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CHAPTER 11

BREAKING THE "MOLD"—STS ALLOWS CELEBRATING INDIVIDUAL DIFFERENCES

Janice Koch
Susan M. Blunck

A MAJOR PROBLEM FOR SCHOOLS

How do we incorporate what we know about the development of male and female learners to move toward more productive and inclusionary science practices and pedagogy? Today schools are striving more than ever to create educational programs that are nonsexist and multicultural in their orientation (Oakes, 1990). The concern is for building science programs that will more effectively meet the needs of all students (NSTA, 1990). The focus of this chapter is on gender issues and the effects of problem-centered teaching practices, especially STS techniques for encouraging the participation of girls and young women in science. The challenge for science educators is to examine current teaching practices in light of the research on gender and education.

THE "FIX 'EM" MENTALITY

The underachievement of girls in science has been met with cries of "What's wrong with the girls?" However, when half the population of students are turned off by science, we need to ask, "What's wrong with the science education?" Science educators have been quick to embrace stereotypic notions of the successful science student. Students who have different needs, experiences, and beliefs are often dismissed in traditional science classrooms as being not good enough (AAUW, 1992). In many situations, blame and shame are cast on the students if they do not succeed in science or choose not to participate

(Kelly, 1987). As a result, many students move away from science and achieve success in other areas.

Breaking away from this stereotypic thinking is perhaps one of the most important challenges science educators face today. It is often our beliefs and attitudes from the past that get in the way of change (Fullan, 1990; Sarason, 1990; Magolda, 1992). Many female as well as male students have been thought of as being so different from the stereotypical science student in the traditional science classroom that their potentials in science have been overlooked. The goal for many science teachers has become to "fix" the students who are different so that they fit the mold. As Sheila Tobias (1991) expresses it, science educators are looking in the "out groups" for "in-group" types. The belief that only certain types of students tend to achieve in science limits the potential for broadening participation in science, while reinforcing notions that science educators seek to produce duplicates of themselves.

Research is beginning to emerge that suggests that the molds be broken and cast aside; that the role of the teacher be examined closely. Differences among students in the science classroom should be celebrated and nurtured. Teachers must come to see themselves as guides on the side rather than sages on stages. The ultimate goal is to empower both the students and teachers through the development of their natural abilities.

We must help students develop all their thinking skills by providing experiences that challenge their current views and take them from the previous self into the developing self (Magolda, 1992; Belenky, 1986; Blunck, Giles, and McArthur, 1993; Kelly, 1987; Koch, 1993; Rosser, 1990; Wilbur, 1991). Traditional science teaching practices fall short in terms of meeting the needs of all students. In a 1992 report titled *How Schools Shortchange Girls*, published by the American Association for University Women, researchers point out many ways that girls are shortchanged in science and mathematics education (AAUW, 1992). The teaching practices that limit girls' participation in classroom science include: calling on boys more frequently, allowing girls to opt out of complex hands-on experiences, encouraging boys to solve problems on their own while "doing it" for the girls, using the male pronoun "he" to represent all scientists. These will be further addressed later.

Equity in science education implies fairness in the distribution of services, equal access to programs/courses, and the inclusion of nondiscriminatory teaching practices in science. Segregation in our schools on the basis of gender has become a legal as well as moral issue since the advent of Title IX in 1972. Even though efforts spearheaded through Title IX have tried to provide for equal access to science courses and extracurricular activities related to science, research shows students are still treated differently on a number of student attributes including gender (AAUW, 1991, 1992; Good and Brophy, 1987).

Most attempts to deal with gender effects have failed because they have focused on the "problem" population and do not deal with the dynamic complexities of learning that occur within the context of the classroom (Magolda, 1992). The remedies have often taken the form of pull-out curricula, or fragmented curricula, which involved add-on components that failed to blend with other dimensions of the curricula or address personal needs of the students (Wilbur, 1991). This lack of integration and coordination often portrays the experiences as corrective rather than nurturing. Again the notion of fixing the student to "fit the mold," stands out as the most common remedy. Many successful intervention programs on behalf of girls and science have not been mainstreamed into dominant curricula when funding runs out (Tobias, 1992).

A great deal of research has focused on "fixing" students. A number of studies point out how male and female learners differ. The majority of research and discussion on gender issues has been concerned with characterizing the learner and defining the problem. Researchers have examined psychological and developmental differences (Kelly, 1987). Kahle and Lakes (1983) found that a number of factors, including societal and parental pressures, affect student attitude toward science. It has been known for some time that female students have been shown to exhibit less positive attitudes toward science than their male counterparts (Skolnick, Langbort, and Day, 1982). Males tend to be more confident in the area of science (Kelly, 1987), and females do not perform as well as males when it comes to science (Kahle, 1983). Females between the ages of nine and fourteen lose interest in science (Hardin and Dede, 1978; National Assessment of Education Progress, 1978, 1988). What does this type of research really tell us? Certainly, this type of research fails to examine the complexities of learning that are both individual and interactive. It helps us identify differences but leaves us wondering how best to deal with these differences in the science classroom.

Celebrating Diversity—Creating a New Paradigm

Research is beginning to emerge that holds promise for a brighter future for both male and female learners with respect to science education. New models for science teaching and new curriculum design are being implemented that are based on the needs, experiences, and beliefs of the learner. The majority of these problem-solving approaches embrace the tenets of Constructivism. Central to the constructivist approach is the idea that knowledge is not passively received but actively constructed by the learner. Cognition is viewed as being adaptive; allowing for personalized organization of the material world (von Glasersfeld, 1988; Yager, 1991).

Individual student differences become the cornerstone for instruction. Students are invited to engage in active collaborative interactions with peers and their teachers nurturing a mutual responsibility for learning. Our goals for the nineties and beyond should not be centered on replacing a womanless curriculum with a manless curriculum, but rather to transform the curriculum to include everyone (NSTA, 1990). Connecting students to their science experiences should be the goal. Students should be given the opportunity to question the relationships between science and technology in a social context allowing students to assess the benefits for the environment and other human beings critically. Rosser states that adopting this perspective may be the most important change that can be made for all people, both male and female (Rosser, 1990).

Freedom of expression is encouraged and contradictory points of view are valued. This type of approach requires that teachers see themselves as "constructed knowers" and increase in their abilities to be "fluid and flexible" in teaching practice rather than relying on standard teaching formulae (Magolda, 1992; Belenky et al., 1986).

Marcia Magolda (1992) reports on an extensive, qualitative, longitudinal study of students' learning at the college level. This research is different from other pioneering work in that both males and females are part of the sample. The study traces the cognitive growth of the students through an extensive interview and coding system. Conclusions from this study suggest that learning patterns are related to but not dictated by gender. Some patterns may be used more frequently by one gender, but both genders combine approaches at different stages of their development. Patterns for both genders are equally complex and must be equally valued to create the climate where lasting learning can occur. Magolda's work moves us closer to reducing the stereotypic notions about the ways women and men learn.

Early childhood experiences traditionally provide boys with greater opportunities to build and construct models. Koch's erector set theory (1993) maintains that girls are at a disadvantage in science because they have not had equal opportunities to build models with blocks and erector sets and knock them down and build them up again. This form of early risk-taking behavior allows boys to be more comfortable with possibilities of failure in science activities, understanding that they can try again, if at first their model, activity, investigation, experiment does not work.

Other research on curriculum transformation provides a vision for bringing male and female students together as a community of learners. Emily Style (1988) uses the metaphor of windows and mirrors to support the belief that curriculum needs to provide mirrors for students in order for them to see themselves reflected in the course of study as well as providing windows into new knowledge. In most traditional science classrooms, girls do not see their experiences or the experience of women in science mirrored to them. Establishing

these personal connections is an essential element in creating quality science experiences. The idea of connections is perhaps one of the most important characteristics of an inclusionary approach (Belenky et al., 1986; Koch, 1992; Style, 1988; Wilbur, 1991). In a recent study of science-avoidant college women, there was an overwhelming belief that "science did not have anything to do with the real world or with my life." This was considered the major influence in turning college women away from science and science-related fields (Koch, 1993). Connections between science and human beings are a very important concern. These connections could serve as the link to attract more women, people of color, and males not now attracted to science as it is taught in the traditional manner (Rosser, 1990). These connections provide students with the opportunity to see themselves reflected in the day-to-day experiences in the classroom. The "connected curriculum" should serve to connect students to:

1. themselves—by providing an environment that builds positive feelings toward science-related personal attributes;
2. science—by encouraging the development of a personal interests stemming from *student* questions and experiences;
3. each other—by helping students establish relationships based on the appreciation of people's talents and strengths;
4. the teacher—by creating a relationship built on personal support and mutual respect; and
5. the real world—by encouraging students to question their surroundings and get involved outside the classroom.

The goal in developing inclusionary practices should be to normalize the effect on the differences between male and female learners. Many gender issues that arise in traditional science classrooms result from exclusionary pedagogical techniques (Belenky et al., 1986; Rosser, 1990; Wilbur, 1991). Wilbur identifies six attributes of a "gender fair" approach to science teaching. A gender-fair approach:

1. should acknowledge and affirm variation;
2. should be inclusive, viewing differences within and among groups of people in a positive light. Students should see themselves reflected in the approach and identify positively with the personal messages they uncover;
3. should be accurate, helping students uncover information and ideas that are valuable and capable of withstanding critical analysis;
4. should be affirmative, emphasizing the value of individuals and groups;
5. should be representative, allowing students to uncover multiple perspectives on all sorts of issues; and
6. should be integrated, weaving together the interests, needs, and experiences of both male and female students.

When these elements are in place, national assessments have shown that student attitudes become more positive for middle and high school students especially female students (NAEP, 1978, 1988).

STS Instruction and Female Attitudes Toward Science Class

Not until recently has evidence started to emerge on the differential effects of inclusionary approaches. How are students affected by these practices? The Iowa Chautauqua Program, an inservice program for science teachers of kindergarten through twelfth grade, has been looking at just this question. The Chautauqua teachers use the STS approach in their classrooms. The Iowa definition of STS has considered and incorporated the inclusive characteristics presented in this discussion.

Before STS instruction, females exhibited more negative attitudes toward science. Some interesting changes in student attitude have been discovered. These attitude shifts reflect more positive perceptions about science in general and specific teacher characteristics. But most important, the gap between female and male learners has narrowed.

Blunck and Ajam (1991) looked at gender-related differences in students' attitudes toward science, science classes, and science teachers. The experimental design involved using pretest-posttest measure of treatment and control groups. Using data collected by twenty Iowa Chautauqua teachers, the researchers found that female students enjoyed their science classes more than males when STS practices were used. After their STS experiences, the attitudes of females shifted significantly. Female students also exhibited more positive attitudes toward their science teacher.

Perhaps the most exciting finding from this study is that STS instruction seems to be narrowing the gap that usually exists between female and male learners. Figures 11.1 and 11.2 reveal changes in student attitude related to students' perceptions of science and their science teacher.

Mackinnu (1991) has investigated the differential gender effects of STS instruction compared to a textbook approach. Over 700 students and teachers were involved in this study. Comparison of the t-tests on pretest and posttest scores showed a decrease in the number of classes with significant differences between male and female learners. "This means that STS instruction does minimize the gap between the female and male attitudes toward science for the teachers involved in this study" (Mackinnu, 1991, p. 118).

These studies represent a beginning in terms of research on inclusive constructs in science teaching. Much more research on gender effects is needed. It is imperative that science educators be collecting a wide variety of evidence

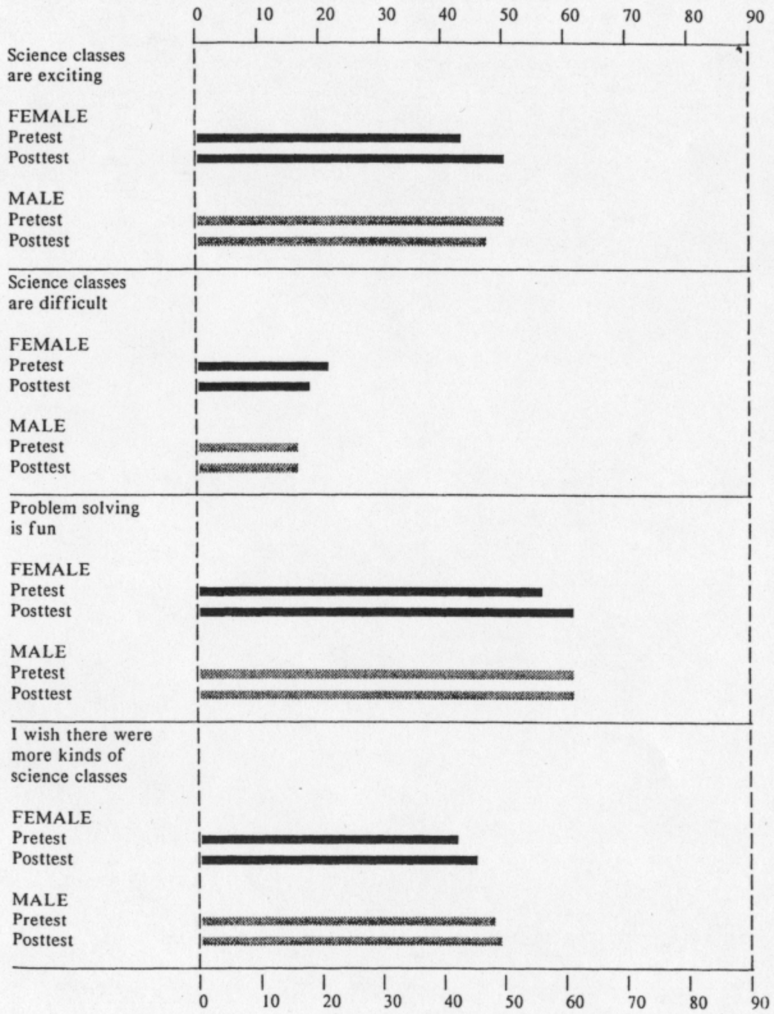

FIGURE 11.1 Students' Views of Science: Areas Where STS has Shown a Normalizing Effect Favoring Females

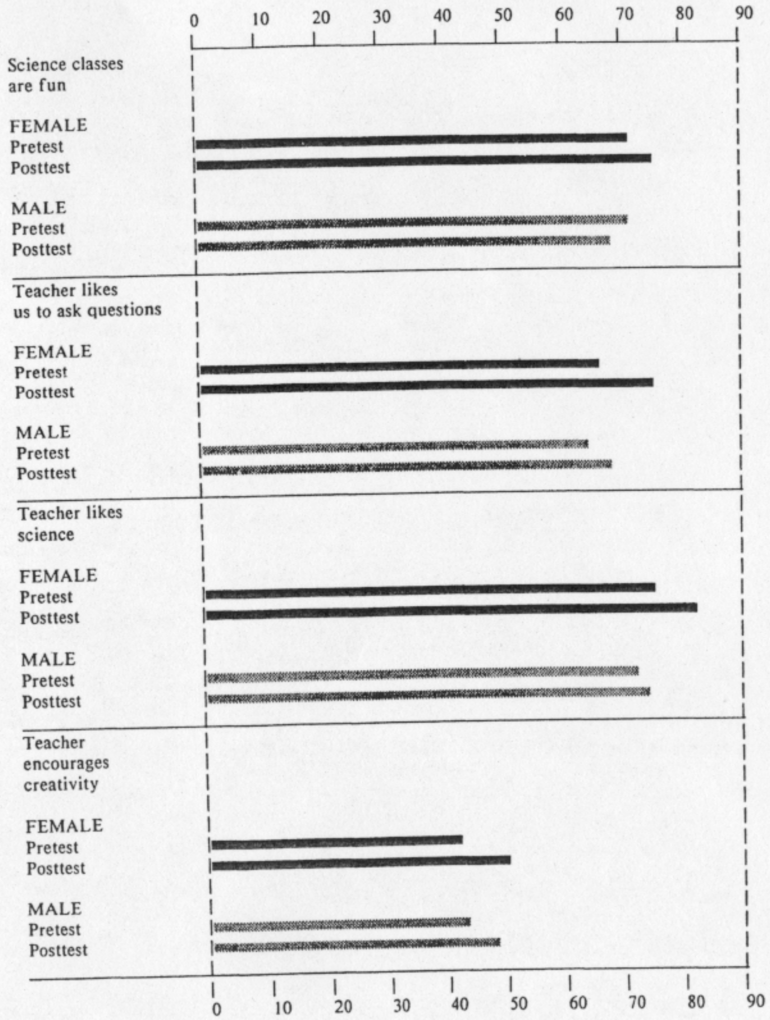

FIGURE 11.2 Students' Views of Science: Areas Where STS has Shown a Differential Effect Favoring Females

that will show the ways in which female and male learners are changing as a result of their involvement in an inclusionary learning environment. How can these environments be best described and established?

Creating Girl-Friendly Science Classes

Strategies of encouragement and inclusion can be developed by teachers at all levels with STS approaches. Koch (1992) identifies specific techniques for creating "girl-friendly" science classrooms:

1. Demonstrating the connections between science and technology and their lived experience is extremely enhancing for girls. These connections are part of the fabric of STS education and offer teachers a wonderful possibility for changing the way girls have traditionally viewed science.
2. Cooperative learning techniques have been very successful in encouraging the participation of girls in science and technology (Mastny, 1992). When cooperative learning groups are structured and planned to include a heterogeneous group with respect to race, gender, ethnicity, and ability, all students more readily contribute their talents to the problem with which the class is engaged.
3. Teachers need to listen to the small, soft voices of girls, in the face of frequently more vocal, aggressive, male voices, especially in the upper grades. Students who do not feel entitled to doing and knowing science and technology frequently pull inward and do not express themselves in class. All students need to be actively engaged in classroom conversations and all students need to hear scientists referred to from both genders. At every school level, cultural norms inhibit the identification of girls with science.
4. Frequently science teachers *do* the lab or project for the female students who ask for assistance, while encouraging the boys to figure it out on their own. Far from helping these girls, the message that is communicated is that "you are not able."
5. Science is seen as a male province where assumed female squeamishness and lack of mechanical aptitude has no place. These assumptions are an example of cultural stereotyping that prevents girls from fulfilling their potential in science and technology. Despite these girlhood stereotypes, which do not allow for girls to "get messy," it is most often the women they become who do the real "messing about" as they maintain the fabric of daily life. Teachers would be well advised to bring this gender agenda to the formal curriculum and enable girls to relate to the ways in which women traditionally "get messy."
6. People who have traditionally felt excluded from science and technology have not been socialized to believe that they can succeed in these fields.

They need to meet people in science and technology who can serve as role models and mentors. Local professional organizations are willing to provide visitors for schools and classrooms. Science educators need to make their classrooms more inviting and inclusive to compensate for the lack of role models and cultural encouragement.

Teachers often unwittingly create classroom inequities. Fortunately, gender equity workshops for science educators have enabled teachers to identify their own patterns of bias in the classroom and correct them. Teachers are often surprised that their own behaviors have not been in the best interests of all their students. Once they have learned to code their interactions with students in terms of equitable treatment and expectations, they are able to change their teaching style significantly (Griffin, 1991).

Conclusions

Attempts to reform school science programs are currently focused on making science more meaningful for all (NSTA, 1990). It is extremely important that science teachers develop a sensitivity and understanding of the needs of both the female and male learner. The development of inclusionary practices must address gender issues from a new perspective. The challenge comes in trying to move away from creating interventions to "fix" science students to accommodate traditional science programs. The focus rather should be on fixing the science programs. Students must be provided the opportunity to make a genuine contribution in their science experiences—questioning, testing, and analyzing the natural world in the context of human experience. The National Coalition of Girls' Schools Symposium on Math and Science for Girls in 1991 asserted that nurturing a sense of connectedness with the natural world and valuing the ability to question is necessary for equity to exist in science and mathematics education. Because we are all part of what we are trying to change, there needs to be a conscious and deliberate effort to transform traditional science curriculum and change teaching styles and classroom culture to include us all.

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CHAPTER 12

ADVANTAGES OF STS FOR MINORITY STUDENTS

Joan Braunagel McShane
Robert E. Yager

DIFFERENCES BETWEEN MINORITY AND MAJORITY STUDENTS

In the United States, blacks, Hispanics, and Native Americans make up approximately 18 percent of the population, but comprise only 2.2 percent of the science and engineering work force (Malcolm, 1985). According to NSF (1984) estimates, females earn 12.2 percent of the doctoral degrees, 24.8 percent of the master's degrees, and 15.3 percent of the bachelor's degrees in science when employment in the labor force was studied. An NSF report (1980) suggests that males without graduate degrees find careers in science more easily than females with either a master's or a doctorate.

Racial minorities and females have been consistently underrepresented in mathematics and science majors and careers for at least the last five decades (Hill, Pettus, and Hedin, 1990). This fact has led to a growing national concern for increasing the participation of minorities and females in science and technology careers (NSF, 1984).

Researchers concerned with cultural diversity and multicultural education maintain that certain people of color differ in their worldviews and cognitive styles from those held by the dominant culture (Anderson, 1988; Banks and Banks, 1989; Banks and Lynch, 1986; Burgess, 1986; Gollnick and Chinn, 1990; Hale, 1986; Kagan and Madsen, 1971; Ramirez, 1978; Sleeter and Grant, 1988). These researchers compare the philosophical worldview of certain minority groups with their nonminority counterparts in a variety of dimensions. Table 12.1 provides a summary of this research.