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ABSTRACT

This paper reviews research concerning women's negative or ambivalent attitude toward science and how that attitude is often reinforced by teachers. It explores prescriptions for teachers, students, and parents in an attempt to remedy this classroom dilemma. Research concerning the reason why many women have negative or ambivalent attitudes toward science points to two main factors: parental and societal perceptions and teacher behavior and expectations. The way girls and boys are treated appears to be the primary cause for the existing gender gap in science and math. A variety of factors such as parental and teacher expectations, lack of experience with scientific observations and instruments, peer pressure to conform to traditional sex-role expectations in career choice, little or no contact with female role models, and unconscious teacher bias contributes to the failure of girls to excel in mathematics and science. Confidence was also found to be strongly related with continuation in math and science. Technology, mathematics, and science are still viewed as nontraditional arenas for girls and these perceptions are often reinforced by instructional techniques that put females at a disadvantage. On the basis of these findings, prescriptions are presented, with a view to ending gender differences in the perception of and ability to do science by women. Contains 27 references. (JRH)

"AND THEY IS US"
Gender Issues in the Instruction of Science

A study of existing research concerning women's negative or ambivalent attitude toward science and how that attitude is often reinforced by teachers. The article also explores prescriptions for teachers, students, and parents in an attempt to remedy this classroom dilemma.

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"AND THEY IS US"

Gender Issues in the Instruction of Science

There has been an extensive body of research concerning the reason why many women have a negative or ambivalent attitude toward science. This reason points to two main factors: parental and societal perceptions and teacher behavior and expectations. As Pogo used to say in the comic strip: "We've met the enemy, and they is us."

Since young children formulate their attitudes at an early age, elementary education is crucial in developing positive feelings toward science. "The teacher plays the central role in communicating the essence of science to children" (Estes, 1990). And, teachers who do not like science, will likely have students who do not like science (Shrigley, 1974).

Over 83% of elementary school teachers are women--women who have been conditioned by society and their teachers to dislike science or to feel they cannot do science. It is not surprising, then, that the majority of these same teachers spend less than two hours a week instructing science (Manning, et al, 1981).

Considering that most teacher teach the way they were taught, a rather frightening circle of instruction and attitudes seems to be self-perpetuating. It is imperative that educators become aware of gender bias factors, especially in elementary and middle schools, if our cycle of poor science achievers is to be broken.

Unfortunately, gender differences in science achievement are not decreasing and may, in fact, be increasing. The average science proficiency for nine-year-old boys and girls is approximately the same; however, a performance gap favoring boys becomes evident at the crucial age of thirteen and increases by age seventeen (Blake, 1993). Gender differences in achievement between nine- and thirteen-year-olds increased from 1978 to 1986. Gender differences are largest for seventeen-year-olds, and these differences have not changed since 1978 (AAUW Education Foundation, 1992). These data reflect the fact that differences in science achievement seem to begin at the elementary level.

Reasons for this difference point to the way girls and boys are treated as the primary cause for the existing gender gap in science and math. A variety of factors such as parental and teacher expectations, lack of experience with scientific observations and instruments, peer pressure to conform to traditional sex-role expectations in career choice, little or no contact with female role models, and unconscious teacher bias contributes to the failure of girls to pursue mathematics and science.

Most psychologists and sociologists believe the differences have stemmed from what girls are taught, directly and indirectly, and the social expectations of females. Despite the fact that developmental psychologists report few differences in the behavior of infant girls and boys, parents soon begin to interact with them differently. As children grow, mothers talk more to female toddlers and encourage them to stay near them while they play. Boys, on the other hand, are allowed to explore and wander farther away from their mother (Dembo, 1991).

In her book, The Cinderella Complex, which deals with the socialization of women, C. Dowling points out that "girls. .. are trained into dependency, while boys are trained out of it" (Dowling, 1981). For example, when a little boy falls, he is told to get up and try it again, whereas a little girl is picked up and cuddled. Girls, it seems, are not receiving the same encouragement as boys for independence. Girls also "learn" that they are to be passive in their behavior. Disagreements are to be resolved peacefully, whereas more aggressive behavior in boys is more socially acceptable, just because they are boys.

These early traits are traditionally reinforced and extended, first by parents, then by teachers. For example, the toys offered to boys have emphasized competition, achievement, and problem solving, while those for girls have encouraged care-taking skills, community consciousness, and supportive behavior.

In the nursery and primary school classroom, boys and girls choose different kinds of activities and tasks at times when their choice is free. Boys played with bricks, trucks, and climbing apparatus, and girls primarily played at housekeeping tasks (Measor & Sikes,

1992). The suggestion is that early experience of playing with these types of toys can facilitate in boys the development of mathematical and certain mechanical and spatial skills which are important elements in the later development of scientific skills (Measor & Sikes, 1992).

By contrast, girls spent most of their time on activities which facilitated reading skills. This choice is reinforced by a general expectation among parents and teachers that, when they are young, girls will more naturally like and choose book and picture-based activities than boys. Therefore, girls are given books and encouraged to spend time on these activities (Lee, 1980).

Because girls have significantly less experience in manipulating objects than boys of comparable ages, girls are apt to feel more apprehensive than boys about using equipment and instruments in a science environment. As a result, often, in a laboratory situation, the male works with the equipment while the female writes down the observations (Rosser, 1990). The female's clerical skills are improved, but she has gained no experience or confidence in the manipulation of science equipment.

As they grow, girls and boys continue to have different science experiences. Girls, for example, are more apt to be exposed to biology related activities and less apt to engage in mechanical and electrical activities (AAUW Education Foundation, 1992). By the third grade, 51 percent of boys and 37 percent of girls had used microscopes, while by the eleventh grade, 49 percent of males and only 17 percent of females had used an electric meter (AAUW Education Foundation, 1992).

Similar differences in experiences have been reported for family visits to science centers and for enrollment in out-of-school science centers (Sex Equity in Educational Opportunity, 1991). The author has observed similar occurrences at the St. Louis Science Center, where boys are five times more likely to utilize exhibits containing simple machines than girls.

This lack of early hands-on experience may contribute to a physiological learning factor. It seems that the socialization of young girls may interfere with the initial development of brain patterns that enhance math and science learning. Studies have shown that an enriched environment produces distinct physiological changes within the brain that enhance learning. Thus, if the brain receives repeated stimulation, it develops strengthened neurological pathways enabling faster and more complex processing of information. At the same time, chemical changes within the brain further increase the capacity to process complex information. The more a brain pathway is used, the faster and more permanently the synaptic activity occurs. For girls, who are not commonly exposed to manipulating objects as play and in the classroom, these neurological pathways may take longer to develop than they would in boys (Hanson, 1992).

Equally important from a physiological viewpoint is the limbic system in the brain, which acts as the emotional center. Emotions have a biochemical effect on the learning process and can either inhibit or enhance memory and learning. Depending on the affective feelings of the individual as influenced by the environment, this center can release chemical neurotransmitters that affect actual learning. When a person experiences pleasure or joy, the limbic system releases neurotransmitters that increase the speed of learning. Stress, however, actuates a different set of neurotransmitters and shuts down the brain's ability to retrieve or process information (Hensel, 1989). Because of their socialization and lack of experience in manipulating objects, many girls do not feel comfortable in the science classroom, thereby inhibiting, physiologically, their ability to excel.

Confidence is also strongly correlated with continuation in math and science. Girls, feeling less confident in their abilities in these areas, self-select out. The issue of self-selection, making choices to opt out of activities that put girls into settings where they can develop an understanding and appreciation for math and science, may well be in place by the time girls reach elementary school. For students, there are two key decision making times: 8th grade, when they decide to take algebra, and 10th grade, when girls are more

likely than boys to stop taking math (Dossey, et al, 1988). These two times are crucial for girls, because the amount of math students take acts as a filter limiting a science career. A four year high school math sequence is necessary for college majors in science and technology. Without three or more years of sequential mathematics in high school, an entering college freshman effectively is locked out of 75 percent of the college majors possible (AAUW Education Foundation, 1992).

Although diminishing, the strong social message still remains that technology, mathematics, and science are nontraditional arenas for girls. Both boys and girls define math and science as "male" as early as the second grade, and both male and female students in a 1991 Michigan State Board of Education study agreed that math, science, and gym favored males (Hanson, 1992). Their explanations for this were traditionally gender stereotyped: girls only need math for grocery shopping; girls avoid computers because they "don't want a brainy image;" and "girls can't get into science the ways boys do because it just doesn't have anything to do with their future or careers" (Hanson, 1992).

These perceptions are often reinforced by instructional techniques in the science classroom which put females at a disadvantage. Girls approach problem solving from the perspective of interdependence and relationship rather than from the isolated skill analysis viewpoint favored by boys (Blake, 1993). In the teaching of science, most instructors underline the importance of objectivity rather than involvement of the scientists in approaching the subject of a study. This approach can be detrimental to girls.

While instructional methods in math and science classrooms may alienate female students, the interactions between teachers and students may inadvertently convey the message that girls are not as important as boys and discourage female participation. In elementary and secondary schools boys are five times more likely to receive attention from teachers and eight times more likely to call out in class (AAUW Education Foundation, 1992). Teachers, also, tend to accept call-outs from males, but remediate the behavior of girls and advise them to raise their hands when they call out answers (Dembo, 1991).

Teachers call on males more than females; ask males more complex, cognitively demanding questions; and give males positive feedback more frequently (Sex Equity in Educational Opportunity, 1991). In subject areas like math and science, where inquiry and questioning are important conditions for success, lower rates of interaction between the teacher and female students during instruction place females at a disadvantage.

Studies of male and female classroom teachers show them encouraging and rewarding mathematics and science endeavors in males more than females, even though both students are of equal ability (Church, 1989). These lower expectations for girls in math and science manifest themselves in the way teachers interact with their students, sending subtle cues that boys are more able than girls. If a girl has trouble answering a question, a teacher is likely to answer it for her or ask a different student. Teachers tend to encourage boys to solve problems on their own (Rothman, 1991). Teachers, also, instruct males in performing a task, but they often do the task for female students (Blake, 1993). (The author has observed this in the elementary, secondary and college science laboratory. If a female has a problem with an experiment, the instructor will show her how to do it. When a male has a problem, the instructor usually gives a hint and leaves.) Research further indicates teachers use shorter wait-time when asking girls questions, reward girls for non-academic achievement such as neat penmanship or getting along with others, and address males by name more than females (Sadker, 1985).

Teachers are normally unaware of this pattern of bias despite the fact their interactions with students reinforce the message that females are inferior (Hanson, 1992). As a result it comes as no surprise that girls suffer a significantly greater decline in self-esteem and confidence in science and math, as compared to boys, during adolescence (Fenneman & Sherman, 1977). Neither is it hard to understand why girls live "down" to their teachers' lower expectations for them in math and science.

A combination of student-teacher interaction and course materials make the majority of female students passive and dependent but provides male students with learning

experiences that help them become self-assured, competitive and independent. Schools have become a "sexist amplifier" because of many conscious and unconscious decisions made by teachers in areas such as selections of learning materials, subject content, divisions of tasks in class, and different interaction with males and females (Marland, 1983; Dembo, 1991). For example, although females mature earlier and are ready for math, as well as verbal skills, at a younger age, the school curriculum and the process by which knowledge is transmitted has been constructed to mirror the development of males (Shakeshaft, 1986). As such, decisions about the grade in which children should learn specific math or science skills are based on he developmental patterns of boys, not girls.

Scope and sequence of curriculum are traditionally set by textbook companies. These texts, in the elementary school, also over-represented males, and when girls did appear, their roles were strikingly different from boys. Girls were less likely to be involved in identifying or solving problems, to be skillful and competitive, and to offer to show someone else how to solve problems (Measor & Sikes, 1992).

Meaningful contributions by women to science are also seldom cited or referenced (Rosser, 1990). This failure to integrate female experiences in science is seldom questioned and drives home the message that girls and their experiences are "other" or inferior and that they are not part of the general history (Shakeshaft, 1986). While all children need to learn about he contributions of females in math and science, it is especially important that girls are able to identify and "connect" with female contributions and positive role models.

These findings point the way to prescriptions that will aid in ending gender differences in the perception of and ability to do science by women. These interventions will be of benefit for both boys and girls.

First, parent and teacher encouragement is vital in girls making decisions in taking math and science. Girls who continue in science and math are bucking societal expectations and peer pressure. They need support in their endeavor.

Teacher preparation and inservice is required to make instructors aware of their unintentional biases toward girls. This training would focus on classroom management techniques (allow wait-time for girls, alternate calling on boys and girls, etc.) and on techniques to encourage girls in science and math which feature hands-on activities. The teachers, most of whom are women, will teach science by doing science.

It is vital that girls are presented with female role models successfully involved with science. Unless significant changes occur soon in the sex-segregated work force, the teacher will be the primary example of women doing science. And, the role model will not be lost on all children, boys and girls alike.

Intervention programs for girls in science and math must begin at the elementary level and be expanded during the middle school level. These programs should have participatory classroom styles which feature hands-on and discussion learning. These teaching styles are a key to keeping girls interested in science and are viewed as "being fun" by the participants.

Science programs that affect omen and girls should be fun and not considered "like school," be much less concerned with increasing cognitive knowledge than with helping girls do things, be relaxed with little or no emphasis on individual competition, provide opportunities for girls to speak informally with role models, and provide plenty of time for questioning and individual help (Rosser, 1990).

These programs should also utilize gender sensitive textbooks and supplementary material. The texts should highlight female contributions in science and emphasize the applicability of science and math to everyday life.

Often, these programs take the form of interventions outside the school arena. One-day workshops, or annual summer programs, just for girls, have increased girls' interest in science, decreased the participants stereotypes about people who were good in science, reduced feelings of isolation, and strengthened their commitment to careers in science (Campbell, 1990).

Interventions as described above work. There is no science or math gene that women lack which doom them to inadequacy in certain fields. We need to break this discriminatory cycle. Our future depends on it. There is a great need for scientists and engineers. "Women make up half of our population, but they make up less than 10 percent of our scientists and engineers. . . . We have a great reservoir of talent that we are not tapping (Church, 1989). It seems that the only thing that is stopping us is "the enemy, and they is us."

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