these leadership experiences that today's educational leaders have influence and control.

c. Support yourself. Educational leaders need to develop and maintain support systems made up of colleagues who share similar goals and values. These groups can provide a sounding board for new ideas, comfort, and feedback when big plans meet a roadblock and insurance for those moments of despair.

d. Support students. High ability students, in elementary and/or middle schools, can be given the opportunity to work on mathematics projects during school time. This kind of opportunity can be supervised in the elementary and middle school by senior high school students, college students, or parents providing another opportunity for interaction with role models. More importantly, it provides young female students with a group of identified peers who share an interest in mathematics.

4. *Provide appropriate role models.* Educational leaders can exert considerable influence in this area by making female and minority role models available who are numerate, enjoy mathematics, and are informed about the importance of the study of mathematics for future goals. It is important that young women see female administrators and teachers who participate in the supervision of advanced mathematics and science courses.

5. *Consider changes in curriculum and school organization.*

a. Experiment with new diagnostic tools. Diagnostic systems should be made more developmental in nature. Such systems

[14] Inquiries may be directed to: Dr. Eugene Maier, Oregon Mathematics Education Council, 325 13th St. N.E. Unit 301, Salem, Oregon 97301.

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should be based on Piagetian theory, providing educational leaders valuable information on which to base decisions about what, when, and how to teach important mathematical concepts. These would require that the study of mathematics be viewed more openly. We may be turning many students off to the study of mathematics because we rush into abstract concepts when developmentally students are still in the concrete operational stage or we may be keeping bright students in concrete operations too long and turning them off with curriculum that does not challenge their development level.

b. Try exchange teaching. This offers real possibilities for successful interventions. Female elementary school teachers may have difficulty, due to "math anxiety," in teaching mathematics in a way that is conducive to encouraging their students to continue the study of mathematics. One way of breaking the cycle of having math anxious teachers teach mathematics is by either having a specialist teach mathematics or by finding among your staff someone who is really turned on to mathematics and having that person teach all the mathematics classes.

c. Keep a critical eye on educational materials. Educational leaders must continue to exercise guidance in the selection of textbooks and teaching materials. Nonsexist and nonracist materials will need to be purchased. More importantly the sexist or racist portions of current curriculum materials must be brought to the attention of faculty.[15] Once faculty are aware of the limitations of the materials, teaching strategies should be developed that will work towards eliminating sexist and racist stereotypes.

d. Institute remedial mathematics programs. Educational leaders may need to consider the development of remedial mathematics programs similar to the programs in reading. Mathematics instruction must include techniques for reaching a variety of cognitive styles just as in remedial reading instruction.

e. Provide career education programs for students, parents, and teachers. In obtaining resources for such efforts care must be exercised to include as speakers at assemblies or career conferences role models that young women and minority students can accept. Singling out any female guest as the black chemist or the female engineer is not advisable. They should be included because of the information about their respective careers they can share, not as minorities or females. Information about career choice and future earnings should be made available and stressed by teachers and counselors.

6. *Inform parents.* The importance of a full mathematics education for their daughters as well as for their sons must be communicated to parents. They need to know algebra and geometry are important for access to noncollege vocational and technical skills, and that trigonometry is essential for the college bound student. Providing parents with this information presents educational leaders with an opportunity to get parents involved in mathematics education.

7. *Try a "report card" for your school.* Continuous evaluation of progress in increasing the number of female and minority students enrolled and successfully completing advanced placement mathematics courses is critical. Casserly suggests that educational leaders consider using a "report card" for their schools, particularly at the secondary level. She proposes that the mathematics ability of students by sex be obtained in grades seven, eight, and nine, and that in the following years educational leaders should work to see that appropriate proportions of female and minority students succeed in various mathematics sequences or courses. If inspection of this data indicates there are less than representative proportions of girls and minorities in upper level math courses, then the system is not providing appropriate basic education to that segment of its population. Sells suggests similar techniques for evaluating progress and success.[16]

Most of the interventions suggested do not require large sums of money. They do require that educational leaders direct their efforts toward interventions in the organizational structure of educational systems. The directions for change suggested in this article should make it possible for educational leaders to begin to make changes that will be in line with the spirit of equal educational opportunity and have a high chance for success. It is a challenge to all of those in positions of leadership that cannot go unheeded. EL

[15] Contact the Council on Interracial Books for Children, 1841 Broadway, N.Y., N.Y. 10002, for an array of useful materials.

[16] P. Casserly, in *Perspectives on Women and Mathematics;* L. Sells, in *Perspectives on Women and Mathematics.*

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