

EDUCATIONAL PIPELINE ISSUES FOR WOMEN

Nancy G. Leveson

Information & Computer Science Dept.
University of California, Irvine
Irvine, CA 92717

In July, I was asked to give a panel presentation at the CRA Snowbird meeting on educational pipeline issues for women. This is a transcription of that talk with some added information that there was not time for at Snowbird. Much of the information in this presentation comes from Sheila Widnall's excellent paper in Science (September 30, 1988, pp.1740-1745).

A cartoon by Gary Larsen depicts a baby in a park crying and two birds sitting on the baby carriage. One bird says to the other, "It's still hungry ... and I've been stuffing worms into it all day." I have found that there is no lack of good will and good intentions with respect to including women and minorities in our field, but our efforts may not always be well-directed.

We need to understand the dimensions of the problems we face before we can devise effective solutions and not just keep stuffing worms into the baby. Although I will focus on the problems of women, most of the statements I will make are equally true for underrepresented minorities.

THE SCOPE OF THE PROBLEM

The Taulbee report shows that the percentage of Ph.D.s in Computer Science going to women has remained relatively steady at 10-12% since 1978. In comparison, the percentage in the physical sciences and mathematics is now at 17% and has been steadily rising. Only engineering is below us with about 8%, although it too has been steadily increasing.

Women make up 6.5% of the tenure-track faculty in the Ph.D.-granting departments included in the Taulbee Survey (7% in CS faculties and 3% in CE). Things look even worse when the distribution of female professors is considered. About one third of the Ph.D.-granting departments do not have a single female professor.

The small number of women in academic positions means that there are few role models for women students to demonstrate that an academic career for women is possible. Some female graduate students at universities where there are no female faculty have complained about their feelings of isolation. A woman who has been a faculty member for a long time writes:

“As a woman who has served for many years as a computer scientist within a college of engineering framework, I have either been the single woman, or one of two women, within the entire college. As a graduate student, I never had a woman professor. As a young assistant professor, I occasionally encountered real hostility from engineering students who felt that I did not fit their image of the professor. Twenty years later, I am one of at most two women that my students will encounter in their undergraduate (and sometimes graduate) careers. Yet there are many more women students in my classes. There is still a considerable reserve on the part of my male colleagues toward the hiring of women in general. And in some cases, there is overt hostility.”

UNDERGRADUATE EDUCATION

Women drop out of the natural science and engineering educational pipeline primarily when choosing an undergraduate major and during graduate school. An OTA report described an initial group of 2000 male and female students at the ninth grade level. At the end of high school, 280 males and 220 females will have completed sufficient math to pursue a scientific degree. The first big drop occurs with the choice of majors in college: 50% of the qualified males choose a scientific career compared to only 16% of the qualified females. Once the choice of a major is made, women actually are more likely to complete their degrees (45% to 33%), and they enter graduate school in the technical specialties in proportion to their attainment of bachelor's degrees. But a combination of attrition and stopping at the M.S. degree creates the second major drop for the women students in the pipeline.

The first major decline for women in the pipeline occurs when choosing an undergraduate major. Computer science has, in the past, done relatively well here with around 35-37% of bachelor's degrees in CS awarded to women. Although no careful statistical analysis has been made, I have found some evidence that in the past 2-3 years the number of female undergraduate computer science majors has plummeted, without a correspondingly severe decrease in other technical majors. This may be one factor in the drop in CS majors seen nationwide. At the University of California, Irvine, 36-38% of bachelor's degrees in computer science used to go to women, but this percentage has now dropped to 15-20% while percentages of female science and mathematics majors have stayed constant or increased slightly (female engineering majors decreased slightly). After checking with several universities around the country to see if this is just a local problem, I found our experience is typical of most of the schools I contacted. The reason is unknown.

For those who do choose a technical major, the stage for graduate school is set in their undergraduate education. In 1981, 80 high school valedictorians in Illinois (46 women and 36 men) were followed through their college years. These students all graduated at the top of their high school classes, and by their senior year in college were still doing well, with the females slightly ahead in terms of grade point average (3.6 for the women versus 3.5 for the men). However, there were distinct differences between the two groups in terms of their self-esteem.

The two groups were comparable at the end of high school when asked to estimate their intelligence relative to their peers with about 20% of each group placing themselves in the highest category. But while the self-esteem of the men increased slightly during their college years, the female self-ratings dropped significantly despite the objective record of their success in school. The biggest drop occurred by the sophomore year where the same percentage (20%) of the men still placed themselves in the highest category but only 3% of the women still did. By their senior year, not a single woman rated herself in the highest category whereas 25% of the men did.

Something is happening to women in college, and researchers have attempted to find out what it is. Studies using videotapes and observations of the college classroom have found that women receive different treatment than men. Professors remembered the names of men better, called on them more, asked them more challenging questions, listened and positively responded to them more, etc. Both men and women teachers display this behavior. They are quite unconscious of it and are usually shocked to see it in the videotapes of their own classes. It is interesting to note that graduates of all-women colleges are proportionally more successful in mathematics, science, and business careers than women graduates of coed schools.

A woman who recently received a Ph.D. in Computer Science writes:

“I want to respond with a few comments about oppression in the classroom. I think it is very subtle, and the women who experience it have so little power to do anything about it. ... I can't tell you how many times in a math class I gave a suggestion for a proof and got no response from the professor, only to have one of the nearby males in the class suggest the same thing a few moments later and be congratulated for a good suggestion. I hate this -- I never forgot how much this hurt and actually came to expect it after a while. Even in graduate school, I have seen my ideas met with coolness while similar ideas from my male colleagues were recognized. I suppose all of this is what drove me to female advisors for every graduate degree I earned.”

“I have recently attended some undergraduate classes once a week to refresh my memory of the class level (before starting to teach next fall). I was saddened by something I observed there. Guess what? The instructors (even a female TA) only called on men. While I certainly did not expect them to know every student by name, I found that the only students whose names they knew were men. ... When group presentations were made, I was again depressed by the attitude towards an all-female group. The other groups' presentations were accompanied by playful chatter and lots of feedback from the audience. When the female group had their turn, the room was very quiet. It was as if they were trying to be more polite, but it would have made me feel like an outsider. The instructor also used a tone of voice much different than he did with the other groups -- more like a tutor or something.”

“Anyway, if I could have avoided this type of environment when I went to school, I think I would have a much better sense of my own ability and would expect greater achievements for myself. I don't think the women in the classes I have recently

observed will think of computer science as a place where they belong.”

Although she had an outstanding graduate career and shows great research potential, this woman decided to seek employment at a university without a Ph.D. program.

GRADUATE SCHOOL

The second place where women are dropping out of the pipeline in large numbers is during graduate school. There have been major studies of male and female students preparing for scientific and technical careers at Stanford (1984) and MIT (1986,1987). At Stanford, 627 graduate students in medicine, science, and engineering were surveyed while 1476 students in all departments at MIT were queried.

In general, these studies found women were indistinguishable from men in objective measures of preparation for graduate school (women had slightly higher GPAs), career aspirations, and performance (in terms of graduate school GPA). They differed significantly, however, in financial support, self-confidence, the pressures and roadblocks they encountered, and the strategies they developed for coping with these pressures. Let's examine each of these.

Financial Support:

A larger percentage of women than men is to some extent self-supporting during graduate school. (The disparity in self support is even greater for blacks.) Women are less likely to get financial support of any kind, but if they do, it is most likely to be a TA-ship. TA-ships are the least desirable form of support since teaching delays acceptance into a research group (which is most facilitated by an RA-ship) and offers less time for work that will lead to successful completion of a degree. A smaller percentage of women graduate students than men in all fields of science are supported on RA-ships.

Self-Confidence:

A well-documented phenomenon called the “imposter syndrome” with an accompanying fear of being “found out” is found in much higher percentages of women and minority students. I think a major reason for these feelings is the lack of role models. White males have lots of successful men with whom they can identify -- they benefit from the self-reinforcing concept that they “belong.” On the other hand, women and minorities have few role models who have been successful before them, and they often feel like outsiders.

In questions on the Stanford survey to elicit information about self-confidence in academic settings, women consistently scored lower. Twice the percentage of women than men questioned their ability to handle the work (30% to 15%). Half the percentage of women than men stated that they felt confident speaking up in class (30% to 57%) while

33% of the women (versus only 9% of the men) feared that speaking up would reveal their inadequacies (the imposter syndrome rearing its ugly head).

A higher percentage of women in the Stanford study reported that their preparation for graduate school was inadequate despite objective data showing their academic backgrounds were comparable to their male peers. Women, in general, tend to downgrade their capabilities. Many studies have shown that women tend to explain their success in terms of hard work while men explain their success in terms of innate ability.

Pressures and Roadblocks Encountered:

Stress is an integral part of all graduate education programs, but women more than men appear to experience feelings of differences from the majority, feelings of powerlessness and invisibility, and feelings of increased pressure and isolation.

During their graduate education, women may be unintentionally excluded from informal social interactions between faculty and grad students or they may get the impression that they are unwelcome at such gatherings. Racial minorities also experience this same type of social isolation. In the MIT survey, women often concluded that this was a direct reflection of the quality of their research.

Women report less satisfaction with the information available from department channels on the structure of qualifying exams and financial support policies. Much of this information is available informally through the student network, but women are less well integrated into these networks.

Women experience academic isolation in addition to social isolation. The MIT and Stanford surveys showed that women meet less frequently with their research advisors. More women than men report that their interaction with faculty do not provide helpful feedback on their research projects. Some of the communication problems between women and their male advisors may stem from the fact that women may be seeking a different type of information than basic research guidance. Because of their usually different backgrounds and exclusion from important social networks, women often need and want advice about the political aspects of graduate and academic life, i.e, how to “play the game.”

Women report more often that they do not feel free to disagree with their advisors and that their ideas are not respected. A very disturbing result of the Stanford survey was that 20% of women versus only 6% of men reported never having major responsibilities within their research group. This has important implications for self-confidence and for gaining the skills necessary to be successful in an academic position. In both the MIT and Stanford surveys, women graduate students reported less opportunity to publish or less frequently being first author on publications. This coincides with other studies that show that women in all the sciences and engineering have fewer publications upon completing a doctoral degree than men.

Perhaps the lower self-confidence and self-esteem of women merely reflects what others

feel about them. Women give their advisors a great deal of power in assessing their ability, and women are apt to internalize and validate their perceptions of this assessment. This is not surprising since women in our society are taught to be more receptive to social cues, that is, to be more externally-oriented socially. Lowered expectations by an advisor, whether conscious or subconscious, are quickly perceived by the female student.

There is a great deal of evidence to support these hypotheses of lowered expectations and lowered evaluations. Studies where male and female names are applied to resumes, proposals, and papers and then evaluated by both males and females consistently show that the documents with women's names attached receive lower evaluations from both men and women evaluators compared to the same documents with male names attached.

In addition, studies of group meetings show that women are interrupted by men much more frequently than are other men and that women's contributions are often ignored or attributed to one of the men in the group. I'm sure that most of the women reading this have experienced this behavior. Occasionally, to save time, I just ask a man sitting next to me to make my suggestion when I think I have the solution and I am anxious for a meeting to end.

Finally, women often experience additional pressures that men do not have to face. Many studies show that women graduate students report being subjected to inappropriate treatment by faculty and student colleagues. Women students report the necessity to continually fend off such inappropriate behavior in order to be allowed to concentrate on the professional issues of grad school.

Even today, there are still a few faculty members who publicly, or in discussions with faculty colleagues, take the position that women do not belong in grad school. There are instances where these types of statements have been made in graduate classes. This behavior is usually tolerated and seldom publicly challenged by their colleagues. Department chairs are often reluctant to speak to a faculty member about this even after several complaints have been recorded.

I have found that complaints by women graduate students of inappropriate behavior by faculty members are often not taken seriously by male faculty, even when there are repeated instances of the same behavior reported independently by several students. Because of this and because of fear of jeopardizing their careers, most women are reluctant to speak up.

Here is how one graduate student at a world-class research university described her experiences as a student -- unfortunately, her experiences in graduate school are typical:

"I was very lucky in my early career development, because I was given a lot of mentoring that allowed me to develop some self-esteem. I worked as a computer operator before starting college and had a supervisor who, knowing I eventually wanted to become a programmer, encouraged me to work on programming projects, taught me how to write project proposals, and just generally let me know he thought I was doing good work. When I got to college, my boyfriend listened to me

complain about bugs in the material for the introductory programming course, convinced me to send mail to the professor about it, and later encouraged me to request my instructor as an academic advisor. Probably as a result of this, I ended up with an advisor who told me how good I was a lot and kept giving me scholarship applications to fill out. I won two of the scholarships, one of which is paying for my current graduate work.”

“In contrast, my master’s work was absolute hell. I had a supervisor who was supremely inattentive, and even when we did get together we were on such different wavelengths I never understood anything he said. The only other person there whose work was closely related to mine wanted me to be his mistress. I was in a different city from all my friends. I’m not sure I would have gotten through that if it weren’t for the knowledge that I’d put four years into it already that would be wasted if I didn’t just keep on plugging. It’s been three years since I finished it, and I’ve just in the past six months started to feel good about my academic work again. I would have dropped out when I got my master’s, but I was so wasted I messed up my job interviews. I ran out of money, and had a scholarship to come back here, so I went ahead and registered.”

“It seems like every other woman grad student I’ve talked to has also decided to drop out at some point then stayed after all due to some sort of fluke. Are there any of us who continued in school through other than an act of the Fates?”

“I am still having difficulty in getting anyone to acknowledge my work in grad school. I’ve gone through several advisors so far on my Ph.D. research, and the only response I’ve gotten is polite indifference. An example is that providing a financial supplement to scholarships is standard practice at our school. But the one time I got up the courage to ask for it, I was told the professor would ‘rather save the money for a new grad student’ (what does that make me?) So I’m mostly making progress right now due to sheer, stubborn rebelliousness.”

Strategies for Coping with the Pressures:

In the Stanford and MIT surveys, most of the comments were complaints about the current system. But there were subtle differences in the responses of women and men. Men often expressed anger at the system and suggested ways it should be changed, while women more often described the effect that the current system had on them and expressed feelings of frustration and discouragement. Widnall presents two typical quotes from the surveys:

- 1) From a man: “The absolute insensitivity of the professors, department, and university to the inevitable depression experienced by young scientists when their research doesn’t work so well. The university’s willingness to ignore all graduate students but the top 10% elite...”

- 2) From a woman: “Despite denials, as a woman in ... science, I had something to prove -- and yet the most difficult part about it is that I don’t know what it is or how to prove it. There is just the knowledge that I have at least one more test to pass than my male counterparts. Or maybe it’s one more test to pass daily.”

Many more women report serious consideration of dropping out of graduate programs. There is little data on the actual attrition rates, but anecdotal evidence suggests that women do drop out at a higher rate. One recent study of graduate women in four departments (chemistry, physics, computer science, and electrical engineering) at a leading research university found that women graduate students had an attrition rate that was double the rate for men. In the Stanford study, 23% of the women versus 9% of the men reported that they thought they were on the verge of a nervous breakdown.

A self-fulfilling prophesy seems to be operating here: Prior socialization diminishes the level of self-confidence of women before entry to graduate school. The graduate school experience further erodes their level of self-confidence. The loss of self-esteem leads over time to lowered performance and lowered career objectives. Women are more likely to be underemployed with respect to their academic training, and they are paid less at all levels in computer science (as well as in all other technical fields).

WOMEN IN FACULTY POSITIONS

And what happens to the few women who do make it through the pipeline? Whether through choice or through exclusion, women hold fewer faculty positions in CS and CE Ph.D.-granting departments than would be expected by the percentage of doctorates they receive. The number of women at the higher levels of academia in CS is extremely low (and almost non-existent in CE).

There is one recent study that attempted to examine this problem with respect to faculty in chemistry, physics, computer science, and electrical engineering at a leading research university. Because only one university was involved and the numbers were quite small, it is difficult to generalize from the results. But they do not seem untypical of what I have experienced or what I hear from other women faculty. The researchers surveyed 117 faculty members including five women (two each in computer science and physics and one in chemistry). One woman was tenured at the time of the study and two recent former women faculty were also interviewed.

The women faculty members generally felt that they had a precarious toehold in academia, even when they were quite successful. They also reported differential treatment of junior male and female faculty by the senior male faculty members, especially regarding invitations to participate in joint research grants.

It is common for female faculty who are not in the top two or three CS departments to have difficulty in making inroads into the funding agencies. They are less likely to have a mentor that helps them to learn the ins and outs of funding and that introduces them to the right people at these agencies. Women who try to make their way into these agencies

alone may be considered to be “pushy” or, because of socialization, they may feel uncomfortable about displaying the type of aggressive behavior required to accomplish this. A woman professor who has been very successful in the CS research community writes:

“When I arrived at the university as an assistant professor, I noticed that new male faculty seemed to be quietly taken under the wing of the senior male faculty and introduced into the funding agencies. When I asked for names of people I could contact, everyone seemed to have selective amnesia -- they couldn’t even remember the names of their own contract monitors. I finally got the name of someone at AFOSR and, after several days of getting up enough nerve to contact him, I nervously made the call. He was quite cold, told me they weren’t interested after listening to me for a couple of minutes, and hung up. Luckily I have been very successful at getting NSF and industrial money because I have never had the nerve to approach another DoD agency.”

Computer science proposals submitted by women to NSF are as likely to be funded as those submitted by men, but in many of the other funding agencies, women are underrepresented in relation to their proportion in academic positions.

Two of the women in the study mentioned above had resigned their positions to take appointments at teaching colleges where they felt that they would be better accepted. Given that there were only seven women in the four departments surveyed, two women constitute a significant proportion. I have heard recently of two women who have given up tenured positions at research universities and dropped out of computer science completely.

Sue Rosser in *Female-Friendly Science* (Pergamon Press, 1990) reports a communication with a woman research scientist that describes her despair over the fact that she and most of her female colleagues were considering quitting research:

“Despite the fact that I have tenure and am very successful at getting grants, I’m thinking of leaving science. I shouldn’t quit because I’m really very good at it. However, I miss relationships with other people, particularly women. Every time another female colleague opts out of scientific research, I become a bit more isolated. I’m not sure how much longer I can continue to hang in there.”

The social and academic isolation of women is not unique to graduate students, but continues and perhaps even gets worse when women attempt to take their place in academic and industrial research.

The feelings of invisibility also persist. Although in most CS areas women are successful in getting their papers accepted in prestigious conferences and journals in the same proportion with which they are submitted, they are not always equally represented in the more subjectively selected positions in our field such as program committees, distinguished lecturers, invited and keynote speakers, colloquium speakers, editorial boards,

etc. Studies have found that when asked to suggest names for invited speakers, both men and women are likely to think of only men. When asked specifically to suggest women, they have no trouble producing women's names, and there appear to be no differences in terms of quality of those on the two lists generated this way. This becomes a vicious circle -- those who are often invited to speak are also those who people think of when they are issuing invitations. It is not surprising then that women often have less visibility than the quality of their research warrants.

WHAT CAN WE DO?

Although there appear to be some specific problems that stand out at each stage of a woman's career, e.g., classroom discrimination as an undergraduate, advisor/mentor problems and learning opportunities in graduate school, funding and visibility problems as a professor, there are also some themes that are constant throughout -- feelings of powerlessness, isolation, and invisibility, attacks on self-esteem, and exclusion leading to feelings of being an outsider and not belonging. None of these problems will be easy to solve, but there are things that can be done.

Increased awareness on the part of faculty of their differential treatment of male and female students will help as will providing opportunities for female undergraduates to participate in research projects and interact with faculty and graduate students outside of the classroom. The Illinois Valedictorian Project found that the most successful antidotes to women dropping out of the pipeline after a bachelor's degree were the opportunity of women undergraduates to have some successful professional experiences in terms of participating in independent research with a professor, professional employment, opportunity for interaction with graduate students, and support and encouragement by a faculty mentor. These are all things that we could provide in computer science.

The climate for female and minority graduate students can be improved by providing mentoring opportunities and trying to break down the barriers to communication between faculty and female graduate students. At UCI, Prof. Debra Richardson and I try to meet monthly with the female CS graduate students to provide support and information. There are also more formal mentoring programs at both the undergraduate and graduate levels. In these mentoring programs, the female or minority student writes a proposal with a faculty member (male or female) and, if selected, receives financial support to work on the project. A voluntary mentoring program for women faculty is also in the planning stages. Other universities have similar programs. Schools could set up programs to provide mentoring and role modeling for undergraduates and graduates at other universities when there are no female faculty at their own school.

All of us can publicly challenge professional colleagues who make prejudicial or inappropriate remarks about female or minority students and increase our sensitivity to the seriousness of women as professionals. We can also attempt to include qualified women in appointed positions and as invited speakers to help them feel they are a part of the community and to increase their visibility.

Providing help to junior faculty members equally, regardless of sex or race, will help them to rise to a level commensurate with their abilities. We need to remember that they may need extra information, advice, or support due to inequalities or deficiencies in their previous experiences.

There are lots of other possible approaches we might try to solve some of these problems. More suggestions can be found in my report for NSF titled "Women in Computer Science" (available from Harry Hedges at NSF (202) 357-7349 or by sending a request to leveson@ics.uci.edu).

Scientific and technological progress will reach its fullest potential only when those with the most ability, regardless of gender or race, have an equal opportunity to participate and contribute.