

WOMEN IN PHYSICS: REVERSING THE EXCLUSION

Commitment and deliberate action by both institutions and individuals are necessary to rectify the conditions that now turn women away from physics careers.

Mary Fehrs and Roman Czujko

Two decades ago US women earned about 4% of the nation's physics PhDs. Today, they earn about 5%. Although discussed in various forums in recent years, the low representation of women in physics persists. The problem is especially perplexing given the dramatic increases in the percentages of women in other sciences and in engineering.

Where have we gone wrong? And what can we do to turn things around? The main changes that have to be made are attitudinal and will require little expenditure of money. But they do call for deliberate and consistent effort. In general, those physics departments and individuals who have succeeded in bringing in more women students and faculty have done so because they identified this as a top priority.

Many readers will agree that it is desirable to increase the participation of women in physics. Still, at a time when employment opportunities in the field appear to be decreasing, it seems reasonable to ask, Why encourage women (or men) to go into physics? There are several reasons. The current employment picture is indeed rather dark. But many of us remember the terrible job market of the early 1970s, and between then and now there have been times of great opportunity. If one assumes that talents are evenly distributed between the sexes, then the underrepresentation of women in physics is a huge waste of talent and potential contributors. Furthermore, when a woman is discouraged from becoming a physicist because of her sex, she is unfairly impeded in her path toward what might be a rewarding career.

Numerous theories exist to explain the poor represen-

tation of women in physics, but almost all derive from one basic premise: The physics community and society at large exclude women from physics—both deliberately and unintentionally. This exclusion takes many forms, from subtle but constant differential behavior toward women to overt sexual harassment. Reversing the exclusion is what is needed to bring more women into the field.

How women are excluded

The treatment of women based on sexual stereotypes—on what are deemed appropriate female roles and behavior—is pervasive in the physics community. Stereotyping is practiced by faculty, fellow students, teaching assistants, department secretaries, families and the mass media. In subtle and unsubtle ways, the idea is constantly reinforced that physics is not a fit intellectual endeavor for women. A woman who shows an interest in theoretical physics may be reminded that nearly all the past and present great physicists are men and that she probably lacks the mathematical aptitude necessary to do theoretical physics. But she may also be told she won't cut it as an experimenter, because everyone knows women are inept when it comes to equipment, and who could trust her in the machine shop? The day in-day out flow of such comments and attitudes is wearying and places an extra burden on women physics students. In a collegial enterprise, the net effect is to devalue women as colleagues.

In this environment, women are not taken seriously as physicists, and as a result they become academically invisible. They aren't called on in class; they are excluded from discussions or study groups; they are not encouraged to consider demanding careers or programs in physics. Academic invisibility leads women physics students to doubt their own abilities and talents.

In physics, as in society at large, the total reliance on male pronouns reinforces female invisibility. It's true that the use of "he," "him" and "his" avoids awkward

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language, but given the current environment in physics, “she,” “her” and “hers” should also be used.

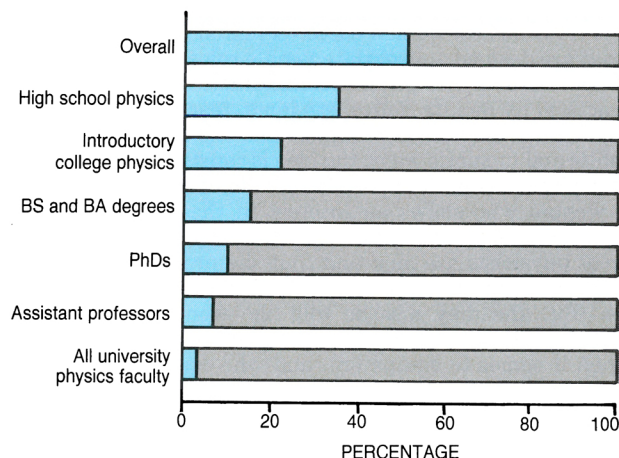
Academic invisibility is often accompanied by heightened social visibility. One colleague went to a grad school where the department listed the male students by first and last name but listed women as “Mrs.” or “Miss.” Because she had not indicated her marital status when applying, the woman was listed as “Miss.” After arriving on campus, she was asked out on dates by several of the men in the department, who became outraged to learn that she was married. This kind of social overattention is common in departments that are predominantly male, and it further devalues women as serious professionals.

In the extreme, social overattention can cross over the line into sexual harassment. At the 1990 Conference on Recruitment and Retention of Women in Physics, held in Chevy Chase, Maryland, the women in the largely female audience at one session were asked if they felt they had been sexually harassed on the job or in school. At least half of the female attendees raised their hands.

Data confirm the problem

We now turn to some of the data on the participation of US women in physics and in related disciplines and on the representation of women in physics in other countries.

Women are underrepresented at all stages along the so-called physics education pipeline in the US. In addition, the degree of representation decreases as one moves along the pipeline toward a career. As figure 1 illustrates,



In the physics pipeline, females (data shown in blue) are underrepresented at all stages compared with their male peers (gray). What's more, the percentage of women in physics dwindles as they move from high school through college and into careers. This situation has persisted since the mid-1980s. (Data from AIP, US Department of Education and Introductory University Physics Project.) **Figure 1**

in the late 1980s women made up 51% of the student-age population, but they represented less than 40% of high school physics students, less than 25% of introductory physics students in college, 16% of physics bachelor's degree recipients, 10% of new physics PhDs and only 3% of the physics faculty in universities and colleges.

High school. Not only do women drop out of the physics education pipeline faster than men, but they are also less likely to get into the pipeline where it begins—in high school. One of the most common explanations for this early exclusion is that women do worse in math than men and, because physics is quantitative, they therefore do worse in physics. It is well documented that females score lower than males on standardized tests of mathematics achievement. But is math ability a good predictor of physics achievement, and do gender differences in test scores account for the gender differences in enrollments?

A series of studies carried out in the 1980s by the US Department of Education provides some insight into these questions. Because physics is math based, it is assumed that students with higher math ability are more likely to take physics than those with lower ability. This is precisely what figure 2 shows. But the figure also illustrates that among students of identical math ability, girls are significantly less likely than boys to take physics. Physics is unique in this regard. In chemistry, trigonometry and geometry, no such gender differences are found.

Bachelor's degrees. While half of all bachelor's degrees are awarded to women, figure 3 shows that the representation of women in physics is well below that in most related disciplines. The exception is engineering, but even there the participation of women has grown dramatically over the past couple of decades, from near zero to a level just below that of physics.

Figure 3 further weakens the hypothesis that poor math ability is the reason for the low participation rate of women in physics. Nearly half of all bachelor's degrees in mathematics go to women—a proportion three times higher than that in physics. (These data do not include degrees in accounting and business math.)

PhDs. As depicted in figure 4, the pattern of PhD attainment by women in physics and related disciplines is similar to that for undergraduate degrees: Physics is again near the bottom. While the proportion of physics PhDs earned by women was higher in 1990 than it was 15 years earlier, most of the increase occurred during the late 1970s and early 1980s. There has been virtually no change over the last six years.

The sizes of the disciplines in figure 4 differ greatly. Table 1 lists the numbers of women earning advanced degrees in selected disciplines in 1980 and 1990. The number of women earning physics PhDs doubled over the decade—from 67 to 149—but much of that is due to an increase in the number of foreign citizens getting doctorates. Today more than half of the women earning physics PhDs in the US are foreign citizens.

Fewer US women earn PhDs in physics than in mathematics, even though the total number of physics PhDs awarded each year is greater than the total number of math PhDs. In 1990, there were about 1200 physics

PhDs awarded in the US, of which 63 went to US women; in math there were about 900 PhDs, of which 82 went to US women. The growth in the number of women earning PhDs in engineering stands out dramatically: The participation of women has more than quadrupled over the past decade, so that nearly three times as many women now earn PhDs in engineering as in physics.

It has been said that one reason so few women have PhDs in the so-called hard sciences is that they are reluctant to make the commitment in time and energy required to become PhD-level scientists. Yet in 1990, when 63 female US citizens earned PhDs in physics, over 5000 earned medical degrees. One would be hard-pressed to argue that physics calls for 80 times as much training, preparation and career commitment as medicine. Clearly, every year thousands of women with high skill levels and strong career goals earn advanced degrees in a variety of disciplines—but physics does not get its share.

Faculty positions. It has been suggested that women are not drawn to physics because the field lacks role models for them. In fact, over half of all physics-PhD-granting departments in the US do not have any women on their faculties (see figure 5). And in 1985 only about 110 women held professorial positions in physics-PhD-granting departments, out of a total professoriat of about 4600.

The percentage of physics faculty in four-year colleges who are women is higher than the percentage in universities—about 4.5% versus 2.5%. But four-year schools generally have much smaller faculties than PhD-granting schools, so less than one-fifth of the nearly 500 four-year college physics departments have women on staff.

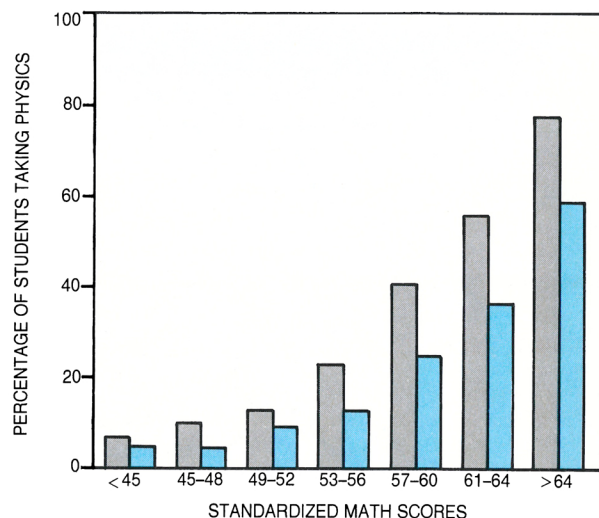
International comparisons. As table 2 reveals, the participation of women in physics is considerably lower in the US than it is in other developed countries. Admittedly, the years to which the data refer vary, and each country defines physics faculty differently. However, no matter how you examine the data, the US still comes out near the bottom.

Taking deliberate action

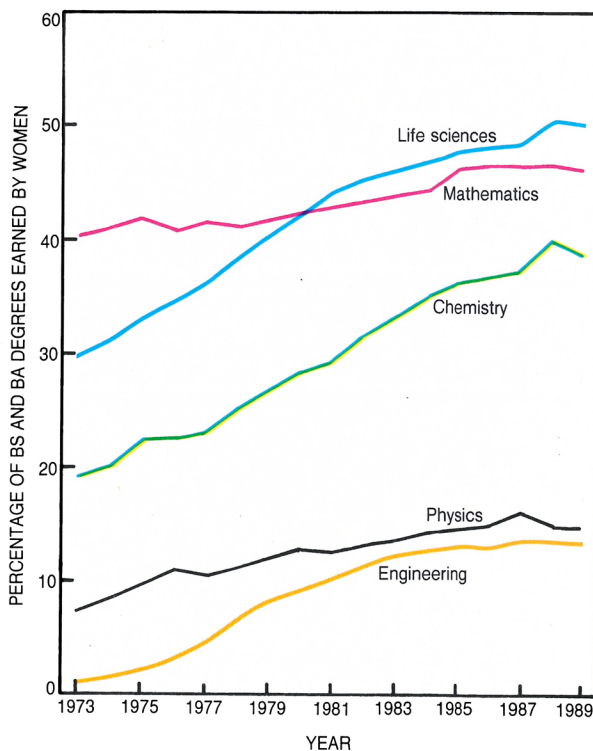
A number of deliberate actions—large and small, formal and informal—are necessary to reverse the exclusion of women from physics.

In academia, much information flows through informal channels—channels from which female physics students may be shut out. Physics departments should therefore make sure that all relevant information on summer research opportunities, jobs in the department, graduate school, careers and so on reaches women students. Women students, like their male peers, need help in career planning; departments must make sure that advisers work in the best interests of all the students, both male and female.

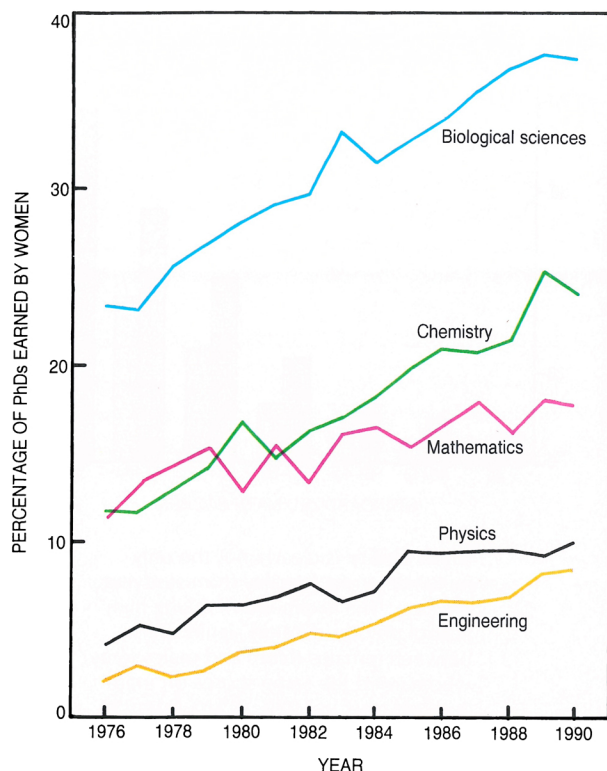
Other ways in which the physics department can help are to watch for signs of sexual harassment when reviewing faculty; to take the lead in forming a “women in science” club; to encourage nonthreatening, informal interaction between the faculty and students, such as weekly “physics lunches” for undergraduate majors and professors; and to invite students to receptions for



Math ability is clearly not the only factor deterring females from studying physics: The likelihood of taking high school physics differed significantly between females (blue) and males (gray) who earned the same scores on math aptitude tests in 1980. (Data from US Department of Education.) **Figure 2**



Percentage of bachelor's degrees in physics earned by women in the US compares poorly with the percentages in most related fields. (Data from US Department of Education.) **Figure 3**



Share of PhDs in physics awarded to women in the US has remained virtually flat since 1985, while continuing to climb (on average) in related fields. (Data from National Research Council and NSF.) Figure 4

visiting speakers.

Even if the physics department as a whole doesn't make a consistent commitment, the actions of one or two faculty members can still have an impact. As one woman physics professor recalled, "When I was a graduate student, having a couple of faculty members treat me as though I had promise as a physicist made a tremendous difference."

For whatever reason, women react more strongly to both positive and negative comments than do men: They are more encouraged by good grades and more discouraged by poor grades. The performance of women students is often improved when a faculty member accentuates the positive. But that doesn't mean lying; often it is a matter of putting things in perspective. For example, students often don't realize that grades in physics are usually much lower than in other disciplines.

In the classroom, the main rule is to avoid differential treatment of men and women. Some common complaints of female students, which are supported by research, are that teachers attribute their comments in class to male students and that teachers don't encourage them when they are answering questions as much as they do the male students. Faculty should therefore take pains to attribute comments accurately, encourage both men and women to give more complete answers, and avoid interrupting or allowing others to interrupt when students are speaking. Also, teachers should make sure to address questions requiring explanatory answers to both men and women; a common complaint is that teachers direct such questions at the men, while women are asked mostly questions

requiring simple factual responses. Faculty should use the same naming conventions for men and women, and eliminate sexist jokes and comments.

Departments need to keep a tight rein on teaching assistants: They can reverse much of the good a department is doing. Women students indicate that TAs often are the source of the most negative interactions for undergraduates—sometimes destroying a student's interest in physics during the introductory course. Women students complain of being hounded by male TAs who seem to view their female students as potential dates and of TAs who treat them as if they don't belong in physics. A department that does not properly train its TAs and clearly and explicitly set forth rules for appropriate behavior between TAs and students can effectively undo its commitment to recruiting and retaining women students. This is particularly true in large universities where much of the student contact is with the TAs.

The importance of women faculty

The presence of women on the faculty is crucial to drawing other women into physics. These women act as role models and advisers, and, more important, they reinforce the notion that women physicists exist and that there is room for them in the professional world. Many of the women who are now physicists were undergraduates at women's colleges, where typically at least some of the physics faculty are women. Imagine how much easier it is to drop out of physics if you are a woman who has never seen a woman physics professor, or any woman physicist for that matter, and if few of the other students in the department are female. Imagine how many men would become physicists if the situation were reversed—if they never met a male physicist, if 99% of the references to physicists, living or dead, were to women, and if one's "fellow" students were all female. (In the box on page 38, three women physicists describe some of the influences, both positive and negative, that affect women's careers.)

But how can a physics department increase the number of women on its faculty? The first step is the job interview itself. A department's commitment to women is reflected in how well and how professionally female job candidates are treated. Some readers may find it surprising that this matter is even mentioned, but unprofessional job interviews are a persistent complaint among women faculty. For example, women are often asked inappropriate or illegal questions about family issues, or they may be asked personal questions unrelated to the job for which they are being considered, while not being asked questions regarding professional issues such as research and funding.

Physics departments need to recognize and attempt to accommodate dual-career couples. Dual-career couples are common enough, but the fact that 45% of all female physicists are married to physicists further complicates the issue: Finding two positions in the same field in the same location can be very difficult. Progressive institutions are willing to discuss the situation, remain flexible and search for creative answers. One of the best solutions is to have formal administrative procedures that address this issue; some of the programs that schools have

implemented include offering one or two years of salary for the spouse of the faculty member who is being hired; arranging a sabbatical position for the spouse (not necessarily at the hiring institution); splitting a position between the spouses, with both halves being tenure track; and keeping a list of employment opportunities in the area.

Many female faculty and graduate students are torn by the competing demands of family and career. The reality is that women deal more with child care and the care of aging parents than do men; a flexible and supportive leave policy will help ease the conflict. The cost and availability of day-care for children are especially pressing concerns, as are the availability of health care for children and health care coverage for pregnancy.

Once a department has hired a woman, the temptation to "showcase" her by including her on every campus committee should be resisted. Female faculty are an important influence on female students, but this does not mean that they should carry the primary responsibility for recruitment of women students and faculty. Expecting women faculty to fulfill such showcasing duties on top of their regular faculty responsibilities places an unfair burden on them. However, if an institution or department really wants its women faculty members to concentrate on these service roles rather than on research, then it must have the agreement of the faculty members and must acknowledge these roles in its criteria for tenure.

The fact is that even without formal service assignments, women faculty often act as *ad hoc* ombudsmen for women students. Many women faculty report that female students come to them with complaints of sexual harassment or sexual stereotyping by other faculty members. Dealing with such complaints is time consuming and, more important, is often risky. It is not unheard of for women faculty members to face pressure and discrimination when they follow through on complaints from women students.

Changing the physicist's image

Most women never even seriously consider physics careers, primarily because of the long-standing stereotypes of the life-style and work-style of the physicist. Many young women may feel that it is impossible to be a physicist and "have a life"—get married, raise children, be active socially, pursue other interests—because physics would totally dominate their time. Likewise, many wrongly assume that the physicist works as a "lone ranger." These perceptions of a narrow life-style and lonely work-style combine to form the image of the mole-physicist, working day and night in the lab and speaking to no one until making his Nobel Prize acceptance speech. This erroneous picture makes physics unattractive to women who have been socialized to enjoy and favor working with others and to have lives beyond their jobs.

Such perceptions start early, so changing female students' attitudes toward physics should also begin well before college. A number of community-based programs exist partly to do this, including summer science camps, science fairs and outreach programs sponsored by the national labs. In general, though, colleges and universities are missing from this effort. A starting point would be

Table 1. Women earning advanced degrees in selected disciplines in the US

	1980	1990
Physics PhDs (US and foreign citizens)	67	149
Physics PhDs (US citizens)	45	63
Mathematics PhDs (US and foreign citizens)	95	158
Mathematics PhDs (US citizens)	73	82
Engineering PhDs (US and foreign citizens)	90	414
Engineering PhDs (US citizens)	64	248
MDs (US and foreign citizens)	3486	5138
MDs (US citizens)	NA	5084

Sources: US Department of Education and NSF. NA, not available.

for universities to get involved with local schools, from supplying guest lecturers to bringing high school teachers and students into research.

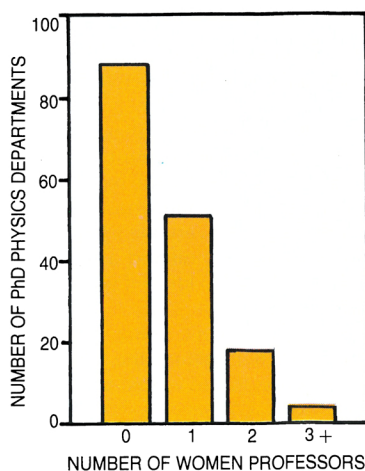
Parents should also be educated on the realities of physics. Most parents hold the conventional stereotypes of physics and physicists, and so they discourage any interest their daughters may have in the field. Physics outreach programs for middle school and high school students should therefore involve parents as well.

Keeping women in the pipeline

Few college students take physics courses with the intent of majoring in physics; more likely such courses are required for their intended majors or professions. The introductory course is often the only meeting ground between physics and the nonphysics student. Thus a department whose introductory course conveys the beauty and excitement of physics and its relevance to students' social concerns and intellectual interests can expect to recruit more majors.

In her book *They're Not Dumb, They're Different* (Research Corp, 1990), Sheila Tobias notes that attracting students to science involves more than just the content of an introductory course. Additional issues are "atmosphere," grading and approach to subject matter. Women physics students themselves have said that they are turned off when professors place them in female-only lab teams or problem-solving groups or schedule special sessions for them based on the assumption that women need more help in math and physics than do men.

When women progress beyond the first course, faculty



Over half the physics-PhD-granting departments in the US had no women faculty in 1985. (Data from AIP.) Figure 5

Warnings, Advice and Encouragement: Thoughts from Three Women Physicists



DONALD GOLDSMITH

Vera C. Rubin (shown with granddaughter Laura Young, the daughter of astronomer Judy Young) is an observational astronomer whose career has been devoted to studies of the motions of stars and gas in galaxies and of galaxies in the universe. Rubin earned a BA from Vassar College in 1948, an MA from Cornell in 1951 and a PhD in astronomy from Georgetown University in 1954. For the next ten years she worked at Georgetown, eventually reaching the rank of assistant professor of astronomy. In 1965 she joined the Department of Terrestrial Magnetism of the Carnegie Institution of Washington. The following excerpts are adapted from an after-dinner talk she gave at the November 1990 Conference on Recruitment and Retention of Women in Physics, in Chevy Chase, Maryland.

"You should do OK as long as you stay away from science," intoned my macho high school physics teacher when I told him I had gotten a scholarship to college. He was unaware of my serious interest in becoming an astronomer; his physics classes and laboratories were a boys' club in which the few girls were politely ignored....

I have asked other women scientists for the most outrageous statements made to them because of their sex and their profession. Here are a few chosen from those that I can politely repeat:

▷ "In my day we didn't have any contaminants," stated a 90-year-old scientist who returned to his former laboratory and found a young woman crystallographer working there....

▷ "Go and find something else to study," said the department chairman to the young woman entering graduate school....

▷ "Why don't you just go off and get married?" advised the young adviser to the woman student who came to him with a problem....

And then there are the little "playlets" that we are unwilling participants in: the eminent scientist who is assumed to be the spouse when she arrives at the registration desk with a colleague; the woman in a group whose hand is left dangling as the new arrival shakes everyone's hand but hers; the advanced professional who is offered a job at a fraction of her current salary. It is hard to know if we should laugh or cry at these tales....

What are we, the science establishment, doing wrong? I think our greatest failure is in not getting the fun and excitement of doing science across to the young; too many think that science is not for them. We have to show young

people that science is not drudge work in a dark, lonely laboratory. We too seldom stress that science requires imagination, creativity and ardor.

We are failing by not giving little girls role models early on.... Television is the worst offender I know in this regard, and I shudder at the TV commercials in which grown women discuss the color of their sinks, their floors, their wash....

We are failing by not nurturing every girl who enters college thinking that she wants to be a scientist. Such a student has already done something unusual in resisting peer and societal pressures. Yet every woman who enters college interested, prepared and intending to become a scientist, and then turns to another field, reinforces the view that colleges are often part of the problem rather than part of the solution....

My advice to women students: Don't quit. Muddle through. Get your "union card" (PhD) if you want to do research. Don't think you can't succeed if you're not first in your class, or even in the middle, or even below that. Academics admit to being notoriously poor in predicting which of their students will succeed in science. You will increase your confidence as you go along....

Although many of you may disagree with this, I routinely advise women undergraduates not to enter graduate departments that have no women faculty, and not to enter departments where they will be the only woman student. It's too hard. Equally important, I urge the student to tell the college the reason for her action. It is one of the very few weapons for change that is available to young women students.



BILL REDIC

Sara Majetich, an assistant professor of physics at Carnegie Mellon University, earned an AB in chemistry from Princeton in 1979, an MA in physical chemistry from Columbia in 1980 and a PhD in physics from the University of Georgia in 1987. From 1987 to 1990 she was a postdoc at Cornell, after which she joined Carnegie Mellon. Her research involves the use of lasers to study semiconductor nanocrystallites. The following excerpts are taken from a talk given at the November 1990 Conference on Recruitment and Retention of Women in Physics.

Now that I am an assistant professor, I look at the women students and see myself not too many years ago. I strive to help them avoid the problems that I encountered, and I try to ensure they receive the same benefits I did. When I ask myself if women faculty members do make a difference, my answer is without a doubt yes....

When I look back on my experiences since graduate school, I find that three factors helped me to succeed: my postdoctoral environment, my preparation for the outside

world while a postdoc, and efforts to help me cope with the problems of a dual-career marriage. . . .

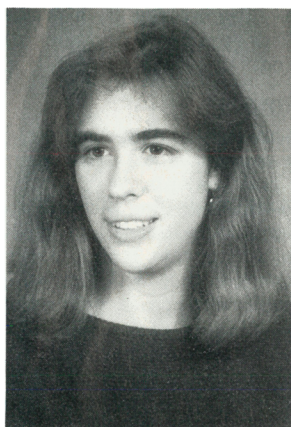
I noticed the different environment even while interviewing for my postdoctoral position [at Cornell]. Not only were there large numbers of women graduate students and two women faculty, but my future adviser referred to the newest female faculty member's "brilliant" experiments. I had never heard this adjective applied to the work of a woman scientist. . . . My postdoctoral adviser turned out to be a mentor as well, teaching me important professional skills such as proposal writing and group management, and giving me extra freedom to guide my research project. All of these small things taken together conveyed the message that I was important, that the faculty cared about the workplace environment and that they wanted me to be successful in the future. . . .

When I was ready to start interviewing for permanent positions, I found discussions with women faculty members particularly helpful. They told me what to expect, prepared me to handle the illegal but frequently asked questions, and suggested strategies to ensure that my scientific ability would be the focus of the interview. . . .

The problem of the dual-career couple remains intransigent. Right now the burden of commitment and flexibility rests solely on the couple, and it affects women disproportionately. . . . More effort should be made to find creative solutions. For example, my husband was offered a sabbatical position at Cornell while I was a postdoc. Though he didn't accept it, he took a one-semester sabbatical position at Carnegie Mellon when I moved there. Because dual-career couples are frequently encountered, it would help to have an official procedure for dealing with them. More often than not, I had to call the deans, provosts or chairmen of my husband's department to inform them of the situation and try to negotiate a solution once I had an offer. . . .

Not being taken seriously made it far more difficult for me to become an assistant professor. I found many prospective employers who refused to believe I would stay at a position that required me to live apart from my husband. . . . I was asked by a prospective postdoctoral adviser, "You don't really want this job, do you?" My reply was that if I weren't interested, I wouldn't have applied. . . .

I counsel women students to ask themselves if the advice they receive is really in their best interest. I encourage them to know their own goals and what is required to achieve them, so that they can judge for themselves.



Sarah Bolton is a third-year graduate student at the University of California, Berkeley, whose concentration is in experimental condensed matter physics. She earned bachelor's degrees in physics and biophysics from Brown University in 1988. The following excerpts are adapted from a paper she gave at the 1991 summer meeting of the American Association of Physics Teachers, in Vancouver, British Columbia.

One of the most important and frequently overlooked factors in women's lives as physicists is physical danger. Rapes do occur in and around campus buildings, and there have been several at Berkeley in the past couple of years. Although leaving buildings and labs unlocked at night may be more convenient, it is unsafe for the women who have to work there. This problem is even more critical for experimental scientists, for whom working at home is not an option. . . .

Sexual harassment is equally very prevalent. During my career I've experienced difficulties with both peers and professors, and most women graduate students I know have also found this to be true. . . .

Women also face other problems of a more subtle nature. . . . In graduate school, in particular, women seem to have problems joining the ubiquitous study and problem-solving groups. A woman I know said that when she asked a group of men if she could study with them, one man told her, "Well, when you're around I can only think about things other than studying, so I won't get any work done if you join us." . . .

When I won a place in a research program as an undergraduate, one of the men in my class stopped speaking to me. I finally found out through a mutual friend that this was because he "knew" that they had given me his place because I was a woman. The fact that my grade point average was approximately double his never seemed to enter his mind. . . .

There are 275 graduate students in my department. That means about 25 women graduate students. We have 3 women faculty at the moment and 5 or 6 women postdocs. So it's not difficult for us to build a network. A lot of women I've met are terrified of sending their women undergraduates to big schools, because they think that's a really intimidating experience. But it's the best experience I've ever had. I went to an undergraduate school where I was the only woman in the department and was totally isolated. . . .

We have a formal network for our first-year women graduate students. We send out a list of all the other women graduate students with their phone numbers in the lab and at home, so that they can call someone when a crisis happens. . . .

The value of discussing research with a group of peers who happen to all be women is very high. Most of us have never discussed physics with other women. . . . In the absence of role models, it helps a great deal in envisioning yourself as a physicist to sit with a group of women and seriously discuss your work. . . .

Along with networking, a couple of graduate students and I decided to do some grass-roots consciousness-raising. Although the department in general is supportive of women's issues, sexist incidents still do occur. One day we were sitting around discussing this problem, and we decided to hold an open meeting. In the middle of the night we put up posters all over the department with a three-inch heading: "Is There Sexism in the Berkeley Physics Department?" Much to our surprise, over a hundred people attended our meeting. . . . It started with a few women talking about things that had happened to them. Then a lot of men started to ask questions: "If I do this, why is that a problem?" and "Why is it that you guys [sic] behave this way, when we expect you to behave that way?" . . .

After the meeting, everyone stuck around and talked about whether there was sexism in the department and what they could do about it. . . . I don't know if anybody's mind was changed, but it certainly brought issues to the surface.

Table 2. Women physics faculty and degree recipients in various countries

Country	Physics faculty (percentage)	Recent PhDs who are women	Recent bachelors
Hungary	47	27	50
Philippines	31	60	28
USSR	30	25	34
Italy	23	21	29
France	23	21	24
Turkey	23	17	38
Brazil	18	31	24
Poland	17	17	14
Spain	16	21	17
Belgium	11	29	33
India	10	26	25
South Africa	9	21	24
East Germany	8	18	12
Ireland	7	20	22
New Zealand	6	11	10
Netherlands	6	4	20
Japan	6	4	7
United Kingdom	4	12	16
United States	3	9	15
Korea	3	5	20

Source: W. J. Megaw, "Gender Distribution in the World's Physics Departments," paper prepared for the meeting Gender and Science and Technology 6, Melbourne, Australia, 14–18 July 1991. Reprinted from *Women in Science and Engineering: Increasing Their Numbers in the 1990s*, Natl. Res. Council, Washington, D. C. (1991).

should encourage their early participation in research. Research allows women to become familiar with tools and apparatus, and the experience makes them more confident as physicists and gives them a better sense of what physics is really like. The department can help as an information clearinghouse and as a source for projects. What is important is to get students started on some hands-on activity, however mundane or unglamorous it may seem.

One approach that has been successful in retaining female science undergraduates is the Science Dormitory at Rutgers University. What started as one floor in a coed dorm has since become a separate building with a microcomputer lab, a resource library, a large lounge for programs and ten graduate students in residence. The science dorm has been effective in dealing with many of the issues described earlier: It provides an informal and inclusive science community; it is a place where peer support and encouragement develop; it furnishes a safe location for group work; and it offers formal and informal career guidance. Of course, this approach may not be the answer for everyone, but students who have lived in the science dorm feel that it made a difference in convincing them to stay in science.

To ensure that more women continue on to graduate school, departments should work to expand the pool of undergraduate women interested in graduate study rather than just focus on those who are already interested. In general, faculty should encourage all undergraduates to try for the best graduate program or most demanding career they are capable of; likewise all graduate students should be encouraged to apply for the best postdoctoral fellowships or the best positions in industry or academia they can handle. An additional caveat applies to women undergraduates, who may be naive about the "real world": A student should be advised against entering a situation where she is set up for failure—for example,

attending a graduate school where she is the only female among 150 students.

The physics department at Oregon State University has developed a successful program for actively recruiting more graduate school applicants and has subsequently increased the percentage of women in the department. After gathering lists of graduating physics majors from all US colleges and universities, Kenneth Krane, the department chair, sends a personal letter to each student, briefly describing Oregon State's program, along with a reply card. Each student who returns a reply card receives an application, a follow-up letter from Krane and a letter from the research group in which the student has indicated interest. Leading applicants are invited to visit the campus at the school's expense. Up to this point, male and female applicants are treated equally; during the campus visit, however, they are escorted by a graduate student of their own sex. This seems to permit a more uninhibited flow of information.

The need for commitment

We all realize that budgets are tight and time is short. But if an institution is truly committed to attracting and retaining women faculty and students, then it will be flexible, creative and persistent in dealing with the issues we have discussed. Genuine commitment and goodwill can often make a dollar go a long way. It should also be noted that most of the changes that will increase the number of women in physics will attract men as well: These days more men have family responsibilities and professional spouses, and in general they would also welcome fair treatment and a more inclusive community. Regardless of the specific projects or policies, physics departments and faculty that show a consistent commitment to valuing women as physicists will make progress in getting and keeping more women in the field. ■