Women in Statistics in Academe:
Mentors Matter

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ABSTRACT
Federal and state agencies, private industry, and professional societies are developing programs to encourage women to enter the education 'pipeline' for careers in science and technology. To reverse female students' underrepresentation in science and to retain in-coming women in these fields, especially those entering academia, requires the active support of women and men faculty as mentors. The focus of the present manuscript addresses this issue. Here, we give a profile of women in statistics, and more broadly, in the sciences, and we outline the elements of a good mentor. Statistics are presented in support of our argument, but case studies form the basis for the recommendations.

INTRODUCTION. Female scientists in academia are few in number. Women drop out of the education pipeline before arriving at the professional pool of individuals with science doctorates. Those women who do obtain doctorates in science and then enter academia may not find a warm, welcome environment. Hornig (1979) asks us to consider whether some simple adjustments in the training of scientists might not make these disciplines more attractive and more rewarding for women. The position advocated here is that change will occur when the men and women of the academy take part in improving the academic climate. Perhaps more than any institutionally sponsored program, the individual efforts of scientists as mentors are essential for increasing the participation of women in the sciences.

The benefits of mentorship are difficult to measure quantitatively (Merriam, 1983, Merriam et al., 1987), but in academic settings it is commonly accepted that having a mentor is a decided advantage at the start of a career (Simeone 1987, Hall and Sandler

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1983). My own experiences in the academic world support this assumption; they also support the belief that women in the sciences may need particular assistance for finding mentors (Miller, 1976, Rowe, 1981). To this end, identified here are the elements of mentorship that enable a new scientist to come into her own. These elements provide a relationship context from which junior researchers can develop professionally and participate fully in the scientific community. Ideally, this scientist can then pass on the benefits she received from good mentoring as a role model for younger women. Also discussed are ways senior researchers and administrators can foster a work environment in which mentoring is encouraged. The ideas put forth here are grounded in my experiences as a new, female statistician in academe. I have also taken note of the experiences of other female scientists at other universities and of the literature on mentoring. It is my hope that these ideas will be adopted by the men and women in academia to the benefit of women in science.

BACKGROUND. The following statistics on women's participation in the scientific community are presented to provide a context for a discussion of mentoring. These data include figures on the representation of women in the sciences and the loss of women from the science-education pipeline.

First from a historical perspective, in the early part of this century in America, statistics along with botany, microbiology and clinical psychology was a "feminine" science.[1] Employment figures for the federal government in the 1930's show that, next to nutrition, statistics was the most highly feminized scientific field. Ironically, at the time, only ten percent of the federally employed statisticians were women.

This relatively large concentration of women in a scientific field is attributable to the convergence of World War I and advances in the area of survey sampling. From

1. The historical perspective of women in statistics is summarized here from Margaret W. Rossiter, *Women Scientists in America: Struggles and Strategies to 1940*, (1982) Johns Hopkins University Press.

1916 to 1919 the federal government hired 250,00 clerks and stenographers, and as the war took men out of the work force, most of those hired were women. With innovations in survey sampling (Kruskal and Wallace, 1980), statistics became a growing field in the government in the twenties and thirties. It grew out of the existing social services, and it was from the clerical positions within these services that women were able to become statisticians.[2] In 1938 the Bureau of Labor Statistics reported that the federal government employed 855 mathematicians and statisticians, and 85 of them were women.

Fifty years later the situation shows little improvement. The National Science Foundation estimates that the federal government employs 281 Ph.D statisticians, approximately 11 percent are women. In the academic world the situation is much the same. According to the 1938 edition of *American Men of Science,* women comprised nearly ten percent of the mathematicians in the academy (forty percent of whom were employed by women's colleges). Currently almost 2,000 Ph.D statisticians are employed in educational institutions in the United States, and women's participation is also about 11%. [3]

Women's numbers decrease relative to men's as they proceed through the education pipeline to a doctorate in science. For example, according to the annual reports of

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2. In 1921, the Bureau of Vocational Information of New York City published "Statistical Work: A Study of Opportunity for Woman." The publication presented evidence for the new job opportunities for women as statisticians. There it was said that in 1918 nineteen women took the Civil Service test for "statistician", all nineteen passed the test and two were hired. One year later, 49 women took this exam, again all passed and this time 12 were hired. Also, that year 639 women took the Civil Service test for "statistical clerk", 245 passed and 91 were hired.

3. Since 1973, the National Science Foundation (NSF) has conducted a biennial survey of the population of individuals in the United States with doctorates in science and engineering. From the 1989 study, NSF estimates the number employed with doctorates in science and engineering to be 448,643. Of these 17.2% are women. Looking at the mathematical sciences, women's representation drops to slightly less than 10%, and for statistics alone, NSF estimates the number of employed statisticians to be 2,744, of which 320 (11.7%) are female. (These figures do not include biostatisticians, econometricians, or social statisticians.) Additionally, approximately 60% of the female and 75% of the male Ph.D. statisticians are employed in educational institutions. Standard errors for these percentages are roughly 1.8%.

the Committee on the Status of Women in Economics [4], in the late 1980's, women were awarded roughly one-third of the BAs in Economics, and one-sixth of the doctorates in the United States. A similar example, on a smaller scale, is seen at the University of California at Berkeley. In the five year period from 1986 to 1990, women were awarded 46 of the 100 BAs in Statistics and 18 of the 97 Ph.Ds. In this same time period, women received 38% of the 1309 BAs and 25 of the 99 Ph.Ds awarded in Economics.[5]

CURRENT CLIMATE. The numbers cited above serve as a background for discussing the challenges facing academic women in science. In interviews with twenty academic women at a large northeastern university (Simeone, 1987), one faculty woman describes the problem:

I think it's the opportunity that differs now; because so much of what goes on in academics is subjective. So much is access to discussing a project over a drink and then going on to work on a paper together and that kind of camaraderie that generates research interest and brings an entering assistant professor into understanding research and active participation is often closed to women ... And then there's the fact that a lot of men just don't feel as comfortable talking over research with a woman as with a man, and these are the same people who, I think, would treat a male and a female with the same record equitably in terms of promotion and in terms of giving them a job. It's just that once they're here - they don't get the same access.

Many of my female junior colleagues at other institutions have expressed similar experiences where they were treated differently than their male junior colleagues by senior (male) colleagues. Their experiences include not receiving invitations to dine with, not having the opportunity to play sports with, nor being included in impromptu lunches with senior colleagues. Others include annoying, yet perhaps less serious, instances of being mistaken by visiting colleagues for a temporary appointee, or for a secretary when organizing after-seminar dinners. One recent example happened to me

4. See CSWEP Annual Report, 1985, *American Economic Review, Papers and Proceedings*, May 1986, pp. 452-457, and CSWEP Annual Report, 1988, *American Economic Review, Papers and Proceedings*, May 1989, pp. 422-425.

5. Statistics provided by the University of California at Berkeley Office of Institutional Resources.

when a senior colleague and I interviewed a prospective graduate student. At the conclusion of the meeting the prospective student thanked both of us for our time, addressing me by my first name and my colleague by his title and last name and offering to shake my colleague's hand. Sandler and Hall (1987) relate many more anecdotal examples of these differences, and go so far as to call the campus climate chilly for women graduate students and faculty.

As a graduate student gender differences went unnoticed by me, in part because of the student/teacher dynamic of graduate school. It was not until I was on the other side of the student/teacher fence that I discovered how differences in treatment and in self esteem impede creativity, productivity, and day-to-day survival. These types of experiences can lead to isolation, adding to a sense of inadequacy. This in turn makes it increasingly difficult to participate in the department, and can progressively separate the young female researcher from her senior colleagues in the department and the larger scientific community. The following review of studies that examine these apparent differences in self esteem and in perception of the academic climate help advocate the need for mentors.

A study conducted by the Great Lakes College Association (GLCA) in 1984, surveyed all women faculty in 11 of the 12 associated colleges. [6] Approximately half (172) the women in the GLCA completed the survey, and of these over 3/4 agreed with the statement that male faculty regard and treat male colleagues differently than female colleagues. In a 1984 survey of American graduate students in science, engineering and medicine at Stanford University (Zappert and Stansbury, 1984), all women and an equal number of randomly selected men in these fields were questioned. Again approximately half (328 women, 299 men) of those surveyed responded. A comparison of those male and female students responding "always" or "often" to the

6. Great Lakes College Association, Women Studies Program, "Work in Progress: Two GLCA Self-Studies on Equity for Women Faculty," 1985, Ann Arbor MI.

following statements is illustrative of gender differences in self esteem. How often do you: trust your own judgement (92% of males, 80% of females); fear speaking will reveal inadequacy (9% of males, 33% of females); question if you can make it in your field (9% of males, 24% of females); feel able to negotiate for needs (62% of males, 42% of females). Another study (Mura, 1987) surveyed all undergraduates in math courses at five Canadian universities; approximately 90%, or 1270, responded. It was found that when asked to predict their course grade at the beginning of the course, 51% of the females over estimated their grade and 23% underestimated their grade. This compares to 61% and 13%, respectively, for the male students.

Recently, the American Astronomical Society (AAS) conducted a survey of its membership. [7] In this 1990 study, respondents were asked if they had witnessed or, in the case of women, experienced discrimination against women in the form of general social treatment. Half of the women said they had witnessed or experienced such discrimination, whereas only 15% of the men said they had witnessed such discrimination. In another recent study, 100 men and 100 women at each of the assistant, associate and full professor ranks were surveyed at a large midwestern public university (Parson et al., 1991). It was found that 59% of the women, as compared to 3% of the men, felt their work was underestimated because of their sex.

Finally, others examine the psychological challenges (Moulton, 1979, Harrison, 1991, Henrion, 1991)) confronting women in science and the exclusion of academic women from collegial networks (Clark and Corcoran, 1986, Simeone, 1987). Billard (1989, 1991) reviews quantitative performance comparisons of academic men and women, and Fennema and Peterson (1985) review studies on gender differences in science.

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7. Information communicated by P.B. Boyce, American Astronomical Society, Washington D.C.

A GOOD MENTOR. It is commonly believed that mentoring at the start of a career (Simeone, 1987) and access to support networks at review time (Menges and Exum, 1983) are particularly important in academics. However there are few quantitative studies measuring the impact of a mentor on a career, especially for faculty mentoring faculty (Merriam et al., 1987). The most extensive literature on mentoring is about the definition of mentor (Speizer, 1981, Fisher, 1988, Hall and Sandler, 1983). In fact, two empirical studies have recently attempted to use factor analysis to describe the multifaceted structure of the mentor relationship (Wilde and Schau, 1991, Sands et al., 1991).[8]

It is not argued here that the elements for successful mentorship are gender specific. Men and women alike can benefit from a mentor, and although the ideas put forward are drawn from my experiences as a female in statistics, they should be applicable to all junior academicians. In the Parson et al. (1991) study of faculty mentoring faculty a large majority of those surveyed (87% of the women and 67% of the men) believed that it would be beneficial to have had a mentor. That women seem to need more support and encouragement than men may be because the implicit support which men receive is not recognized as mentoring (Miller, 1976), or it may be that women expect a different dynamic in the mentorship (Berg and Ferber, 1983).

The goal of a mentoring relationship is to provide an environment in which the mentee develops into an independent researcher, taking with her the support of the mentor yet knowing the work she accomplished is her own. Altogether, if the mentorship has the following characteristics then it has the potential to provide the mentee with a good foundation for doing distinguished work:

(i) draw attention to the mentee's strengths, using them as a foundation for development;

8. Of particular note is the work of Hall and Sandler (1983). It is a guidebook for those in search of a mentor, supplying tips to both potential mentors and proteges and descriptions of a variety of types of mentors, including paper mentors, peer pals, guides and sponsors.

(ii) permit differences between the mentor and mentee, which allow the mentee to maintain a sense of her self and her work;

(iii) offer understanding of the difficulties the mentee faces (this is not an excuse for lack of performance);

(iv) make it safe to make mistakes and so develop both intellectual maturity and self confidence.

These items describe the dynamics of mentoring, not concrete tasks for the mentor or protege. Together they convey the mentor's belief in the mentee. If all goes well, the mentee can internalize this belief, move away from the mentor to develop peer relationships, and later, draw on the self confidence gained from these relationships to mentor others.

EXAMPLES. When first starting as an assistant professor of Statistics, I was fortunate to have had a thesis advisor who was a good mentor. Yet, similar to Hewitt's (1979) experience, continued mentoring after entering academia was important. In the academy, I found mentors in settings other than the typical advisor/student role, and I became aware of the elements of mentorship that promote professional development. In the four examples below, I hope to evoke the dynamics of mentoring described above. These examples also serve to demonstrate the professional development of the mentee, and exemplify the many types of mentoring available.

In the first example, the one-on-one hierarchical mentoring of the student and advisor is described. Ideally, this mentorship provides a starting point for the young scientist's development as researcher. Next, mentoring for the new teacher in a group situation is exemplified. The third case relates to peer mentorship, here the new researcher is included in a network of scientists with similar research interests. The last example describes how the mentee, in turn, mentors other, younger scientists.

(1) My thesis advisor exemplifies many aspects of the mentoring process that enable women to pursue their own creative scientific work. Our meetings typically had me at the blackboard presenting my latest results. We reviewed my work together. I was

able to show him my accomplishments and at the same time he raised questions, showed me alternatives and pointed out mistakes. Other times, he had the chalk and showed me something that he was working on currently. Then I was able to see how he worked, how he made mistakes, and most importantly I felt included in a larger research endeavor. He was accessible. He talked to me. A quintessential example of his mentoring happened when I was on the job interview circuit. My advisor received a phone call from the search committee of a university interested in hiring me. He was asked about my potential, if I was tenure material. His response indicated that he believed in me and my work; something I had already learned via his mentoring style. He said, "Yes, if you talk to her."

(2) As an assistant professor, I participated in a workshop on teaching. The workshop was organized so that each participant presented segments of prepared lectures to the other participants. Feedback from the organizer and fellow workshop attendees was an important aspect of the program. I found it very successful in large part because of the constructive manner in which the organizer channeled our feedback to each other. She had us look for the strengths in the presentations, because she said if we know our strengths, we can most effectively build on them to become strong lecturers. It was notable how each participant had quite different strengths, and it became clear that each could have successful, but different, lecturing styles. For example, one female assistant professor in the workshop had a very informal speaking style, which she viewed as a hindrance to getting respect from students. The coordinator showed her, and us, how a few changes in body motion could convey confidence, yet keep intact her informal style that was open and welcoming to students.

(3) After a couple of years in the university, contact with my advisor-mentor had lessened, yet I was still new to the statistical community. An associate professor at another institution welcomed me into the research community and provided a vital network of communication. We first met when I was interviewing for a job at his univer-

sity. Two years later he attended a presentation I gave at a professional meeting and saw that my current research interests overlapped with his. In conversation after the talk he supplied some background information for this new area of interest of mine; he also told me of his current research problems, and inquired about the results I had just presented. Over the next two years we met and compared notes at statistical meetings, and between meetings we exchanged preprints, references and open problems via electronic mail. His generosity in sharing his research interests and his respect for my work added up to a much-appreciated invitation to a broader statistical community.

(4) Most recently, a young visiting professor and I discovered we shared a concern over the difficulty that we had in talking with colleagues about our work. Too often the conversation drifted to easier topics such as pleasantries about family or administrative issues in the department. We thought that if we had this concern then so must other women in our field, especially female graduate students. We organized biweekly luncheons with small groups of women graduate students that had advanced to candidacy. The lunchtime conversation was restricted to research. We took turns sharing our latest developments. The students, my colleague and I enjoyed these lunches, because we were part of a community of intelligent hard-working women that were serious about their careers as statisticians. The atmosphere was informal; no advisor was present; there was room to make mistakes. Most found that discussing their work helped them focus on it in a different way. They had to make it their own, not an assigned project of their advisor's. This brought them to a better understanding of the nature of their work. The basic questions asked of them helped them to put their work in a broader framework and to realize that they already were experts in their subfield.

THE INSTITUTION. Senior researchers and administrators have a crucial role to play in the advancement of women in the scientific community, for they are responsible for fostering a productive work environment for all faculty. Three examples show ways in which this can be accomplished. The first is based on an essay by Rowe (1981) that outlines how to build institutional devices that help junior researchers find mentors and that help senior researchers become more active in the professional development of their junior colleagues. The second is a performance evaluation program in a statistics department, and the third example is a volunteer mentor program sponsored by a professional society.

To be effective these programs and policies must be open to all junior people. Both men and women can benefit from mentorship and an inclusive policy legitimates the process of mentoring, and will in the long run most benefit the entire academic community.

(1) Rowe (1981) outlines five points for creating a framework for professional development of students, faculty and administrators at the university. They are: top management taking leadership in encouraging senior people to be mentors; constructive women's networks; close communication between top management and these networks; workshops and guidelines to teach junior people how to seek mentors; and performance evaluation programs that encourage sponsorship. Rowe argues that a required program with assigned mentors may be useful in the short term, but it is most important to make mentoring a volunteer activity of the institution.

(2) A statistics department at a midwestern public university has in place the type of performance evaluation program advocated by Rowe.[9] Two senior faculty aid junior faculty in preparing their cases for annual review. They meet regularly with the assistant professors, provide frank feedback on their progress, and advise them on how to prepare their case. They also present the prepared case to the department at review time. This program encourages senior faculty to act proactively on behalf of the junior faculty, and it encourages junior faculty to seek advice and sponsorship from their senior colleagues.

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9. Communication with S. Leurgans, University of Chicago.

(3) A professional society for sociologists designed a volunteer mentor program to match junior researchers looking for assistance on a project with more experienced researchers (volunteers) in their field (Spade, 1991). The mentorship is limited to one year and a specific goal, such as the preparation of a paper for publication. In addition to providing specific feedback on the project, the mentor is encouraged to help the mentee place his or her work in the larger context of the mentee's career development. The mentee is encouraged to participate in professional society meetings. An evaluation of the first year of the program showed that most participants were satisfied overall with the program (92% of the mentors and 63% of the mentees).

CONCLUSIONS. Mentoring can enhance the professional development of junior researchers. It can change the academic climate, making a scientific career more rewarding for women. From the examples presented, it is clear that mentoring need not be limited to the student/advisor relation. Mentors can be found in peers and in group situations. Yet, these examples all have common elements that enable junior researchers to internalize a sense of self-worth, and so contribute to their field. With the aid of good mentoring, the scientist develops in a progression much as described in the case studies. Initially, the mentor provides a container within which the young scientist builds self confidence. Then she can grow into her own scientific identity as a researcher and teacher, and finally come full circle as a mentor and role model for others.

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