

Women graduate students

When I started teaching solid-state-physics courses at MIT, nearly 20 years ago, there were very few women at MIT and very few women students in my classes. It was unusual for women students to ask questions in class or to participate in class discussions. As the number of women students increased, they participated more and more, and in very recent years their class participation has become essentially indistinguishable from that of the men. A turning point appeared to occur when the number of women reached a "critical mass" of about 10-15% of the students in a class. But in some other physics courses at MIT the critical mass hasn't been reached.

Although in 1983 only 2.7% of the PhDs working in physics and astronomy were women, many more women are now majoring in physics, both as undergraduates and as graduate students. As recently as five years ago, the AIP Manpower Statistics Division surveys showed only 10% of those earning bachelor's degrees to be women, whereas the class of 1985 had 14% women. Five years ago 6% of the PhD recipients were women; in the class of 1985, 8% were women.

The upward trend for women physicists is even more favorable in universities with a strong science and engineering focus. For example, in 1984 women undergraduates at MIT were 72% as likely as men to be majoring in physics, compared with 44% just five years before. Though this value has fluctuated from year to year by as much as 20%, the long-term increase is statistically unmistakable, and clearly visible in the classrooms.

At MIT we have an especially encouraging milieu for women students. Vera Kistiakowsky, June Matthews and I are all full professors in the physics department, and Margaret MacVicar, also a physicist, is dean of undergraduate education. George Koster, who is the executive officer of the graduate program, is highly supportive of women physicists. In my opinion, the department practices and believes in affirmative action; that is, if we have two applicants of equal ability, we give the benefit of the doubt to a woman. Over the years I have supervised only a few women doctoral students, but nevertheless the percentage of women among my total doctoral students (about 20%) is much higher than the national average.

Though women students today appear to handle the classroom environment on

an equal basis with the men, the same may not be true in the lab, based on my own experience supervising graduate thesis research. To obtain some meaningful data on the academic environment for MIT graduate students, the MIT Committee on Women Students' Interests conducted a survey in 20 academic departments. Last year the data were thoroughly analyzed for students in the department of electrical engineering and computer science, where in 1984 there were 642 students, of whom 15.7% were women. This year we analyzed data for graduate students in physics and other departments.

The most striking finding of the survey is the essential similarity between women and men graduate students in physics, a department where women represent 14% of the 297 graduate students. Based on the completed questionnaires of 25 women and 86 men physics graduate students, the differences between women and men were smaller in physics than in any other academic department. Essentially all men and women aspire to complete the PhD degree in physics. They were similarly supported during graduate study (by graduate assistantships, teaching assistantships and fellowship support). Neither women nor men experienced significant difficulty in finding research groups, and both men and women were generally satisfied with the types of research they were doing. Interestingly, the ratings women physics students gave their own research performance showed essentially the same distribution as those of the men; for almost all other academic departments, women graduate students perceived their academic performance to be significantly inferior to that of the men, though quantitative measures such as rates of passing qualifying exams and completing degrees indicated more nearly equal performance. Women physics students were as likely as men to present papers at conferences or to be first authors on publications, and women felt that they had no more problems than men in meeting deadlines, in contrast to patterns in many other academic departments. Perhaps the similar career expectations of men and women physics students and a critical mass of women graduate students has helped to create an approximately egalitarian environment.

Some differences between men and women physics graduate students did, however, appear in the survey. Although men and women spent about the same

number of hours per week in academic study, women spent significantly more time (about 10 hours per week more) than men doing research work and less time than men in leisure activities; these findings are consistent with those for the electrical engineering and computer science department. Women found the pace and pressure of graduate physics study more severe than did the men. Women students were more likely than men to feel the pressure imposed by their faculty supervisors or by peers. Women students felt that they got somewhat less help with their research work, both quantitatively and qualitatively, than did the men, and women felt they had slightly more trouble than men in developing research skills. Women students valued the help received from faculty and peers more highly than men did, and especially appreciated the opportunity to participate in group discussions. The "atmosphere" in the research group was more important to women than to men, and women were more apt to feel hindered in their productivity by the lack of availability of equipment or lab space.

With regard to courses, men were more critical than women of below-standard classroom teaching. However, women were more apt to feel that exams did not reflect their true ability than men, consistent with findings in almost all of the academic departments.

Although career opportunities for women in physics have become more numerous, many face the problem of dual-career families. Women graduate students in physics at MIT were twice as likely as men to be married and twice as likely to have children. Surprisingly, men complained more of social isolation than did the women, in contrast to my own perception of the situation a decade ago. Women graduate students found social interactions with peers less of a problem than did men. Over the years, I have noted an unusual number of close friendships among the women physics graduate students and a tendency for them to provide support for each other at stressful times. A small but not insignificant number of women (less than 20%) felt that their sex has hindered their achievement as graduate students in physics. I believe that this number would have been higher a decade ago.

Support by male colleagues has been very helpful to women in physics. It is increasingly common for male physicists to have high regard for their female col-



Sarah L. Gilbert is adjusting a ring dye laser used in her thesis research at the University of Michigan.

leagues and to recognize their contributions to physics. In fact, women have been more likely than men to win elections of The American Physical Society, both at the society level and within the divisions. Nevertheless many physics departments in universities and industrial and government laboratories still have no women physicists on their staffs.

In fields where research results can be evaluated quantitatively, women students tend to feel more secure about their performance relative to that of men. I think women who choose careers in physics, a field where they can expect to be significantly outnumbered, are generally more confident than those in other fields. But they nevertheless need reassurance. Big discoveries are usually made by taking risks, and women are less apt than men to go off in unknown, risky directions. Women students like to review their work with their supervisors and seek to please them by doing what is expected of them. I believe that on the average they get less feedback from their male peers and supervisors because men hesitate to criticize women. So if a woman doesn't receive a promotion she expected, she's surprised. These problems suggest the urgent need to train our women students to be even more independent than the men.

Affirmative-action programs advocate that with two otherwise equal job candidates, an employer should choose the woman in preference to the man. Such programs at Bell Laboratories and IBM, for example, have created a positive ripple effect. Consequently these two laboratories have attracted very strong groups of women in solid-state physics. Once women are in good jobs and doing well at them, they provide more role models for younger women to emulate.

Sometimes a male thesis supervisor can't visualize a woman as being suited for one of the better jobs and instead recommends her for an inferior one. But if he overcomes this mental block, places a woman in a good job and finds that she does well, he becomes converted to helping more women and may encourage other men to do likewise.

It is clear to me that on the average, women students at both the undergraduate and graduate levels perform better when their numbers reach a critical mass, which operationally means when there is another woman student in the classroom or in the same or a neighboring research

group. Their mutual support and shared experiences enhance their confidence and their ability to cope with problems in the academic environment. Faculty and administrators should appreciate this point.

Graduate-student networks are very successful in helping women research students cope with the social and interpersonal problems they commonly face. (Minority students likewise find these student networks essential.) Faculty members should be sensitive to these problems and supportive of student networks.

I have noticed, both with my own students and through the student survey discussed above, that women graduate students, on the average, seek more attention, feedback and help than men, though individual students differ greatly in this regard. Though faculty should be careful not to treat students as stereotypes, sensitivity to this point might be constructive. At MIT, a doctoral student makes a presentation to his or her thesis committee each term. Women students take the event and the feedback more seriously than men students. The average performances of men and women on the various doctoral exams are almost exactly the same. But the women tend to be more anxious about exams than the men and to feel they haven't done as well, even when the results later turn out to be equivalent. I hear from other MIT faculty women that such self-deprecation is typical of women students from department to department.

I have the impression that young women have a greater fear of failure than young men and prefer asking their peers and superiors for help over working on their own to reduce the possibility of failure. I've observed that significant success at an intermediate stage in the thesis work enhances a woman's confidence level and makes her more independent and productive; this is of course also true of men students. Clearly, effective faculty supervision should lead to early student independence.

Women students have a tendency to be more conscientious and to work longer hours. This characteristic should in the long run be an advantage, though in early graduate-school years it may just be a response to insecurity and the need for more help from peers and faculty. Faculty can be especially helpful in channeling this extra effort into productive areas and in helping a student set better priorities for the use of her time.

I believe it is fair to say that women have come a long way in the last decade in gaining equal access to physics research. It is also fair to say that if the opportunities for further gains in the next decade are taken, we will see better use of talent and more rapid progress in physics.

After carrying out the survey of graduate students at MIT, we became aware of a similar survey that had been conducted² at Stanford University. It is impressive that though the questions and approaches of the two surveys were substantially different, they reached similar conclusions with regard to the overall similarities between women and men graduate students, as well as with regard to differences. I hope that the greater anxieties, pressures and insecurities experienced on the average by today's women graduate students will soon vanish as more women enter and contribute importantly to physics. Though much has been gained in the past decade, there is no doubt that much remains to be done.

References

1. M. S. Dresselhaus, *IEEE Trans. Educ.* **E-28**, 196 (1985).
2. L. Zappert, K. Stansbury, "In the pipeline: A comparative analysis of men and women in graduate programs in science, engineering and medicine at Stanford University," *Campus Report* (Stanford Univ.), 14 November 1984, p. 11.

MILDRED S. DRESSELHAUS
Massachusetts Institute of Technology