Reis, Sally M. and Gavin, M. Katherine. *Why Jane Doesn't Think She Can Do Math: How Teachers Can Encourage Talented Girls in Mathematics*. Developing Mathematically Promising Students (April 1999): 133-48.

Chapter 11

WHY JANE DOESN'T THINK SHE CAN DO MATH: HOW TEACHERS CAN ENCOURAGE TALENTED GIRLS IN MATHEMATICS

Sally M. Reis
M. Katherine Gavin

Eva loved science and mathematics as a child and her parents were delighted by her excitement and aptitude. When she was four, she asked her mother how long it was until her birthday and her mother replied, "Two months." She immediately asked, "How much is eight times seven?" Her mother answered, "Fifty-six. Why do you want to know?" Eva replied, "I want to know how many days until my birthday." Eva's favorite activities included taking apart radios, clocks, and old appliances and then trying to put them back together. She loved to build with many different kinds of materials—everything from blocks and Lego toys to materials she found in the kitchen, such as marshmallows, uncooked pasta, and cans and boxes of food. She also loved computer work, especially mathematics programs, and routinely requested these types of gifts while most of her friends were asking for Barbie dolls.

Unfortunately, Eva's interests and talents in mathematics began to fade in elementary school. By the third grade, she had stopped wanting to do mathematics at home and repeatedly told her parents that "school" mathematics was boring. Because of her attitude and her lack of interest in doing mathematics homework at home, she had fallen behind in memorizing her multiplication tables and was not even considered mathematically talented by her third-grade teacher. It is doubtful that she will either be interested in, or qualify for, the prealgebra class when she reaches middle school in two years. How could such a promising child lose her motivation to learn and achieve in mathematics? And—just as important—what can educators do to restore that motivation or, better yet, to avoid the loss of motivation in the first place?

Eva isn't alone. Gifted young females may not receive necessary encouragement to achieve in mathematics. An American Association of University Women report (Wellesley College Center for Research on Women 1992) concluded that "all differences in math performance between girls and boys at ages eleven and fifteen

could be accounted for by differences among those scoring in the top 10 to 20 percent" (p. 25). This means that many of our brightest female mathematics students are not keeping up with their male counterparts. It is clear from this and other research studies discussed in this chapter that many mathematically talented females perform at levels that are not commensurate with their abilities (Reis 1987; Reis and Callahan 1989). This unfortunate situation can be improved: teachers and parents can help talented girls succeed in mathematics.

STEREOTYPING ABOUT FEMALES AND MATHEMATICS

Before we can alleviate the problems experienced by girls like Eva, it is important to try to understand the factors underlying those problems. One of the main reasons that girls do not succeed in mathematics is not any lack of ability or effort—it is simply that they are not expected to. Stereotypes influence perceptions and performance in school and in life, and they are often cited as contributing heavily to girls' shortcomings in school. A great deal of stereotyping and prejudice affects girls in mathematics classes. Unfortunately, mathematics is often thought of as a field for men, and our society's traditional images of scientists, engineers, and mathematicians are almost always male. Most university mathematics professors are male, and evidence exists that girls are regarded as less capable in mathematics by some of their teachers and parents.

As early as 1973, Good and Brophy learned that when teachers treated boys and girls differently in class, these differences were the most pronounced for gifted females. In a more recent study by Cooley, Chauvin, and Karnes (1984), similar findings emerged. Both male and female teachers regarded gifted boys as more competent than gifted girls in critical- and logical-thinking skills and in creative problem-solving abilities, whereas they believed gifted girls were more competent in creative writing. Fennema (1990), in her analysis of the role of teacher beliefs on mathematics performance, reported in a study she conducted with Peterson, Carpenter, and Lubinski that "teachers selected ability as the cause of their most capable males' success 58 percent of the time, and the cause of their best females' success only 33 percent of the time. Most capable females' successes were due to effort 37 percent of the time, whereas best males' successes were due to effort only 12 percent of the time" (p. 178). They also concluded that even though teachers did not tend to engage in sex-role stereotyping in general, they did stereotype their best students in the area of mathematics—attributing to males characteristics such as volunteering answers, enjoyment of mathematics, and independence.

CURRENT RESEARCH ABOUT GENDER DIFFERENCES IN MATHEMATICS TESTS

One source of stereotypes about females' ability in mathematics is probably the fact that they often perform poorly compared to males on standardized mathematics

tests. This performance reinforces beliefs that males are superior in mathematics and gives females lower self-esteem and less confidence in their abilities. Evidence exists that current differences in standardized tests favor males at the highest levels. For example, Halpern (1989) pointed out that "large and consistent differences favoring male students are still found among the upper levels of mathematics aptitude on the PSAT and the SAT" (p. 1156). In 1996, the population of girls taking the SAT averaged 46 points lower than boys on the mathematics section. The number of top-scoring males on the quantitative section of the SAT far exceeded the number of top-scoring females. Eight percent of males (39 369) but only 3 percent of females (19 005) scored 700 or greater (Educational Testing Service 1996). When one examines the numbers of males and females scoring 750 or higher, sex differences are even more pronounced. Girls also score lower on the PSAT/NMSQT, which is used by the National Merit Scholarship Corporation for awarding scholarships to promising college students (Rosser 1989).

Only a few researchers have investigated why these differences occur, but time constraints may have some effect. For example, Dreyden and Gallagher (1989) tested the effects of changing time limits and directions on the performance of academically talented males and females on the SAT. Students took either the SAT-Mathematics subtest or the SAT-Verbal subtest under timed or untimed conditions. Female students' scores on the SAT-M dramatically increased when the test was untimed, suggesting that the difference in the scores of males and females on the SAT-M "may be due more to speed of performance than to ability" (p. 196).

Potentially damaging implications directly relate to the different scores obtained by boys and girls on these tests. Not only do lower scores on the traditional college admissions exams have potential for denying opportunity for scholarships and admission to selective colleges, they may also deny access to certain programs for gifted and talented students—particularly at the secondary level. (In some states, for example, PSAT scores are used as part of the selection process for attendance in Governor's School programs. In Washington, D.C., students who earn high scores on the SAT-Q have the opportunity to attend college courses in mathematics during the summer.) Lower scores may also have an impact on girls' selection of careers.

CLASSROOM CONDITIONS TO ENCOURAGE GIRLS

What type of classroom environment avoids and helps nullify these harmful stereotypes and discrepancies? Eccles (1987) draws several conclusions from the existing literature on mathematics and science teachers who have been successful in reversing stereotypes and keeping females interested in mathematics and science. She notes a pattern of conditions in these classrooms, including:

- Frequent use of cooperative learning opportunities
- Frequent individualized learning opportunities
- Use of practical problems in assignments
- Frequent use of hands-on opportunities

- Active career and educational guidance
- Infrequent use of competitive motivational strategies
- Frequent activities oriented toward broadening views of mathematics and physical sciences
- The presenting of mathematics as a tool in solving problems
- Frequent use of strategies to ensure full class participation

Furthermore, Eccles (1987) suggests an examination of other stereotyped aspects of our society that seem to influence the differential achievement of males and females, supporting the need to find ways to counteract the effects. For example, research has been conducted on strong stereotypes existing in our society about the possession of "natural talent." Mathematics achievement, more than achievement in any other discipline, is often linked to innate abilities. Further, our culture subscribes to an assumption that males have more of those innate abilities.

THE ROLE OF THE TEACHER

Other recent research addresses the critical role of the teacher in encouraging girls in mathematics. For example, Leroux and Ho (1994, p. 45), in a qualitative study of fifteen gifted female high school students, concluded:

> Female math teachers who act as role models are significant influences. Teachers who treat both genders equally, provide a warm, uninhibiting environment, and are approachable seem to provide the most "psychologically safe" environment that is conducive to girls learning.

Demonstrating the kinds of effects that teachers can have on students, Rogers (1990), in a study of high-ability students, found that significant success in attracting females to higher-level mathematics courses was achieved by teachers, either male or female, who created a classroom environment that was open and supportive of all students—one in which the teacher's style was conducive to the nature of mathematical inquiry. In a qualitative study of female mathematics majors at a very competitive college, Gavin (1996) found that almost half attributed their decision to major in mathematics to the influence of a high school teacher. In fact, one-third of the students developed and maintained a personal relationship with these high school teachers throughout their college years. Confirming this at the graduate level, Rossi Becker (1994) conducted in-depth interviews with thirty-one graduate students and found that a successful teacher was frequently described as one who piqued students' interests by providing an enriched curriculum. She concluded that teachers and instruction can make a difference in all students' career choices.

GENDER DIFFERENCES IN MATHEMATICS GRADES IN SCHOOL

Kimball (1989), in her review of literature on women's mathematics achievement, found that although standardized test scores favor boys, grade differences favor

girls. The pattern of performance on standardized aptitude assessment measures is very different from the pattern of grades. For example, while males' mean scores on both the verbal and mathematics sections of the 1996 SAT were higher than females', the females who took the test had a higher mean high school grade point average: 3.27 overall, versus 3.11 for males (Educational Testing Service 1996).

How does this affect gifted females in particular? Rosser (1989) reported that the higher the grades, the greater the gender gap. "Girls with an A+ grade point average averaged 23 points lower on the SAT-Verbal section (9 points lower than the overall verbal male-female gap) and 60 points lower on the SAT-Mathematics section than boys with the same GPA" (p. iv). The information that girls are actually not at a disadvantage and in fact have a grade advantage in many courses may be useful in increasing girls' confidence in their mathematics ability.

CAREER CHOICE

Many gifted females continue to reject mathematics and science as courses of study (Grandy 1987). Using data from the federal National Education Study of 1988, a ten-year data collection project, Gavin (1997) examined a cohort of approximately 1400 high-mathematics-ability students. As seniors in 1992, these students were surveyed to determine their intended fields of study in college. Although all students had been identified as having high mathematics ability, only 27 percent expressed interest in a mathematics or science major, with only 1.8 percent intending to major in mathematics. The numbers for females were quite revealing: Only nine (0.7 percent) selected computer science, forty-six (3.3 percent) engineering, nineteen (1.4 percent) mathematics, and twenty-seven (2 percent) physical science. Examining data on intended majors for females who took the SAT in 1996, of those intending to major in engineering, only 19 percent were female, in computer or information sciences, 25 percent (Educational Testing Service 1996). These remarkably low percentages of career interest in mathematics and science occur despite data cited earlier suggesting that females receive consistently higher grades in elementary school, in secondary school, and in mathematics- or science-related subjects in college.

Much attention has been given to research studies that have reported equal numbers of males and females who declare mathematics as their major field of study. However, it is important to examine which students actually graduate with a mathematics major and pursue a mathematics career. Even though equal numbers of males and females start with a mathematics major, females comprise 43 percent of those completing the undergraduate major and only 20 percent of those completing the doctorate (Linn and Kessel 1995). In terms of related fields, an examination of the distribution of the Ph.D. degrees awarded in 1992 reveals that women were awarded 16 percent of the degrees in computer science, 11 percent of the degrees in physics, and a mere 8 percent of the engineering degrees (National Science Foundation 1992). And although the number of women in the life sciences fields has grown steadily since the early 1970s, the participation of women in physics and engineering reached a plateau at about 15 percent and has remained at this level for the past decade (Campbell 1996).

PARENTAL INFLUENCE ON THE MATHEMATICAL TALENTS OF FEMALES

Recent research has established the importance of parents' attitudes and beliefs on the academic self-perceptions and achievement of their children (e.g., Hess, Holloway, Dickson, and Price [1984]; McGillicuddy-De Lisi [1985]; Parsons, Adler, and Kaczala [1982]; Stevenson and Newman [1986]). Phillips (1987) confirmed this finding in her study of high-ability students, and a recent study of parental influence on mathematics self-concept with gifted female adolescents as subjects found consistently significant correlations between parental expectations and student mathematics self-concept (Dickens 1990).

The area of mathematics achievement appears to be particularly susceptible to the influence of parental beliefs, and it is also characterized by greater gender differences in attitudes about performance (Chipman, Brush, and Wilson 1985). Compared to parents of boys, parents of girls are more likely to report that mathematics is less important than other subjects (Parsons, Adler, and Kaczala 1982) and are more likely to attribute good performance to training and effort rather than ability (Parsons, Adler, and Kaczala 1982).

SPECIFIC STRATEGIES TO HELP EDUCATORS ENCOURAGE GIRLS IN MATHEMATICS

According to the National Research Council's 1989 national report on mathematics, by the year 2000 the need for workers in fields requiring mathematics and science backgrounds will have increased by 36 percent from the 1986 level. We must encourage more females to enter mathematics-related fields. We have failed in our efforts to do this in the past. Research has consistently demonstrated that teachers can affect how girls perceive and relate to mathematics. In fact, many female mathematicians cite teachers as the primary persons who encouraged them as children, and some even attribute their career choice or research interests to one teacher who introduced them to the topic and encouraged them to become more involved in the area. Based on these findings, the following strategies can be implemented fairly easily and quickly and have been suggested by experts or proved to be effective in encouraging young girls in mathematics (Sanders 1986, 1994; Hanson 1992; Campbell 1992). Bear in mind that although these suggestions were written with specific reference to females, most of them can apply to improving and equalizing the classroom environment for students of either gender.

1. Provide a Safe and Supportive Environment

All girls, especially adolescent ones, need a mathematics classroom in which they will be heard and understood and where they can discuss ideas before coming to

conclusions. Teachers should not allow students to call out answers randomly or rush to provide closure to a lesson, for time to think and reflect is often essential for talented girls studying advanced topics. One effective strategy is the Think-Pair-Share technique in which, after time for private thought, students share their answers with a neighbor and then with the entire class. The paired discussion lends credibility to their thinking, fosters mathematical communication, and develops a sense of confidence.

Teachers should also become personally aware of the additional attention they sometimes give to boys. It is hard to deny a waving hand or someone calling out, but increased attention, even negative attention, can reinforce behaviors. Girls need equal attention, and to ensure that teachers provide it, peer observations can be established with colleagues. Using this technique, a teacher observes a peer's class and tallies the number of times girls and boys are called on. One way that some teachers address the issue of classroom equality is simply to alternate between calling on males and females in class.

Opportunities for students to reflect in writing about their ideas and fears about mathematics can also be provided in a safe and supportive mathematics class. A "comment box" enables students to drop a note about their feelings or their understanding of the content of the daily mathematics lesson, including questions they have and related topics they would like to pursue. Feelings can also be addressed in creative journal assignments, including mathematics metaphors, as suggested by Buerk and Gibson (1994). A sample assignment might be the following: If mathematics were a food (color, animal, etc.), what would it be … and why? The results can quickly foster communication and provide information about personal feelings. Consider the following entries written by mathematically talented adolescent girls:

> If math were a food it would be a pineapple. On the outside it appears to be all rough, tough, and prickly. But on the inside, it's soft—sometimes sweet, sometimes sour.
>
> If math were a food, it would be a lobster. It takes a while to get to learn how to eat it, but once you learn, it can be kind of fun.
>
> If math were a food, it would be jelly. It's fun to have, to play with, but it also can be a mess and can taste bad.

Journals can also be used to encourage communication about mathematical concepts and offer talented students a way to bring deeper understanding and new insight to areas they wish to pursue. Journals can stimulate creative writing assignments focusing on feelings about math. The following poem, written by a fifth-grade student, expressed the feelings of uncertainty that may accompany the risk taken by a student who answers a question aloud in math class. The need for a supportive environment that welcomes risk and conjecture is evident:

> Death by Math
>
> A million people to pick
> You had to call on me.
> Everyone else had their hand up
> You had to call on me.

The chalk sounds like a thousand knives, slicing
through the air.
I can't think, everyone's watching, a scream for every stare.
I want to say, "Can't it wait?"
But it's too late.
She's made the date.
"You're right, the answer is forty-eight!"
You're lucky you called on me.

Girls often enjoy the intimate student-teacher dialogue created by the journal writing process. An outgrowth of this experience could be the creation of discussion groups at lunch or in after-school clubs in which girls can discuss their feelings and explore interesting mathematics topics.

2. Assume Personal Responsibility to Encourage Talented Females

Adolescent girls who are talented in mathematics may receive mixed messages from their parents, their peer group, and society in general. They may need specific encouragement from parents, teachers, and peers to help them believe that they are truly talented in mathematics and to encourage them to continue to pursue mathematics in high school, college, and beyond.

In the mathematics classroom, teachers who try to encourage talented girls may believe that they should help their students solve problems. However, *merely* giving them extra help may be detrimental to females' sense of self-confidence. Teachers must establish an environment in which students are encouraged to persist in seeking solutions for themselves, and they should answer questions with a question, giving hints but not solutions. They must have high expectations for girls, let them know it, and praise them for being able to solve challenging problems.

Teachers must also be aware that females who are talented in mathematics are often talented in other academic areas as well. Without encouragement to pursue their talent in mathematics, they often choose other more traditionally female oriented fields. Teachers must make parents aware of the need to support their daughters' talents in mathematics. In school, older girls taking advanced placement courses can be asked to come and talk to younger students to encourage increased participation in these courses. And at every stage, all opportunities should remain available to talented female students to encourage them to take and remain in advanced mathematics classes.

3. Employ Instructional Strategies That Address the Characteristics of Females

During middle school and usually continuing through their adolescent years, mathematically talented females exhibit great attention to detail in their work, strong organizational skills, and for some, a sophisticated level of maturity. These

skills can be used to motivate girls' interest in mathematics. One way to do this is by encouraging them to organize a family mathematics night (Stenmark, Thompson, and Cossey 1986) at the elementary school for parents and children to engage in fun mathematics activities. A book published by EQUALS has a variety of activities specifically designed for such an event. Girls may choose activities for the evening, issue invitations, set up, and actually run the entire event (under the auspices of a teacher-mentor). (See the Family Math Web site: equals.lhs.berkeley.edu.)

Tutoring younger children and organizing mathematics clubs or Saturday enrichment mathematics programs also may encourage and empower talented adolescent females. Some current research indicates that some girls tend to thrive in small-group work, especially all-female groups. In coed groups, boys may dominate, becoming the leaders in the group and monopolizing the discussion, while girls become the recorders of the discussions. This is especially true in computer work. If students work in pairs or small groups, boys often demand and get to use the keyboard far more often than girls, and encouraging girls to work together usually resolves this problem. Because some girls have been socialized to play more often with dolls rather than blocks, for example, they may need more time to work with manipulatives. They may also need in-class time to build models, to see how things work, and to develop their sense of spatial relationships. The activity Cooperative Geometry (EQUALS 1986) is another excellent example of group work with manipulatives that develops spatial thinking as well as encourages a true cooperative problem-solving spirit. The extensions are especially challenging for talented elementary and middle school students.

4. Use Language, Problems, and Activities That Are Relevant to Girls

Suzanne Damarin (1990) examined our traditional mathematics vocabulary and found that it reflects a strong male influence. The language contains goals of *mastery* and mathematical *power.* We teach students to *attack* problems, and our instructional strategies include *drill* and *competitions.* She believes that instead of talking about working toward mastery, teachers should talk about *internalization* of concepts. Instead of attacking problems, students should be encouraged to *interact* with them, *sharing* problems and working *cooperatively* toward solutions.

Rather than focusing on activities relating to football yardage, baseball statistics, and housing construction, teachers should also consciously incorporate problems and activities that more girls enjoy. Problems dealing with endangered species, recycling, the spread of disease, population growth, and quilting have proven to be excellent suggestions. Activities involving patterns including tangrams, paper folding, and tessellations appeal to many girls, as well as those activities involving art, such as making mobiles, computer graphics, and scale drawings.

Some favorite teacher resource materials with activities to encourage girls in mathematics are listed in the appendix to this chapter.

5. Create a Challenging Curriculum That Promotes Deep Mathematical Thinking

Teachers must encourage talented females to feel comfortable with, and even seek, a state of challenge when studying mathematics. Challenging the familiar with ideas that stretch the mind should be a major goal of a program for talented mathematics students. By providing the safe and supportive environment discussed earlier, teachers can nurture this spirit of risk taking in girls. From elementary school exposure to such topics as different numeration systems, the Fibonacci numbers, Lego-Logo, and nonroutine problem solving to secondary school study of non-Euclidean geometry, fractals, chaos theory, and combinatorics, students need to struggle with a change of mindset and relish this struggle, for it fosters a deep, intimate, and broadened understanding of mathematics. NCTM has published a series of addenda books to the NCTM *Standards* that are an excellent source of ideas for topics.

In designing a curriculum for talented females, teachers should include a variety of alternative assessments. Research indicates that females may not do their best thinking during timed tests. Independent and small-group projects provide an ideal medium for these students to showcase their talent. These projects should go beyond a typical term paper and should focus on investigative activities in which students assume the role of firsthand inquirers—thinking, feeling, and acting like a practicing professional. In an enrichment program model called the "Enrichment Triad" model, Renzulli (1977) advocates creating student products to develop research skills and afford an opportunity to use authentic methodology. These projects are most effective when directed toward bringing about a desired impact on an audience, whether it be fellow students, administrators, town officials, mathematicians, or senior citizens. The teacher functions as a facilitator, pointing the student in the direction of resource persons and materials as needed or offering direction in learning methodology to conduct the investigation. Some examples of these projects might include contacting local community officials for needed surveying or design projects, such as a population survey or a statistical analysis on the use of current library facilities, or an energy audit of town hall using mathematical analysis with recommendations to the town council for improved efficiency. The NCTM Addenda series book, *Data Analysis and Statistics across the Curriculum: Grades 9–12* (1992), another resource for such projects, outlines guidelines for both long- and short-term projects with time lines and evaluation criteria.

Another means for offering challenging and interesting mathematics to students is the use of enrichment clusters. *Enrichment clusters* are groups of students who share common interests and who come together during designated time blocks to pursue these interests (Renzulli 1994). The increased use of block scheduling in middle school and high school might make the enrichment clusters easier to schedule. Single-sex enrichment groups, if feasible, might provide an increased sense of confidence for females. During these extended time periods, students can pursue mutual mathematical interests. For example, they might

study fractals using computer models and decide to create programs that generate original fractal pieces. Or, they might gather to start a young architects' guild focused on learning about architectural design and using this knowledge to create a play space for children at a local preschool or redesigning a veterinarian's office space. Again, the teacher acts as a guide and the students are empowered to discover the mathematics and see its relevance in the real world. They learn to value mathematics and, one hopes, become inspired to continue study and pursue a mathematically related career.

6. Provide Female Role Models and Mentors for Girls

Many girls have a unique connectedness to people they view as role models. Teachers should capitalize on this and include an historical perspective in their mathematics curriculum to help students become aware of both the people and the creative processes behind mathematics. The lives of mathematicians, their interest in the subject, and how they made their mathematical discoveries will help young female students to appreciate the creative process as well as the difficulties faced in getting new theories accepted. Concepts as basic as the notion of zero, irrational numbers, and negative numbers were quite controversial when first presented and were adopted only with great difficulty.

The names of the following female mathematicians are usually not recognized by boys or girls: Hypatia, Marie Agnesi, Sophie Germain, Evelyn Boyd Granville, Sonya Kovalevskaya, and Mary Somerville. These female mathematicians made distinguished contributions, and teachers can make these women come alive by celebrating their birthdays, hanging their portraits in bulletin board displays, and encouraging females to perform autobiographical skits dressed in their period costumes. Videotaped interviews conducted between student reporters and a remarkable woman who has suddenly come back to life in the twenty-first century can also be effective. This provides a creative twist to the historical perspective that appeals to some talented females. Role models need not all be historical; examples of women currently working in the fields of mathematics and science—astronauts, engineers, physicists, astronomers, etc.—can be presented as well. Some modern women who have made important contributions to their fields include Rita Levi-Montelcini, a Nobel laureate biologist; Reatha Clark King, chemist administrator; Shirley Jackson, theoretical physicist; Edna Paisano, statistician; Gertrude Elion, a Nobel laureate pharmacologist; Maya Lin, architect; Grace Hopper, computer scientist; and Judith Ressnick, astronaut. Some excellent resources on the lives of female mathematicians and scientists, including interesting family and personal stories, are included in the appendix to this chapter.

A rewarding experience for teachers as well as girls is organizing and participating in a career day in mathematics, science, and technology for girls. At these conferences, which are generally held for girls in middle school or high school, female professionals conduct hands-on workshop sessions with girls, interacting with them and exposing them to actual on-the-job activities that spark career interest in girls. It is exciting and rewarding to visit these sessions and observe

girls listening to a dog's heartbeat with a veterinarian, performing a chemical test on local river water with an environmental engineer; or trying, with an actuary, to determine car insurance rates for teenage girls. Some associations that can assist teachers in planning these days are these:

- Multiply Your Options, PIMMS, Wesleyan University, Middletown, CT 06457
- Expanding Your Horizons, Math-Science Network, 2727 College Ave., Berkeley, CA 94705
- Girls + Math + Science = Choices, Rose Arbanas, Calhoun ISD, 17111 G Dr. North, Marshall, MI 49068.

We have conducted several of these career days and found that, in addition to the hands-on workshops, panels of professional women are also effective and allow a greater variety of careers to be represented. To enliven these panels and encourage interaction between the women and the often shy female students, we highly recommend the Tool Clues activity (EQUALS 1989). In this activity, female professionals provide bags of "tools" used in their careers, and students working in groups try to guess their profession using a twenty-question format.

One of the greatest benefits from these interactions with professional women is the opportunity to establish mentorship and internship programs. Participating in these programs gives mathematically talented females the opportunity to work directly with a female role model in a high-level mathematics-related career position. As Sheffield (1994) points out, "We especially need to encourage girls and other traditionally underrepresented groups to consider careers in highly technical fields that involve strong mathematical backgrounds, and mentorships are an effective means of doing this" (p. 25).

CONCLUSION

Our society is just beginning to address many crucial issues involving gender equity. Far fewer females than males pursue careers in mathematics and related fields. It is our duty to try to make high-tech, high-paying professional careers equally available to all students. As pointed out in this chapter, few talented students of either sex indicate an interest in majoring in mathematics. The majority of the strategies we have suggested above are of the type recommended not only for girls but for all students by the NCTM *Curriculum and Evaluation Standards for School Mathematics* (1989). These strategies and activities focus on constructivist, discovery-oriented learning as the key to building mathematical confidence and understanding in all students. So, in reality, promoting equality in the classroom is also promoting good teaching techniques, developing student problem-solving abilities, and instilling a genuine appreciation for mathematics. Only the wider use of these strategies will provide answers to questions about how we can continue to recruit the number of talented persons we need in mathematics in the future. What should be clear to all of us is that few women see a career involving mathematics as an attainable goal, and so it is important to encourage and support more females to pursue mathematics and science in the future.

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APPENDIX

Annotated List of Teaching Resources

1. Cook, Marcy. *Team Estimation and Analysis.* Balboa Island, Calif.: Marcy Cook, 1990.

   This workbook is a series of group estimation activities integrating social studies and mathematical computation and concepts. Using a series of mathematical clues, teams work together to predict numerical information on historical or geographical topics. The final clues guarantee success—a positive cooperative learning experience for the entire class in grades 4–8. (312 Diamond, Balboa Island, CA 92662)

2. Downie, Diane, Twila Slesnick, and Jean Kerr Stenmark. *Math for Girls and Other Problem Solvers.* Berkeley, Calif.: EQUALS, Lawrence Hall of Science, 1981.

   This book presents a variety of activities that make mathematics fun and challenging. Topics explored include logic strategies and patterns, creative thinking, estimation, observation, spatial visualization, and careers.

3. Erickson, Tim. *Get It Together.* Palo Alto, Calif.: Dale Seymour, 1989.
   Erickson, Tim. *United We Solve.* Oakland, Calif.: eeps media, 1996.

   These books outline activities for groups using manipulatives ranging from pattern blocks to M&M's and toothpicks. Problems have a wide range of topics and difficulty but all have the same format—six clue cards that together provide the information needed to solve the problem. Everyone in a group must work together because each member has different information needed for the solution.

4. Fraser, Sherry. *Spaces: Solving Problems of Access to Careers in Engineering and Science.* Palo Alto, Calif.: Dale Seymour Publishing Co., 1982.

   The activities in *Spaces* were designed to stimulate students' curiosity and interest in doing mathematics. The classroom-tested lessons develop problem-solving skills and logical reasoning, build familiarity with mechanical tools, strengthen spatial visualization skills, and teach the importance of mathematics for opening occupational doors. (Resources 2–4 listed above are available from Dale Seymour Publishing Co., P.O. Box 10888, Palo Alto, CA 94303-0879.)

5. Research and Planning Center, University of Nevada. *Add-Ventures for Girls: Building Math Confidence.* Newton, Mass.: WEEA Publishing Center, n.d.

   This book combines teacher development with strategies that work in teaching mathematics to girls. It includes a chapter on computer equity issues, which gives a list of questions for schools and teachers to assess the computer learning climate for girls. Strategies are also discussed for making computer education more accessible and appealing to girls. (Women's Educational Equity Act Publishing Center, 55 Chapel Street, Newton, MA 02160.)

6. Skolnick, Joan, Carol Langbort, and Lucille Day. *How to Encourage Girls in Math and Science.* Palo Alto, Calif.: Dale Seymour, 1982.

   This book focuses on ways to help girls acquire the skills and confidence they need to pursue a full range of interests in mathematics and science. It includes strategies and activities for developing spatial visualization, working with numbers, logical reasoning, and scientific investigation.

Other Teaching Resources

Gruver, Nancy and Joe Kelly, eds. *New Moon: The Magazine for Girls and Their Dreams.* Duluth, Minn.: New Moon Publishing.

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Perl, Teri. *Math Equals.* Menlo Park, Calif.: Addison-Wesley Publishing Co., 1978.

Sanders, Jo Shuchat. *Lifting the Barriers: 600 Strategies That Really Work to Increase Girls' Participation in Science, Mathematics, and Computers.* Port Washington, N.Y.: Jo Sanders Publications, 1994.

Resources on Notable Women

1. Cooney, Miriam. *Celebrating Women in Mathematics and Science.* Reston, Va.: National Council of Teachers of Mathematics, 1996.

   This book features twenty-two biographies of notable female mathematicians and scientists and shows how their determination, creativity, and intellectual passion helped them excel in their fields. Appropriate for use at the middle and high school levels, the text supplies many references that can be used for history of mathematics courses and is filled with excellent illustrations similar to woodcuts. (National Council of Teachers of Mathematics, 1906 Association Drive, Reston, VA 20191-1593)

2. Edeen, Susan, John Edeen, and Virginia Slachman. *Portraits for Classroom Bulletin Boards: Women Mathematicians.* Palo Alto, Calif.: Dale Seymour Publishing Co., 1990.

   This kit is a set of black-line drawings (8 inches by 11 inches) of fifteen pioneering mathematicians with accompanying one-page biographies for quick bulletin boards or student handouts. It is also available with Hypercard program for student exploration or classroom presentation. (National Women's History Project, 7738 Bell Road, Windsor, CA 95492-8518)

3. Perl, Teri. *Women and Numbers: Lives of Women Mathematicians plus Discovery Activities.* San Carlos, Calif.: World Wide Publishing/Tetra, 1993.

   This multicultural book relates the biographies of thirteen outstanding mathematicians from the ninteenth and twentieth centuries, examining where and how these women's interests in mathematics originated and their accomplishments in their chosen fields. It also includes enjoyable activities based on each woman's contributions to mathematics.

4. National Women's History Project. *Telling Our Stories: Women in Science* (CD-ROM). Windsor, Calif.: National Women's History Project, 1996.

   The compelling stories of eight women scientists and their work are told through interviews, personal photos, interactive experiments, multimedia field trips, and more. A text and photo database highlights an additional 130 women scientists. (For PC Windows or Macintosh)

5. Veglahn, Nancy. *Women Scientists.* Windsor, Calif: National Women's History Project, 1991.

   This book features biographical sketches of eleven women whose accomplishments have won them recognition in their field. Included are Annie Jump Cannon, Margaret Mead, Alice Hamilton, Barbara McClintock, Rachel Carson, Rosalyn Yalow, and Gerty Cori.

6. Warren, Rebecca L., and Mary H. Thompson. *The Scientist within You* (Vol. 1) and *Women Scientists from Seven Continents—the Scientist within You* (Vol. 2). Windsor, Calif.: National Women's History Project, 1994 and 1995.

   In these two volumes, international female scientists take the stage. Each chapter features the work and biography of a scientist, along with a lesson plan including a related experiment, worksheets, and bibliography to make the subject area come alive for students.