Gender Balance: Lessons from Girls in Science and Mathematics

Ann Pollina

If we stop trying to change girls and instead let a feminine approach to math and science inform our pedagogy, we will benefit boys, girls, and scientific inquiry.

Are we emphasizing the right issues when we talk about gender in the mathematics, science, and technology classroom? We are and we aren’t.

The need for equitable treatment of girls and women is beyond dispute: Women are still greatly underrepresented in fields like physical sciences, engineering, and technology. As a matter of simple justice, there should be no field of academic inquiry closed to women.

The economic necessity argument is valid as well, particularly as women make up a greater share of our workforce. And if we are to remain competitive in a world market, U.S. women must be well trained in mathematical, scientific, and technological fields.

But as important as these issues are, we cannot allow them to overshadow a third critical argument: the characteristic approaches that many girls and women bring to learning and scientific inquiry are vital to science and to science education.

Feminizing Scientific Inquiry

Too often in the past, we have focused on girls as if they were the problem. If not enough girls took math and science, we asked, “What is wrong with them, and how do we fix them?” How do we make them more aggressive, more analytical, more competitive, tougher, so that they will survive in these disciplines? For years, we gave girls what researchers at Smith College have called courses in remedial masculinity. Then we wonder why many girls lack self-esteem.

Instead of trying to change the way our female students approach mathematics, science, and technology, we need to study the ways they do learn. We need far more than a grudging willingness to change our pedagogy to simply accommodate girls’ learning styles. We must be willing to learn from them. Even more important, we must come to believe that the messages they have for us are of real value.

The work of a number of women scientists demonstrates how profoundly a woman’s perspective can enrich and enliven scientific study. The unusual insights of Barbara McClintock, for example, opened a new window through which to view the study of genetics. In 1983, McClintock won the Nobel Prize for her discovery that genes can rearrange themselves on a chromosome. The direction of her research was informed by a “feeling for the organism” (Keller 1983).

Jane Goodall and Dian Fossey, who revolutionized the understanding of primate behavior, did not hypothesize and then corroborate by observing a group of apes. Instead, they took a relational approach and focused on a single ape, tracing that primate’s interactions. Their work has become a model for wildlife observation.

These women’s formation of questions and approaches to problems represented a new way of looking at science: They introduced feelings and relationships into the discipline.

Ten Tips from Girls’ Schools

How do we begin to learn lessons from girls in the classroom? The collective wisdom of teachers from girls’ schools can provide all educators with insight into the learning styles of girls. Believing girls’ schools to be an untapped resource in our country’s efforts to find ways to inspire young women to study mathematics, science, and technology, the National Coalition of Girls’ Schools has sponsored three symposiums in these fields. Two were held at Wellesley College, in June 1991 and 1995; and a third in conjunction with the Dudley Wright Center at Tufts University in March 1993. Each brought together educators from public, independent, single-sex, and coeducational schools to examine research and proven strategies for teaching girls in the classroom.

Here are some of the messages from these workshops that I use in my high school classroom at Westover, an all-girls school in Connecticut.

1. Connect mathematics, science, and technology to the real world. My students remind me how much richer mathematics is when we do not divorce it from its history, its philosophical underpinnings, and its functions. Connecting any subject to the lives of real people and the good of the world is a powerful hook for girls.

Some specific exercises:

- Collect examples of decorative borders from different cultures. My geometry students study transformation and isometry using these.

- Establish links with other disciplines. Both the calculus and the European history classes at my school spend some time looking at the powerful effect Newton’s laws of motion had on
the thinking of the Enlightenment, and we share presentations between classes.

Divide a class into groups and ask them what sort of mathematics a prehistoric hunter-gatherer clan might need to survive. You will have a wonderful discussion about the nature of mathematics.

2. **Choose metaphors carefully, and have students develop their own.** For years we have asked girls to tackle problems and master concepts using metaphors and real-world problems more closely tied to boys’ life experiences. We have taught fractions using batting averages and presented parabolas as paths of missiles and rockets. Presenting images of mathematics and science that are comfortable and meaningful for girls is more than a sign of our current preoccupation with political correctness.

In my classes, I often ask students to create their own metaphors. A teacher may gain valuable insights into students’ own perceptions of learning style by asking questions such as:

“If math were a food, for me it would be ________ because ________.”

My favorite response to this question was from a 9th grader entering Algebra I:

If mathematics were a food, for me it would be a sandwich because sometimes I like what’s on a sandwich and sometimes I don’t. When there’s too much stuff on a sandwich, I can’t fit it in my mouth.

After reading this, I knew what that student needed in a math classroom. This exercise is the kind of “window on students’ thinking” that the National Council of Teachers of Mathematics speaks of in its *Teaching Standards* (Leiva 1993–95). Dorothy Buerk, who teaches mathematics education at Ithaca College, has developed a wealth of these exercises (Buerk 1985).

3. **Foster an atmosphere of true collaboration.** Collaborative learning has become the classroom panacea of the ’90s. Although a collaborative environment is attractive to many girls, pulling desks into a circle does not assure a collaborative, non-competitive experience. Small groups work for girls if all members are taught to listen and are responsible for one another’s learning. Some teachers insist that a true group project is one that no single group member can complete without the group’s help.

4. **Encourage girls to act as experts.** When the teacher is the touchstone for all knowledge and answers, students rarely exhibit self-confidence. Only when the group is responsible for verifying its own logic and when students critique their own work and that of their peers do they begin to see themselves as scientists. The technique of the teacher refusing to act as an expert has been used successfully for over a decade in the SummerMath program at Mount Holyoke College. The program is designed for high school girls to address under-representation of women in mathematics-based fields.

5. **Give girls the opportunity to be in control of technology.** The issue of the expert is also a critical one in technology. Both boys and girls need to recognize the masculine cast of the computer industry. Taking any computer magazine and comparing the numbers of men and women pictured or mentioned in advertisements will stimulate a good class discussion.

At Westover, the computer room is staffed and serviced by students, usually from our Women in Science and Engineering (WISE) program. These girls are responsible for basic repairs, for teaching software, and for dealing with data emergencies. At times they teach the required computer literacy course. Girls need to see other girls in control of technology. In coed settings, an all-girls computer club may allow girls to develop more computer expertise.

6. **Portray technology as a way to solve problems as well as a plaything.** Girls use computers differently than do boys. Few girls will play with a computer just because it’s there; most often girls use it as a tool, not a toy, and they need to see its relevance to their lives. One way to encourage girls to play on the computer is to emphasize the networking and communica-
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duction capability. Single-use work stations can be isolating; pairing girls creates a comfortable atmosphere and stimulates discussion.

When asked to create a dream machine, girls want to create things that can help make our lives better. Cornelia Brunner and Margaret Honey of the Center for Children and Technology have created a variety of exercises to explore technological imagination (Brunner and Honey 1990).

7. Capitalize on girls' verbal strengths. Strong writers and good readers—both girls and boys—have valuable tools at their disposal. Yet, often, we are not creative enough in teaching them how to use those tools to their advantage in a mathematics or science classroom.

At the Coalition of Girls' Schools' symposiums cited earlier, teachers presented a wealth of situations in which they used writing. Students were encouraged to express the logic behind their solutions in essay or picture form. Proofs might be essays and well-constructed arguments with a minimum of mathematical notation.

My calculus students keep journals in which they reflect on their experiences in the course, comment on their progress, and set goals for themselves. Two possible journal questions:

You died while doing your physics homework. Write your physics obituary.

You are a spider on the wall of your room observing you doing your mathematics homework. What do you see?

8. Experiment with testing and evaluation. Assessment methods must reflect the research suggesting that girls do not think in linear right/wrong categories. Multiple-choice testing that requires forced choices or contains out-of-context questions and topics unrelated to real-world experiments make no use of girls' ability to synthe-

size, make connections, and use their practical intelligence. The work of Maryellen Harmon and her colleagues at Boston College's Center for the Study of Testing, Evaluation, and Educational Policy suggests that, for this reason, such assessments inhibit science education reform (Madaus et al. 1992).

Alternate strategies that do work well for girls include embedded assessments—activities in which students, usually working in groups, perform experiments, discover patterns, and arrive at hypotheses. A teacher circulates and observes student performance to evaluate them. Another form of assessment is the circus, where stations with reflection questions or experiments are set up around a room. Students go from station to station and are evaluated on the quality of their investigation at each.

9. Give frequent feedback, and keep expectations high. Because girls still may not expect to do well in mathematics and science, they tend to need more encouragement than do boys. The role of the teacher in praising students and verbalizing expectations is critical. Teachers at the girls' schools forums found it vital to provide frequent feedback in the form of homework checks, quizzes, and comments, thereby reinforcing students' belief in their control of the material. Many said they use this strategy to develop the kind of self-reliance that all students need to survive in an inquiry-based classroom.

10. Experiment with note-taking techniques. Girls are dutiful learners. They can get so absorbed in taking down every note and diagram that they are too preoccupied to take part in discussions. Teachers at the symposiums suggested a variety of techniques to counter this tendency, ranging from the "no note taking allowed" classroom to handing out copies of lecture notes or having them available on the computer. My algebra and geometry students take notes on reading material before coming to class. Most teachers at the symposiums included some standard note-taking situations so that students could learn this important skill.

Single-Gender vs. Coed Settings

The number of single-gender experiments in schools from New Hampshire to California bears witness to our interest in equity and our willingness to change. Those experiments are also steeped in controversy, and for good reason. If the purpose of such experiments is to divide girls from boys because girls can't compete in a "real" mathematics or science classroom, then our experiments, by conveying this message to girls, can do infinite harm. But if we begin these experiments believing that our female students have something to teach us, then what goes on in such a classroom can be more subtle and powerful than the absence of boys: it can be the empowerment of girls.

A recent, well-publicized experiment at the Illinois Mathematics and Science Academy in Aurora illustrates this point dramatically. In 1993, the academy, an experimental, residential school serving gifted and talented students, offered an all-girls' section on mechanics as part of a yearlong calculus-based physics course. David Workman, the physics teacher involved, did not simply import his usual classroom methods, but was willing to learn from the young women. He found some approaches successful—collaborative processes, hands-on experimentation, connection of abstract concepts with practical application—and he made these the cornerstone of his class. Then—and this is most vital—he tried to import these methods into his coed setting.

Workman made it clear to the girls that there was nothing wrong with the
way they related to physics or to the physical world. His powerful message:

I’m not just doing these things because you are incapable of learning physics the ‘right way’; I am using the teaching methods that appeal to you because they are valid and important methods of scientific inquiry.

A report on the experimental section (Dagenais et al. 1994) showed it mirrored much of the atmosphere of all-girls’ classrooms that other academy teachers describe: a spirit of co-learning, with both teacher and students feeling free to ask questions, admit mistakes, take risks, express confusion, and so on; a profound sense of responsibility for one’s own learning and that of others; and a special rapport between and among the teacher and the students.

He Said, She Said

Workman’s initial efforts to replicate this collaborative atmosphere in his coeducational classes was foiled: many boys tended to blurt out answers to questions posed to the class as a whole, with predictable results. The other students were suddenly diverted from collective problem solving and inquiry to an explain-the-answer-to-me mode. “In this environment,” said Workman, “all except the boldest and fastest hesitate to be open, ask questions, and take risks.”

To get around this problem, Workman has his students write down answers rather than speak them. Then, moving from table to table, he confirms whether an answer is right or whether the student or group of students needs to work through the problem again.

These difficulties notwithstanding, the single-gender experiment has already helped to level the playing field. Last year, for example, girls performed on a par with their male peers (in prior years their performance declined relative to boys as the semester went on); more girls enrolled in and successfully completed the yearlong physics course than ever before; and girls in the single-gender section gained more self-confidence than did those in coeducational sections.

Workman and his colleagues plan to further analyze the results of the experiment. “We’re going to take what we learned and think harder about how we can preserve the strengths of both male and female modes of learning in mixed classes in order to benefit everyone,” he said.

In single-gender class experiments, the culture that surrounds a class is as vital as teaching itself. If we are willing to stop trying to change girls and ready to let a feminine approach to science inform our pedagogy, we may see some exciting results for boys and girls and for science and technology.

References


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