PROGRAMS THAT WORK

Making Room for Women in the Culture of Science

Keys to success include real-world, hands-on, girls-only activities.

Lots of current research finds that girls do best at learning science in all-girl environments. But those conclusions are usually expressed in pages of data. Rarely do you see an example as vivid as one that gained the spotlight in Boston recently, when an all-girl sixth-grade science club took on some of the best engineering minds in the nation at a Massachusetts Institute of Technology (MIT) robotics contest—and beat some of them. .

The unusual group is the brainchild of Maureen Castellana, a registered nurse and mother of two, who was concerned her daughter would succumb to the fall-off of interest in science girls often show when they're at school with boys (see story on p. 409). "I think boys get a lot more encouragement in the first place," says Castellana, who also has a teenage son. "I also think girls are so susceptible at this age to whether you look 'cool' or not." And for most girls science is definitely not cool.

To change that image, Castellana invited all the fourth-grade girls in her daughter's small suburban school to join a science club: a place where girls could explore without worrying about what boys think. In 2 years, a dozen or so girls have gone on camping trips, held an "animal party" for which each girl learned as much as she could about an animal of her choice, and attended sleep-overs at the local science museum, where they enjoyed the planetarium and hands-on activities. "These girls don't like to listen [to science], they like to do," says Castellana.

As far as hands-on experience goes, the club's most exciting experience came in January when they competed in MIT's seventh annual battle of LEGO robots. Derived from a popular mechanical engineering design contest held for decades at the school, this newer event emphasizes computer science and electrical engineering. Instead of being controlled by a joystick, as in the older contest, machines in this battle are autonomous, with only sensors and built-in programming to control their actions. Walter Bender, father of a club member, is a computer scientist at MIT's Media Lab, and he "thought it would be neat if the girls got involved in the contest." After negotiations with the event's organizers (the contest is part of a graded course), Bender got approval to let the club compete in the preliminary rounds.

To meet the challenge, the girls had to sacrifice three consecutive Saturdays. Bender introduced them to the contest kit: LEGOs, sensors ranging from infrared to magnetic, and a programmable computer chip. Bender handled the programming of the chip, but he made sure the girls were responsible for how their machine would perform. He had them simulate the various parts of a robot, with one girl being a light sensor, another a wheel, and so on. "I wanted them to think about the design process and what a robot is," says Bender. He also had the girls build small robots that demonstrated differences between pivoting and turning and concepts like torque. "They just stuck with it. They were completely absorbed for a long, long time," he says.

From there, the girls tackled the goal of the actual contest, which was to get as many foam-rubber blocks as possible into specified areas. For aggressive types, a machine could attack its competition and prevent the enemy from capturing blocks. The girls went the peaceful route, however, designing a machine that detected the light above the "goal" and pushed any blocks it bumped into that way. "That was enough to beat half the MIT robots. It was simple and robust," says Bender.

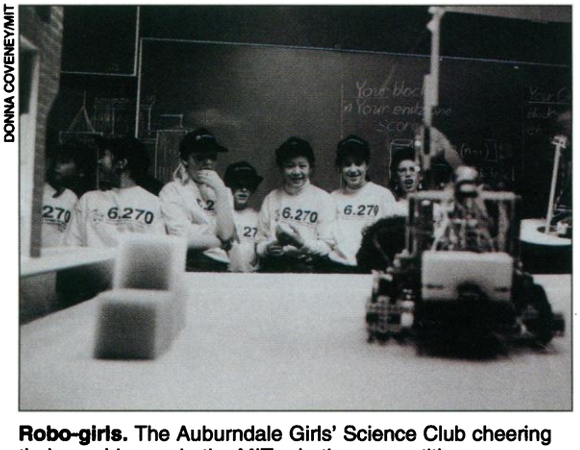
The audience loved it. "The crowd went nuts over the girls," says Bender—applauding the club's machine and booing a team from Microsoft Inc. when they almost beat the girls. To the crowd's delight, an infrared sensor tower fell off the Microsoft robot at the last moment and disqualified it. "A lot of [the other robots] looked real fancy, but they messed up. They were too complicated," comments club member Carolyn Lewenberg.

While great fun, the science club raises the question of whether it is necessary to exclude boys from events like this. Castellana admits the contest made some boys at her daughter's school jealous, but Bender defends the all-girl club vigorously. Having boys involved with the robot design would have changed the group dynamics, he believes. The girls would be less willing to take risks and make mistakes. Many of the girls surprised themselves at how well they did, says Bender, concluding that "if there were boys there, it wouldn't have worked as well. The girls would have been inhibited."

Whether that is true or not, others are eager to follow the club's example. Ever since *The Boston Globe* publicized the girls' participation in the MIT contest, Castellana says she has been inundated with offers of assistance and queries about how to set up similar all-girl science clubs.

–John Travis

DONNA COVENEY/MIT



Robo-girls. The Auburndale Girls' Science Club cheering their machine on in the MIT robotics competition.

Getting Messy

On a typical suburban evening, while some adolescent girls are watching MTV and wondering what the boys are doing, girls who belong to Operation SMART are engaging in very different activities: taking apart a washing machine, dissecting an abandoned bird's nest, opening up a Xerox machine, or building cameras. Operation SMART, run by Girls Incorporated (which used to be called Girls Clubs of America), aims to help girls acquire an attitude of scientific inquiry in everything they do. "We want girls to question, observe, record, take things apart, look for patterns, make mistakes, try again, take risks, get messy, and—most important—to be skeptics and not take anything for granted," says Ellen Wahl, director of programs at Girls Inc.

Tempest in a teapot. One Operation SMART exercise uses soda bottles to show girls how tornadoes form.

By all accounts, Operation SMART (standing for Science, Math, and Relevant Technology) is a model for how informal programs can get girls interested in science and math and keep them interested as they reach junior high school, where girls tend to lose interest in science education. It's around this age that girls feel pressure to play down their intelligence and place second in competition with boys. To counter these distractions, Operation SMART combines regular visits to workplaces, contacts with role models and mentors, and increased hands-on experience.

"We thought about the qualities of a scientist, such as the ability to generate questions, to wrestle with uncertainty and tolerate creative chaos, to have the courage to experiment and learn from failure," said Wahl. "We posited that girls' socialization in this culture inhibits the development of these very qualities. Our answer to this problem was scientific inquiry, an approach that encourages questioning, exploration, discovery, and risk-taking."

Nearly 250,000 girls in 240 club centers across the United States participate in Operation SMART. An assessment of Operation SMART, conducted under the auspices of the Ford Foundation, found that though attendance is voluntary, clubs report that a majority of elementary and junior high school girls from local schools attend science nights regularly. At one urban club, a survey showed that adolescent girls' occupational goals changed from secretary, nurse, and teacher to scientist and engineer after several months in the program.

There is almost universal agreement in the science education community that Operation SMART works. "This is a very, very good program, one that is able to hold girls' attention for a long time and really keep them interested in science as they move through school systems that are often less than sterling in regards to how much attention they pay to girls," said Marsha Lakes Matyas, director of education programs at the American Physiological Society.

Patricia B. Campbell, director of the education consulting firm Campbell-Kibler Associates in Groton, Massachusetts, has studied Operation SMART and says the program succeeds because it is fun, relaxed, and noncompetitive. And there's another key: It's not like school. In fact, girls' participation in the program drops when they sense that they are doing "science activities" rather than SMART projects. Another measure of the program's success is its acceptance by the formal education system. In Rapid City, South Dakota, Operation SMART trainers are working with grammar school teachers to improve science and math education (for both girls and boys).

Operation SMART
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Shedding Chemistry's Uncool Image

One thing that can discourage female students from taking subjects like chemistry is the "science nerd" image that accompanies nights in chem lab. But that doesn't have to be true. Chemistry, after all, is an element of many things that are Hip Right Now: environmental change, pollution, consumer issues, and medicines from rain forest plants. The challenge for an educational program that wants to attract women is to change the image of the science, which is one thing the chemistry department of Fort Lewis College in Colorado is doing.

"We've tried to remove the barriers to success," says Jim Mills, chairman of Fort Lewis College's chemistry department, in explaining the success his department has in recruiting and retaining women. "We realized in the 1970s that too many entering first-year students saw our courses as the ones designed to weed them out of science, instead of giving them the foundation they needed to go on in science."

Today, the chemistry department offers classes on consumer chemistry, science and society, global change, problems and puzzles, writing, and natural products from plants. The real-world content of these courses seems to be particularly good at reaching women students, though the school's male students benefit as well. "We still teach chemistry in a rigorous manner, we just make it more interesting for the students and the faculty," said Mills.

A secondary benefit is that significant numbers of nonscience students take chemistry classes as electives, recruiting a few students to the program each year and making chemistry part of the campus culture. "How many colleges can boast of that?" asks education consultant Sheila Tobias, who has studied this Colorado state school. As a result, few students at Fort Lewis College have the "science nerd" stereotype of chemistry majors.

The program may not be nerdy, but it is hands-on: Undergraduates use state-of-the-art instruments early and often. What is more, since the school has no graduate students, the undergraduates, instead of giving their nuclear magnetic resonance (NMR) samples to a teaching assistant to run on the machine—as happens at most large universities—use the machine themselves. In addition, faculty members have room in their labs for undergraduate research assistants and can provide $2,500 summer stipends.

Part of the secret of success is that the chemistry department emphasizes knowing its students, a process that begins even before a student enters the college. Faculty member John Ritchey writes to every Fort Lewis applicant who has high ACT or SAT math scores—whether or not the student has expressed interest in the department. He encourages students to visit the school and drop in for a chat. The result is that on a per capita basis, Fort Lewis has twice as many chemistry majors as either the University of Colorado or Colorado State, and 40% of its chemistry majors are women.

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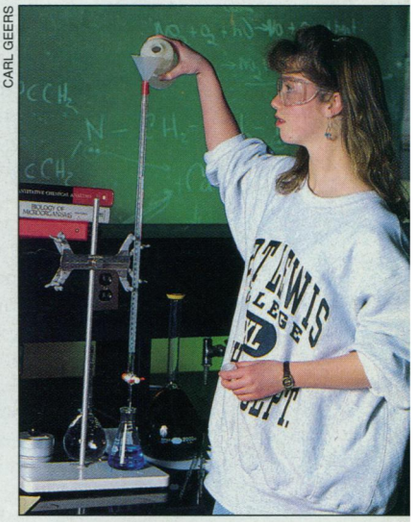
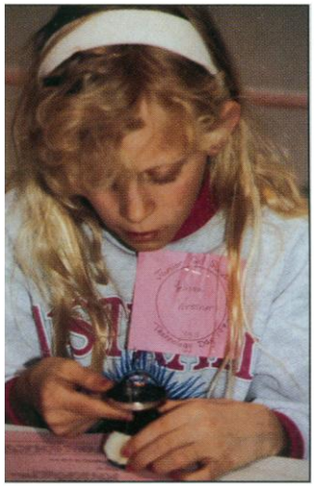


CARL GEERS

Hands on. Fort Lewis College's chemistry department keeps female students by emphasizing practical work and real-world applications.



Concentrating on the practical. "Girls and Science" involves science activities using items available in any household.

Badges of Scientific Merit

One problem with evaluating programs designed to interest girls in science is the lack of objective measures of success. The American Association for the Advancement of Science (AAAS) "Girls and Science" program didn't lack for an objective measure, however, when it was being tested and refined in cooperation with Girl Scout troops in Minnesota and the Dakotas. The bottom line: a 57% increase in science-related merit badges. That may sound like a whimsical measure of success, but, in fact, it reflects the girls' increased comfort with scientific subjects, says the program's former coordinator, Marsha Lakes Matyas, who recently became director of education programs at the American Physiological Society.

Girls and Science sends AAAS staff across the country to run workshops for 30 to 40 participants, training teachers and others in active educational techniques. Currently, the AAAS runs training programs at 25 sites, which will reach a total of more than 100,000 girls; the program recently received a grant from Abbott Laboratories to train Girl Scout leaders in Wisconsin and Illinois. During the workshops, participants meet local women who work in science and engineering, whom they can call on to give talks to girls' organizations. The participants also learn hands-on science and math activities that require only safe household materials.

The program is designed to overcome one significant obstacle to keeping girls in science: the lack of interest and experience elementary school teachers and youth group leaders have in technical subjects. "We started this program because adult leaders need to understand the importance of science and math education for young women, but it's hard for them to get this message across when they themselves don't see how important such training is," said Matyas.

The initial impact on the Girl Scouts was a pleasant surprise to program organizers. "The degree of success surprised even us," said Matyas. For many Girl Scout troops, science activities became a means of recruiting new members and raising funds. In others, older girls themselves became science and math leaders for the younger girls. But girls were not the only beneficiaries. Parents who attend troop meetings and see girls having fun with science go away with a new attitude about how important science training can be in a young girl's life. "If we can destroy some of these stereotypes in adults, then young girls will get more positive messages that will help them overcome some of the poor educational experiences that most of them will get," said Matyas.

Girls and Science: Linkages for the Future
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Stepping Beyond the Campus

The Women in Science Program at the University of Michigan is based at the university, but it doesn't stop at the campus boundaries. "We recognized early on that our undergraduate support program couldn't operate in a vacuum, but had to build on and even counteract the precollege experience," said program director Cinda S. Davis. The precollege outreach includes two summer programs that bring young women to the University of Michigan for hands-on experiences. "Summerscience for Girls" draws eighth-grade girls from around the state to campus for 2 weeks. "Lots of research identifies this as a critical dropout point for women, and we want to show them that science is more than just boring facts," said Davis. The girls participate in projects in engineering, natural resources, chemistry, physics, and space science. They also attend seminars on computers, careers, and ethics in science.

The second program, "Science for Life," is an internship funded by the National Institutes of Health that places high school girls from the Ann Arbor area in labs of women scientists for 6 weeks. Half of the 20 students work on projects at the University of Michigan Medical School; the other half work in research laboratories at the nearby Warner-Lambert Pharmaceutical Co. Interns have their own research projects and participate in a research symposium at the conclusion of the program. "By bringing high school girls into the lab, we try to show them that science is not something you do all alone, that there's a social aspect to it, too," said Davis.

Of course, the program doesn't ignore the women who are already at Michigan. Workshops held throughout the academic year provide career counseling for undergraduates and graduate students and give women a chance to network. Graduate women receive special training in grantsmanship, while undergraduates can participate in seminars such as "Moms in Science" and "Nontraditional Careers in Science."

The Women in Science Program also works with individual departments on problems women face. A program survey of third-year women singled out the cutthroat introductory chemistry and calculus courses as the main reason they switched to nonscience majors. So the chemistry department revamped its first-year curriculum. "There's no more of this, 'Look to your right, look to your left; only one of you will pass the course' nonsense," said Davis. Though final data are not yet available, the university has just finished a survey of students and preliminary analysis shows gender no longer predicts failure or success in chemistry classes—as it did before the curriculum was revamped.

Women in Science Program
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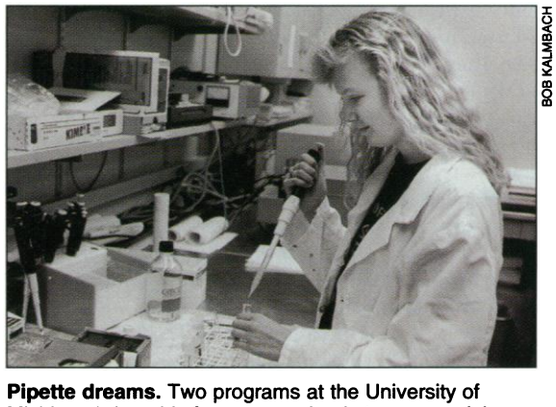

BOB KALMBACH

Pipette dreams. Two programs at the University of Michigan bring girls from area schools to campus labs.

Teaching the Teachers

"Elementary and secondary school teachers are a big part of the problem that discourages girls from pursuing science careers," says Patricia B. Campbell, director of the education consulting firm Campbell-Kibler Associates in Groton, Massachusetts. "But in most cases, teachers don't have a clue that they're sending different messages to girls and boys."

This is the problem Miami University of Ohio's Project Discovery is tackling—with some success. The program grew out of research by Jane Butler Kahle, professor of science education at Miami University. In 1991, she studied the teaching methods of every fourth- and fifth-grade teacher in a school just outside Cincinnati. With few exceptions, she found, boys received more attention than girls in science classes, which naturally had a negative effect on girls' self-confidence and attitudes towards science as a career.

"It wasn't that the teachers were overtly discriminating," said Kahle, who directs Project Discovery, "but both the boys and girls picked up on these differences." Girls were more often praised for neatness or timeliness in completing experiments; boys were recognized for scientific content of their work. Girls were asked, "What is the correct answer?" Boys, on the other hand, were asked, "How did you get that answer?"

Many of the teachers attempted to be equitable by placing boys and girls together when doing group experiments. However, they failed to monitor the groups, and, more often than not, boys did the experiments while girls recorded the data, giving boys the edge in critical hands-on experience.

To remedy this inequity, Kahle and her students ran gender-equity training sessions for teachers. These day-and-a-half sessions (with a brief follow-up a week later) focused on how subtle factors can demoralize girls. In addition, teachers received self-awareness training to help them spot potential problems themselves.

Following the training, Kahle observed dramatic changes in classroom dynamics. Girls became more interested in the subject matter and participated as equals in group experiments. Many teachers stopped using mixed-sex groups, finding that girls did better working with other girls. Girls' interest in science as a career jumped. Based on these promising results, the Ohio legislature has provided Kahle with funds to expand this program statewide. One thing she plans to tackle next: the anxiety many teachers themselves feel about science.

Project Discovery
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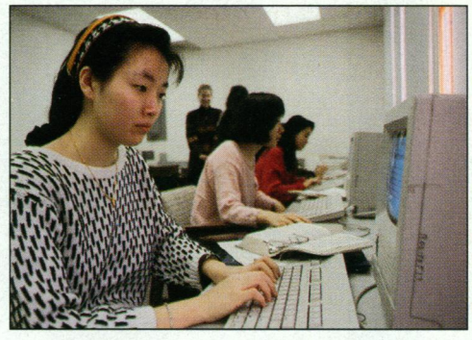
Round-the-Clock Science Peer Group

Many women who make it to the top in science say that along the way they felt isolated. Often, they claim, it was a struggle to stay in science at all, let alone succeed. An innovative effort by Douglas College at Rutgers University aims to reverse that pattern by providing around-the-clock peer support to 100 undergraduate women science students. The students live together in the Bunting-Cobb Residence Hall, where they have access to an on-site computer lab, a science and engineering reference library, and a seminar program. Ten women science graduate students, funded by a special fellowship, live in the dorm as mentors and tutors.

That environment is so tempting that competition for spots in Bunting-Cobb Hall is intense—between 20 and 40 students are on the waiting list each year. Incoming students are judged on high school grades, an essay, and demonstrated interest in science. To remain in the program, students must pass a review that includes an assessment of grades and participation in extracurricular science programs, such as special seminars and research opportunities.

PHOTOS BY NICK ROMANENKO/RUTGERS UNIVERSITY



Scientific community. At Rutgers, an all-female science dorm includes a computer laboratory.

"Bunting-Cobb grew out of a big sister/little sister program that had proven effective in keeping our women in science majors by providing role models," said Ellen F. Mappen, director of the Douglas College program. "Now, not only do the graduate students act as mentors for the undergrads, but the undergrads go out into the community and act as role models and mentors for young women in the local high schools. They're now helping teachers develop curricula and lesson plans, and they're setting up after-school programs, too." Those outreach efforts increase the number of high school women who stay in the pipeline and reinforce what the undergraduate women learn in their own classes. "This experience really motivates them and helps them gain confidence in their own abilities," said Mappen.

Such self-confidence boosters are important because the coeducational Rutgers environment poses many of the same challenges to young women interested in science that prevail in other mixed schools. "We started this whole program because a number of studies showed women were discouraged by the stereotype that science and engineering are not perceived as 'women's careers' and that being around male students seems to reinforce that idea," said Mappen.

Some may argue that this approach pampers women, preparing them not for success but failure once they enter the competitive, mixed-gender world of science. Mappen disagrees: "I don't think we coddle our women students. What we do is provide them with a chance to excel in science, to gain confidence, to be motivated. We don't do their work, and they still have to interact with men. But we do let these students see themselves as professionals, as scientists, mathematicians, and engineers, and this is a message that women have a hard time getting in other environments."

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