The Gender Gap in Science Education

Strategies to encourage female participation in science

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Because the first 12 years of schooling have a tremendous effect on how individuals respond to postsecondary science, all primary and secondary students must have equal opportunities to actively learn science. Unfortunately, though, research has consistently shown a persistent gender gap in primary and secondary science classrooms, especially in physics and chemistry, with female students trailing their male counterparts both in interest in the subject as well as academic performance. The *National Science Education Standards* are based on the premise that all students in the United States must have the opportunity to become scientifically literate (NRC 1996). However, some educational practices implemented in the classroom continue to hinder instead of encourage female science students—a problem that must be rectified.

Turning away from science

In *Lost Talent: The Underparticipation of Women, Minorities, and Disabled Persons in Science* (1990), Jeannie Oakes deals with gender issues in the science classroom. She based her study on a review of major findings on the subject.

According to Oakes's study, young women primarily abandon the science track in high school after they choose not to pursue scientific careers, while blacks and Hispanics primarily leave because of low achievement in mathematics. As early as elementary school, young female students exhibit less positive attitudes toward science and science careers than male students, Oakes discovered. As students move into middle school, those with high interest or high scores in science take advanced classes. According to Oakes, the gap, therefore, widens and by high school young women pursue fewer math and science courses than males. Further, female students continuing in the science pipeline score lower on math and science achievement exams than male students. Once in college, persistence becomes the factor in successful graduation into a science career. This persistence seems to be related to SAT scores, high school grades, class rank, and grades earned in college.

Three critical factors emerged during her study: Opportunities to learn, achievement, and students' decision to pursue science. Young women, minorities, and children with disabilities were encouraged less than white males and had fewer science- and mathematics-related opportunities either in or outside of school. However, when encouragement and oppor-

tunities were provided, women, minorities, and children with disabilities seemed to respond (as well as white males) with interest and participation.

Oakes's study results suggest that young female students don't like math and science as much as male students of the same age, don't see the subjects as relevant to their futures, and don't feel confident in their own abilities to succeed in the subjects. Minorities and women may respond more positively to people than to abstract instruction, and therefore cooperative activities tend to contribute to higher achievement for young men and young women, including minority students.

In *Lost Talent: Women in the Sciences* (1996), Sandra L. Hanson provides further evidence of when and why young women drop out of the science and math pipelines. The decline of female students in science (she refers to both mathematics and science as "science") begins in high school and continues into college, according to Hanson. She focuses on four aspects of experience in math and science: achievement (e.g., grades and standardized test scores); access (e.g., course taking); attitudes; and activities (e.g., use of calculators, microscopes, and computers). Gender is an important factor in students opting out of science, Hanson concludes.

In many ways her findings are similar to Oakes's findings and much of the research she reviewed. Hanson found few differences in the attitudes of young female and male students toward science courses in the lower grades. However, she found that as early as the seventh grade young women begin to fall behind in science and score lower on standardized science exams before they show any significant differences in math.

By the time these young women reach tenth grade, their attitudes toward science become increasingly negative, and the women are more likely than young men to be more afraid of math. Women also score lower on standardized math tests and are less likely to take more math and science. By their senior year young women are less likely than young men to have a concentration in math or science, a trend Hanson found continues into the postsecondary years. As these young women are making these choices, though, they also get similar overall course grades as their male peers in math and science courses. Interestingly enough, Hanson's study found that when all subjects are included throughout their high school years, these same young women have higher overall grade point averages than their male counterparts.

Hanson drew interesting correlations for successful female science students. Young women who maintain high achievement, access, and attitudes have friends who are more likely to also be interested in school and good grades. Peer support, with an emphasis on learning, has a greater effect on females than males. Young women's strongest advantages are maternal involvement and their own positive attitudes. Young women who succeed in science tend to have mothers who have higher educational expectations and who keep track of their daughters' progress.

Closing the gender gap

From this research the following conclusions can be reached. Female students in secondary school may develop very low confidence in science, feel that the physical sciences aren't for them, and believe they will not do well in such courses. Nationally in the 1989–1990 high school senior class, 32% of the females and 26% of the male students said they were advised that they did not need the additional coursework in math and science and were advised against taking these subjects as seniors. Female seniors (35%) were also more likely than males (22%) to say that they did not take math or science because they disliked the subject matter (Bae and Smith 1997). Other research on postsecondary math courses shows that students' beliefs, especially self-confidence, were more of an influence on achievement for women than for men (Stage and Kloosterman 1995). Given that math courses serve as "gatekeepers" to the physical sciences and engineering professions, low self-view in that subject may effectively filter out many students.

To counter negative attitudes and personal disbeliefs among female students, educators need to promote positive self-efficacy in an inclusive, constructivist learning environment. Such an environment must provide lots of opportunities for laboratory discovery while carefully taking into account the different learning styles and approaches students may employ, making learning a positive and fun experience for all. The teacher acts as a facilitator in developing higher cognitive functions of the learners involved rather than as the dictator of the classroom. Unfortunately, the predominant experience of students is just the opposite. Often, recitation prevails and students are expected to sit silently with very little involvement, active learning, or cognitive development (Gallimore and Tharp 1990).

What are some effective ways of creating a strong sense of positive self-efficacy and a constructivist learning environment? Students are especially sensitive to peer pressure, and peers serve a major influence in promoting self-efficacy, both positive as well as negative, such as aggression. Compared with competitive and individual learning situations, working cooperatively with peers produces a much more positive experience in learning and increases positive self-esteem and a feeling of success (APA 1995).

Educators need to encourage students to concentrate on how the right answer was determined and not just on what the answer is. A decreased emphasis should be placed on social comparison, such as calling some kids smarter than others. This will de-emphasize individual weakness as well as provide more focused metacognitive activities, which can be beneficial to both low-achieving as well as high-achieving students (White and Frederiksen 1998).

Classroom teachers need to actively encourage female involvement and participation. Especially given the gender gap in math and science, educators must be more aggressive in including both sexes in class discussions. Because males are taught to be more vocal and outgoing, they may be called on more often than females (Altermatt, Jonanovic, and Perry 1998).

In a cooperative learning environment, students helping one another creates a more positive attitude. The students see others similar to themselves overcome difficulties successfully. Mastery experiences help create a strong sense of high self-efficacy, and students committed mistakes as stepping stones to furthering their mastery rather than failures (Ames and Archer 1988; Bandura 1994). Individualized instruction decreases social comparison and nurtures self-comparison, raising perceived self-capability. The opposite is also true. Learning is stifled in environments where individual competition takes precedence over learning as a community, dooming many students to failure (Bandura 1994; NYSED 1996).

Classroom environment therefore plays a primary role in cultivating self-efficacy. Sense of belonging, relevance of tasks, laboratory experiences, curiosity, humor, and fun all contribute to classroom interest. While recognizing individual differences in the development of the students involved, quality outcomes can be achieved when an environment of high expectations and effort is nurtured.

Teachers who themselves have a low sense of instructional efficacy tend to rely more on penalties and negative sanctions to control their classrooms and create a feeling of futility (Bandura 1994). Some of these not-so-rare teacher practices include rigid, overly structured lessons with little or no room for student inputs, excessive praise, and student groupings according to ability. These practices create an environment that lowers perceived efficacy for all but the few students at the top and stifles the development of higher cognitive and metacognitive skills.

A good start

To tackle gender discrepancies, educators must understand the underlying nature of sexist prejudice in our society and its implications in the classroom. With so much cultural pressure for young women to avoid science, educators must be more than nonsexist. One needs to actively encourage young women's participation and higher cognitive development through constructive inclusive learning environments while promoting positive self-efficacy. This encouragement must start at the earliest grades because female students' decision to major in science for their postsecondary education is influenced by their experience many years before.

We don't believe that the statistics for female science students and female scientists will change by merely creating a multicultural environment in schools. Unfortunately, the conditions of primary and secondary education in general are a cause of great alarm. The reported dropout rates for 1999 (based on the civilian non-institutionalized population) among 16- to 24-year-olds is 11.2% (Snyder and Hoffman 2001). In this article we mainly dealt with the issue of the gender gap in science; however, we would also like to underscore the fact that many students, especially poor and black youth (Kozol 1992; Ferguson 2001) and those with special needs (Alexakos 2001) face special obstacles, and they too need to be addressed and rectified. "Science for all" has not yet been achieved, but it is an exciting and rewarding goal. ■

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NSTA Connection

The NSTA Multicultural/Equity in Science Education Committee is currently revising the Women in Science Education position statement, which was adopted by the NSTA Board in 1985. The new statement—Gender Equity in Science Education—is expected out later this year. Watch *NSTA Reports!* for updates about this revised position statement.