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WIDENING PATHS TO SUCCESS, IMPROVING THE ENVIRONMENT, AND MOVING TOWARD LESSONS LEARNED FROM THE EXPERIENCES OF POWRE AND CBL AWARDEES

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To better understand the barriers and discouragements encountered by female faculty members in science and engineering, this article compares the experience of National Science Foundation–funded Professional Opportunities for Women in Research and Education (POWRE) awardees and Clare Boothe Luce (CBL) Professorship recipients. Because most POWRE awardees work at research institutions, and many CBL professors teach at small liberal arts colleges, this study helps in understanding the experiences of female faculty members across a broad spectrum of academic settings. Their experiences suggest positive changes in institutional policies or practices to increase the satisfaction, retention, and success of female faculty members in fields in which they are the least well represented. The retention of female faculty members becomes critical for attracting undergraduate students as they consider the wisdom of choosing careers in academia.

INTRODUCTION

At the dawn of the 21st century, several promising developments indicate the willingness of the scientific and engineering professions and the academy to address the underrepresentation of women that has continued for decades, despite federally and foundation-funded programs to increase the number of female faculty members (Rosser & Lane, 2002a). In March 1999, the Massachusetts Institute of Technology (MIT) released *A Study on the Status of Women Faculty in Science at MIT*, creating a stir that spread far beyond the institutional boundaries of MIT. Five years earlier, senior biology professor Nancy Hopkins (1999) initiated the collection of evidence documenting that the 15 tenured female faculty members in science had received lower salaries and fewer resources for research than their male colleagues. Dean Robert Birgeneau recognized that in addition to salary disparities, the data in the report revealed systemic, subtle biases in space, startup packages, access to graduate students, and other resources that inhibited the careers of female scientists relative to their male counterparts.

In January 2001, MIT president Charles Vest hosted a meeting of the presidents, chancellors, provosts, and 25 female scientists from the most prestigious research universities (the California Institute of Technology; MIT; the University of Michigan; Princeton University; Stanford University; Yale University; the University of California, Berkeley; Harvard University; and the University of Pennsylvania). At the press conference held at the end of the meeting, they recognized that barriers still exist for women and that "this challenge will require significant review of, and potentially significant change in the proce-

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dures within each university, and within the scientific and engineering establishments as a whole" (Campbell, 2001). Almost simultaneously, the National Science Foundation (NSF; 2001) initiated ADVANCE, a new awards program, which provided funding of $17 million for 2001. The program offers an award for institutional solutions to empower women to participate fully in science and technology.

The continuing dearth of female faculty members can be traced in part to relatively small numbers of women graduating with undergraduate and graduate degrees in many areas of the sciences, engineering, and mathematics. Currently, 55.9% of undergraduates (National Science Foundation, 2000, Table 1-5) and 54.3% of graduate students (National Science Foundation, 2000, Table 3-12) are women. Only 49% of the undergraduate degrees, 39.3% of the master's degrees, and 32.8% of the doctoral degrees go to women majoring in science and engineering (National Science Foundation, 2000).

The small number of women receiving degrees in the sciences and engineering results in an even smaller percentage of female faculty members in these fields. For example, only 19.5% of science and engineering faculty members at 4-year colleges and universities are women; 10.4% of the full professors, 21.9% of the associate professors, and 32.9% of the assistant professors in science and engineering at these institutions are women (National Science Foundation, 2000, Table 5-15). Although many have interpreted these statistics as suggesting that women will reach parity with men in these fields as they advance through the ranks, the MIT report and other studies to assess the situation for women on campus (Riley, 2001) indicate that more substantial changes must occur to make the climate favorable enough to retain senior women in these fields.

Many female scientists and engineers have faced barriers and discrimination such as that described by molecular biologist Susan Branton in her interview for this study:

Former Clare Boothe Luce (CBL) Professor Susan Branton, at age 53, looks back on her career and believes that the reason she has been successful as a female scientist is that she is stubborn and has stayed focused on doing research rather than worrying about the status of the institution at which she would have a position. She consciously chose a position at a small liberal arts college because of negative experiences she and colleagues had had at prestigious Research I institutions and large companies.

Because of an abusive advisor, Susan had a horrible experience as a graduate student at a prestigious, midwestern Research I public medical school. Although she ultimately received her Ph.D., she won one of the first sexual harassment suits filed in the 1970s to obtain it. Fortunately, as a postdoc, she worked for a wonderful man at the National Institutes of Health (NIH) whose lab seemed like a paradise for scientists compared with her experience in graduate school.

When she finally went on the job market after 7 years as a postdoc, Susan scrutinized institutions carefully to ensure that she did not land in another untenable situation. She believes that she dodged a bullet at a private, midwestern research institution whose biology department was grumbling about being under pressure to hire a woman. The position she turned down was accepted by a woman who brought a high-profile suit against the department in later years. Susan was pleased to accept a position at a small liberal arts college in the Northeast.

Although she was somewhat reluctant to return to academia after the positive experience at the NIH, receiving the CBL Professorship gave Susan confidence that someone would be watching out for her. She believes that the institution's awareness that someone with financial power would know if she were treated badly and denied tenure provided some

insurance for her. She also received a Professional Opportunities for Women in Research and Education (POWRE) award from the NSF. Because all of her graduate students have been women and because she has applied for grants for summer science camps for girls, as a CBL Professor, Susan has attempted to attract other women to science.

Although she herself does not have children, Susan believes that childcare becomes a significant barrier for female scientists, particularly because of the competition between the biological clock and the tenure clock. Other more subtle barriers, such as those revealed in the MIT report, result from men's perceptions that women deserve fewer resources in terms of space, startup packages, support for and access to graduate students, and pay equity.

In Susan's specific discipline of yeast molecular biology, the climate has improved dramatically. The older women are tough and watch out for the younger women. The relatively large number of women in the field results from the help and efforts of these female pioneers.

Statements by college and university presidents, deans, and department heads that it is impossible to retain highly qualified female science and engineering faculty members in their institutions led to a study conducted at The Henry Luce Foundation. The unpublished data submitted by more than 180 colleges and universities reveal that the retention rates of faculty members hired into tenure-track positions in the physical sciences, mathematics, and computer science over the past 15 years are virtually identical for women and men (73%). Unfortunately, the data also indicate that the rate of tenure and promotion is lower and slower for women. In their comprehensive study of almost 60,000 faculty members at a representative sample of 403 institutions, Astin and Cress (2003) found that with the exception of engineering, men attained tenure in a shorter amount of time than women in all other fields.

METHODS

In an effort to better understand the barriers and discouragements encountered by female faculty members in the sciences and engineering, this article analyzes research comparing the experiences of POWRE awardees and CBL Professorship recipients. POWRE awardees are women who received peer-reviewed funding from a focused NSF program in fiscal years 1997 to 2000. They are primarily untenured assistant professors in tenure-track positions at research universities (Research I and Research II), as described by the Carnegie Classification of Postsecondary Institutions (Evangelauf, 1994). The POWRE awards were capped at $75,000, with a typical duration of 12 to 18 months. A series of papers written by one of us (Rosser, 2001; Rosser & Lane, 2002a, 2002b; Rosser & Zieseniss, 2000) documented the research on 389 of the 598 POWRE awardees during the duration of the 4-year POWRE program (for the details of the POWRE program solicitation, see National Science Foundation, 1997).

The CBL Professorships were created by Clare Boothe Luce's generous bequest to The Henry Luce Foundation on her death in 1987. One hundred thirty-three women have been supported since then. CBL Professors are primarily assistant professors in their first tenure-track positions at liberal arts colleges. Each CBL Professorship provides for the assistant or associate professor's salary, benefits, and a highly flexible career development account (generally $15,000 to $20,000 annually in recent years) that is administered by the recipient. Support typically lasts for 5 years (for the details of the CBL Professorships, see The Henry Luce Foundation, 2000).

We were particularly interested in examining the CBL Professors because of the emergence of anecdotal reports that some female scientists actively choose to avoid research universities (Schneider, 2000) because of their hostile climates. Research universities have research and doctoral education as primary parts of their missions and expect faculty members to publish research in reputable journals and attract peer-reviewed, competitive research funding to receive promotion and tenure. In contrast to research universities, 4-year institutions of higher education "are highly heterogeneous," including very prestigious liberal arts colleges, comprehensive institutions, and faith-based institutions. "What they have in common is that research and doctoral education is less central to their mission than is the case for research universities" (Kuh, 2003, p. 126). Data supporting these anecdotes of women's avoidance of research universities documented that women make up 40% of tenure-track science faculty members in undergraduate institutions (Curry, 2001), compared with less than 20% (National Science Foundation, 2000, Table 5-15) when data from 4-year colleges were combined with those from universities.

To examine this trend and to understand some of the reasons behind the data and anecdotal reports, we extended the e-mail questionnaire and interviews administered to POWRE awardees (Rosser & Lane, 2002a, 2002b) to female scientists and engineers concentrated at small liberal arts colleges. Although the POWRE awardees included individuals from all types of institutions and at varying ranks, the overwhelming majority held the rank of untenured assistant professor and came from large research institutions. As reported in previous publications on this research (Rosser & Lane, 2002b), 67 of the 96 POWRE awardees for fiscal year 1997, 119 of the 173 awardees for fiscal year 1998, 98 of the 159 awardees for fiscal year 1999, and 105 of the 170 awardees for fiscal year 2000 to whom the e-mail survey was sent responded. The nonresponse rate ranged between 23% and 37% over the 4-year period; the sample responding to the e-mail questionnaire in all 4 years appeared to be representative of the population of awardees with regard to discipline, and the nonrespondents did not appear to cluster in a particular discipline. The limited data available from the e-mail responses revealed no other respondent or nonrespondent bias.

The CBL Professorships offered a group of female scientists and engineers concentrated at small liberal arts colleges and private institutions who, like the POWRE awardees, had received an externally validated, prestigious award. In the annual report information she collects from the current CBL Professors, Jane Daniels, program director of the CBL Professorships, included the same e-mail questionnaire that Rosser had sent to the POWRE awardees. Daniels also sent out the questionnaire to the former CBL professors. Forty-one of the 46 active CBL Professors responded to the questionnaire; 8 of the 84 former CBL Professors responded.

The two primary questions analyzed in this article were the same ones previously reported on for the almost 400 POWRE awardees (Rosser & Lane 2002a, 2002b):

1. What are the most significant issues/challenges/opportunities facing women scientists today as they plan their careers?
2. How does the laboratory climate (or its equivalent in your subdiscipline) impact upon the careers of women scientists?

Rosser then contacted a subsample of the CBL questionnaire respondents with a "request to interview you" e-mail that resulted in her conducting telephone interviews,

asking the same five questions of the 11 CBL Professors (10 current, 1 former) to which 40 POWRE interviewees responded. The telephone interview questions were as follows:

1. Tell me the story of your professional career, including the major influences, opportunities, and challenges that enabled you to become the woman scientist (engineer) you are today? *Example follow-on clarification: since you suggest that you are an exception, what do you think are the most significant issues/challenges/opportunities facing women scientists today as they plan their careers?*
2. How did receiving a Clare Boothe Luce Professorship award impact your career? *Example follow-on clarification: Although it seems that the award was very positive for your career overall, did it have any negative impacts?*
3. Do you think that the Clare Boothe Luce award you received helped to attract and retain other women in science? *Example follow-on clarification: What other sorts of programs at your institution or others have you found to also be useful in attracting and retaining women in science (engineering)?*
4. What are the key institutional barriers to women in science and engineering having successful academic careers? *Example follow-on clarification: What solutions can institutions pursue to remove those barriers? Does your institution have an NSF ADVANCE award? If so, are you involved with ADVANCE?*
5. What is the overall climate for women in your specific discipline? *Example follow-on clarification: How does the laboratory climate (or its equivalent in your subdiscipline) impact on the careers of women scientists?*

RESULTS

Table 1 lists the 17 categories into which we divided the responses to Question 1 by the female scientists and engineers. The categories emerged from the coding of the textual replies (see Rosser & Zieseniss, 2000, for further methodological details). The categories and data were discussed at a national conference by 30 social scientists, scientists, and engineers whose work focuses on women and science (Rosser, 1999). The same codes and categories were applied to the responses from the POWRE awardees, as well as the responses from the CBL Professors. Although most respondents replied with more than one answer, in some years, at least one awardee gave no answer to the question. Although the survey data are categorical and therefore not appropriate for means testing, differences in responses across award years and across directorates from which the POWRE awardees received their awards clearly emerge when response frequencies are examined.

As Table 1 documents, the CBL Professors give very similar responses to those of the POWRE awardees to Question 1, about the most significant issues, challenges, and opportunities facing female scientists and engineers as they plan their careers. Even more strongly than their POWRE awardee counterparts, the CBL Professors found "balancing career with family responsibilities" (Response 1) to be the most significant issue. The CBL Professors also ranked "low numbers of women, isolation, and lack of camaraderie" (Response 3) and the "two career" problem (Response 5) as significant issues, as had the POWRE awardees.

Contrary to the implications of Schneider's (2000) study, the responses of the CBL Professors and POWRE awardees were remarkably similar, despite the differences in institutional size and type, with a few exceptions. CBL Professors ranked "time manage-

Table 1. Question 1: "What are the Most Significant Issues/Challenges/Opportunities Facing Women Scientists Today as They Plan Their Careers?"

Category	1997 POWRE % of Responses	1998 POWRE % of Responses	1999 POWRE % of Responses	2000 POWRE % of Responses	Current CBL Professors % of Responses	Past CBL Professors % of Responses	Total CBL Professors % of Responses
1. Balancing work with family responsibilities (children, elderly relatives, etc.)	62.7 (42/67)	72.3 (86/119)	77.6 (76/98)	71.4 (75/105)	73.2 (30/41)	87.5 (7/8)	75.5 (37/49)
2. Time management/balancing committee responsibilities with research and teaching	22.4 (15/67)	10.1 (12/119)	13.3 (13/98)	13.3 (14/105)	0.1 (1/41)	38.0 (3/8)	8.2 (4/49)
3. Low numbers of women, isolation and lack of camaraderie/mentoring	23.9 (16/67)	18.5 (22/119)	18.4 (18/98)	30.5 (33/105)	26.8 (11/41)	—	22.4 (11/49)
4. Gaining credibility/respectability from peers and administrators	22.4 (15/67)	17.6 (21/119)	19.4 (19/98)	21.9 (23/105)	9.8 (4/41)	12.5 (1/8)	10.2 (5/49)
5. "Two career" problem (balance with spouse's career)	23.9 (16/67)	10.9 (13/119)	20.4 (20/98)	20 (21/105)	9.8 (4/41)	—	8.2 (4/49)
6. Lack of funding/inability to get funding	7.5 (5/67)	4.2 (5/119)	10.2 (10/98)	8.6 (9/105)	4.9 (2/41)	12.5 (1/8)	6.1 (3/49)
7. Job restrictions (location, salaries, etc.)	9.0 (6/67)	9.2 (11/119)	7.1 (7/98)	5.7 (6/105)	—	—	—
8. Networking	6.0 (4/67)	<1 (1/119)	0 (0/98)	4.8 (5/105)	2.4 (1/41)	—	2.0 (1/49)
9. Affirmative action	6.0 (4/67)	15.1 (18/119)	14.3 (14/98)	12.4 (13/105)	2.4 (1/41)	—	2.0 (1/49)
10. Positive: active recruitment of women/more opportunities	6.0 (4/67)	10.1 (12/119)	9.2 (9/98)	14.3 (15/105)	14.6 (6/41)	12.5 (1/8)	14.3 (7/49)
11. Establishing independence	3.0 (2/67)	0 (0/119)	6.1 (6/98)	2.9 (3/105)	—	—	—
12. Negative social images	3.0 (2/67)	3.4 (4/119)	2.0 (2/98)	<1 (1/105)	2.4 (1/41)	—	2.0 (1/49)
13. Trouble gaining access to nonacademic positions	1.5 (1/67)	1.7 (2/119)	1.0 (1/98)	1.0 (2/105)	—	—	—
14. Sexual harassment	1.5 (1/67)	<1 (1/119)	2.0 (2/98)	1.9 (2/105)	—	—	—
15. No answer	0 (0/67)	<1 (1/119)	1.0 (1/98)	1.9 (2/105)	—	—	—
16. Cutthroat competition	—	—	1.0 (1/98)	1.9 (2/105)	—	12.5 (1/8)	2.0 (1/49)
17. Gender bias in student evaluations	—	—	—	—	2.4 (1/41)	12.5 (1/8)	4.1 (2/49)

Note. POWRE, Professional Opportunities for Women in Research and Education; CBL = Clare Boothe Luce.

ment/balancing committee responsibilities with research and teaching" (Response 2) much lower than the POWRE awardees. In fact, only 1 of 41 current CBL Professors mentioned this issue in the e-mail questionnaire responses. The likely reason that Response 2 received a lower ranking from CBL Professors than from POWRE awardees became evident from comments both in the e-mail questionnaire responses and the interviews. The CBL Professors had the advantage of the flexibility of the CBL money (as opposed to the restrictions of federal money awarded through POWRE) that can be used to buy out teaching while establishing research, as well as for laboratory renovations, childcare, travel, hiring students, and other needs. As suggested in the following quotations, the CBL Professors appreciated the advantages of flexibility:

> The most useful thing is the freedom to determine how to best spend the discretionary funds. I can use the funds to hire research assistants if needed without going through a lengthy proposal process. I can use the funds to buy myself some course release time so that I can spend more time on research and on mentoring female students. (Respondent 26)

> The most useful aspects for me are the reduced teaching load and the research money. (Respondent 36)

CBL professors realized that buying out too many courses at liberal arts institutions, at which teaching performance receives heavy emphasis in promotion and tenure decisions, might work against them in tenure decisions. However, as indicated by the following quotations, the 5-year commitment of the money and the relative flexibility of how it could be used came up repeatedly in e-mail and interview responses of the CBL Professors as very positive features of the CBL Professorships:

> Child care benefits—I've never heard of anything similar elsewhere, and it's really a great way to make it easier for women in academia to balance work and family (not that it's ever easy). (Respondent 31)

> I like the money available for supplies and small equipment purchases and attending national meetings. It's very useful. (Respondent 19)

The fund given in addition to the academic salary has been very useful, especially since the things it could be put toward were left up to us (within reason). I have been able to use this fund to start a new project in the lab (that I had not accounted for in my start-up package), hire an undergraduate technician for the summer, and buy computer equipment that made my teaching duties easier. (Respondent 4)

In contrast to the CBL Professors, a number of the POWRE awardees bemoaned the relatively small size of the grant, its short duration, and the relative inflexibility of funds (Rosser, 2004):

> Unlike standard NSF grants which often provide funding for 2-3 years, POWRE funding is capped (in $ amount) and typically provides funding for a single year. While I understand that there are budgetary constraints, allowing a larger amount of funding for multiple years will allow POWRE researchers to make more substantive long-term proposals. (1997 POWRE Respondent 32)

In her interview, CBL Professor and mathematician Colleen Ivy particularly underlined the significance of the flexibility feature:

Colleen Ivy identified herself as good in math and science while in grade school and high school. The daughter of two Ph.D. scientists, a physicist father and a biochemist mother, she naturally assumed that she would also pursue a Ph.D.

In college, Colleen didn't really plan what her major would be. Eventually, she realized that she had taken so much math that she might just as well major in it. After college, she took a year off before going to graduate school.

Very successful in graduate school, Colleen received several prestigious fellowships. Near the end of her Ph.D., after completing her course work, she began to lose steam. Colleen attributes this partially to less reinforcement, particularly because her advisor was Dutch and not voluble in his praise. Later, Colleen was amazed to learn that he considered her to be one of his best students.

Colleen married another Ph.D. mathematician just before she finished her Ph.D. She and her husband decided to move together, even if one didn't have the best situation professionally. Although both put their family first, at that point, they moved to the West Coast, where she received an excellent postdoctoral position. After searching for jobs for a while, her husband left mathematics, changing careers to computer science. While there, she studied with her first female role model and mentor, who also had a husband, child, and similar interests. That led Colleen to understand that unconsciously, she had used her mother, who worked part-time, as a role model. Because of her new mentor, Colleen realized that she could apply for full-time, tenure-track positions.

Soon after she took the position at the small liberal arts college in New England, Colleen had her first child; 2 years later, she had her second. Originally, both she and her husband worked full-time, but now, he stays at home with the children. Fortunately, the rural part of the state where they live opens the possibility of living on one salary.

The CBL Professorship gave Colleen flexibility to spend money on extra options, such as laptops, professional memberships, and childcare, that made a difference in the quality of her life as a professional. She also hired women as research assistants, which provided opportunities for her to serve as a mentor to them.

With a teaching load of five courses per year, Colleen still finds balancing her career and her family to be the biggest challenge. In her opinion, the climate for women in mathematics is generally good, although prominent speaking and symposium slots tend to be skewed toward men. Subtle bias in both professors' interpretations of women during interviews and student evaluations of female faculty members may persist.

"Gaining credibility/respectability from peers" (Response 4) constituted another difference in responses between CBL Professors and POWRE awardees. Approximately 20% of all 4 years of POWRE awardees cited "gaining credibility/respectability from peers and administrators" as a problem, whereas only about 10% of CBL professors cited this. Several of the POWRE awardees mentioned that because POWRE was an initiative for women only, many of their colleagues viewed the grant as less prestigious than other NSF grants, despite the program's very competitive success rate.

In contrast, as the following quotations suggest, many of the CBL Professors underlined the named professorship as a factor that conferred prestige and respectability on them, opening opportunities and doors, particularly with senior colleagues:

> The CBL professorship is a tremendous help in two regards. First, simply the prestige

> of having a named professorship has been useful. Second, the financial security provided by this fellowship has allowed me to undertake risky projects in the lab. Since these are the types of projects that have the highest possible reward, this flexibility is greatly appreciated. (Respondent 28)
>
> People take notice that I have a named chair. (Respondent 2)

The positive aspects of being a woman who receives more opportunities and was actively recruited emerge again in the differential responses of POWRE awardees and CBL Professors to "positive: active recruitment of women/more opportunities" (Response 10). Several CBL professors indicated in both e-mail and interview responses their belief that the CBL awards had led to their recruitment and to positive attitudes of their colleagues and institutions toward them and other women in science. The following two e-mail responses illustrate this:

> I appreciate the prestige associated with the award and the commitment it represents by the University to further women in science. The discretionary fund is also a very welcome element of the award. (Respondent 25)
>
> The most useful aspect of the CBL professorship is the recognition of Clare Boothe Luce's contribution to women in society. Many parents of female students take comfort in hearing about my professorship, and from this understand that women engineers are well accepted here. As well colleagues around the country either recognize her [Clare Boothe Luce's] name, or learn about her contribution through this professorship. (Respondent 11)

The Clare Booth Luce Professors responded similarly (see Table 2) to the POWRE awardees to e-mail Question 2: "How does the laboratory climate (or its equivalent in your subdiscipline) impact upon the careers of women scientists?" The responses to Question 2, in contrast to Question 1, reflected less consensus. The response of the CBL Professors for "balancing career and family/time away from home" (Response 2) was even stronger (24.5%) than the primary response of the POWRE awardees across all years (15.6%). Somewhat fewer (2.0%) of the CBL Professors than POWRE awardees (12.1%) indicated that they had "not experienced any problems" (Response 3). More of the CBL Professors than POWRE awardees indicated that they "benefit by working with peers" (Response 14), but also that they face a "hostile environment/intimidating/lack of authority" (Response 7).

As with Question 1, the nuances of difference and context for the responses become clearer from the qualitative answers given by the CBL Professors:

> Successful laboratory work often requires long blocks of time, which may often impinge on family time (if relevant) so that women who are primary caregivers for dependents have to work even more efficiently. Some constraints may also be imposed if the female scientist has other obligations. It is nearly impossible to successfully complete laboratory-based or field-based projects without being able to spend large blocks of time in the environment. When experiments are not successful, morale declines and motivation for the woman scientist may also decline. (Respondent 39)
>
> A practical reality of biochemistry is that, to be highly successful, the scientist must inevitably spend long hours in the lab. This is particularly difficult for women who are trying to juggle small children with work. (Respondent 28)

Table 2. Question 2: "How Does the Laboratory Climate (or its equivalent in your subdiscipline) Impact Upon the Careers of Women Scientists?"

Category	1997 POWRE % of Responses	1998 POWRE % of Responses	1999 POWRE % of Responses	2000 POWRE % of Responses	Current CBL Professors % of Responses	Past CBL Professors % of Responses	Total CBL Professors % of Responses
1. Don't know/Question unclear	16.4 (11/67)	4.2 (5/119)	7.1 (7/98)	5.7 (6/105)	12.2 (5/41)	12.5 (1/8)	12.2 (6/49)
2. Balancing career and family/time away from home	13.4 (9/67)	19.3 (23/119)	16.3 (16/98)	13.3 (14/105)	26.8 (11/41)	12.5 (1/8)	24.5 (12/49)
3. Have not experienced problems	11.9 (8/67)	16.8 (20/119)	10.2 (10/98)	9.5 (10/105)	2.4 (1/41)	—	2.0 (1/49)
4. Not in lab atmosphere/can't answer	11.9 (8/67)	5.9 (7/119)	1.0 (1/98)	8.6 (9/105)	2.4 (1/41)	25.0 (2/8)	6.1 (3/49)
5. Lack of camaraderie/communications and isolation	9.0 (6/67)	11.8 (14/119)	9.2 (9/98)	14.3 (15/105)	12.2 (5/41)	12.5 (1/8)	12.2 (6/49)
6. "Boys club" atmosphere	9.0 (6/67)	9.2 (11/119)	18.4 (18/98)	9.5 (10/105)	12.2 (5/41)	—	10.2 (5/49)
7. Hostile environment/intimidating/lack of authority	9.0 (6/67)	14.3 (17/119)	15.3 (15/98)	8.6 (9/105)	19.5 (8/41)	12.5 (1/8)	18.4 (9/49)
8. Establishing respectability/credibility	9.0 (6/67)	10.9 (13/119)	10.2 (10/98)	3.8 (4/105)	—	25.0 (2/8)	4.1 (2/49)
9. No answer	7.5 (5/67)	6.7 (8/119)	5.1 (5/98)	<1 (1/105)	—	—	—
10. Positive impact	6.0 (4/67)	10.1 (12/119)	6.1 (6/98)	11.4 (12/105)	2.4 (1/41)	—	2.0 (1/49)
11. Lack of numbering/networking	4.5 (3/67)	6.7 (8/119)	12.2 (12/98)	4.8 (5/105)	2.4 (1/41)	—	2.0 (1/49)
12. General problem with time management	4.5 (3/67)	1.7 (2/119)	5.1 (5/98)	3.8 (4/105)	—	25.0 (2/8)	4.1 (2/49)
13. Safety concerns/presence of toxic substances (health concerns)	3.0 (2/67)	0 (0/119)	4.1 (4/98)	1.9 (2/105)	2.4 (1/41)	—	2.0 (1/49)
14. Benefit by working with peers	3.0 (2/67)	2.5 (3/119)	3.1 (3/98)	5.7 (6/105)	14.6 (6/41)	25 (2/8)	16.3 (8/49)
15. Problem of wanting research independence	3.0 (2/67)	0 (0/119)	1.0 (1/98)	<1 (1/105)	—	—	—
16. Lack of funding	1.5 (1/67)	<1 (1/119)	5.1 (5/98)	<1 (1/105)	—	—	—
17. Benefit from time flexibility/determine own lab hours	3.0 (2/67)	1.7 (2/119)	3.1 (3/98)	1.9 (2/105)	2.4 (1/41)	—	2.0 (1/49)
18. Did not answer	0 (0/67)	0 (0/119)	3.1 (3/98)	0 (0/105)			
19. Department doesn't understand basic issues	—	—	—	<1 (1/105)			
20. Cultural/national stereotypes for women	—	—	—	6.7 (7/105)			
21. Space	—	—	1.0 (1/98)	0 (0/105)			
22. Better bathroom facilities	—	—	—	<1 (1/105)			

Note. POWRE, Professional Opportunities for Women in Research and Education; CBL = Clare Boothe Luce.

The responses from the following four CBL Professors describe particularly well some of the reasons that women appear to benefit from collaboration compared with the more hostile, competitive environment fostered in many labs:

> My field is extremely competitive, and I believe that it is important to create an environment where beginning scientists can be introduced to the discipline and to the scientific process in a nurturing environment. Providing this nurturing, though challenging environment has the ultimate goal of allowing beginning scientists to recognize their own strengths and gain the confidence that will allow them to succeed in this field. I think that the aggressive nature of the field in general, a tone that has been historically created, tends to dissuade women from pursuing careers beyond the postdoctoral level. (Respondent 32)

> I am fortunate to have worked in laboratories where the environment was very stimulating and supportive. I know many, however, who have had less pleasant experiences. Some of my female peers have left laboratory research altogether because they found the competitiveness of larger laboratories too stressful to cope with. (Respondent 31)

> I think that this touches upon the same issues as above. The laboratory climate tends to be fiercely competitive, rewarding those who work the longest hours. This can put real pressure on women who have spouses and children to care for at home.
>
> Physics labs also tend to be run along an aggressive model in which colleagues are encouraged to criticize each other's work, rather than to work constructively together. This can be completely demoralizing—I saw a lot of talented women wash out of my graduate program because they internalized the criticism of their fellow students. I'm not sure that there is much anyone can do about this, though, other than to resolve to create a more constructive climate in her own lab! (Respondent 23)

> An open and supportive laboratory climate is very important to the well-being of women scientists. Here at the college, I feel we have a very positive climate for women in our classroom and research laboratories. This is in part due to the high percentage of women in our science classes, reaching almost 70%. A sense of camaraderie often develops. Female students tell me that gender is really a non-issue in the laboratory setting. Doing field work, however, can bring up some gender issues/stereotypes. For example, for some female students it bothers them if male students are stronger and hence do some more of the field work (e.g. pounding in a soil corer) more quickly or apparently effortlessly. (Respondent 9)

In her will, Clare Boothe Luce stipulated 13 colleges and universities (one has since closed) and schools to receive funding annually in perpetuity. Other institutions are invited to participate in the program by a selection committee. Recently, this committee has awarded CBL Professorships to several larger institutions, including the University of Washington, Stanford University, the University of Maryland–College Park, and the California Institute of Technology. The smaller, private colleges at which the CBL Professors concentrate can more easily provide this positive, nurturing environment for female students that the female faculty understand as being important to retaining women in science.

In the following responses to the e-mail questionnaire, many of the CBL Professors emphasize the efforts they make to provide this supportive atmosphere in their labs:

> Positively. The laboratory is a place where women can learn, challenge themselves, make mistakes, and work together in a community. (Respondent 34)

> The laboratory climate varies vastly. Clearly, in a rewarding or at least positive environment, any woman could envision a career doing research. It is my hope that the experiences my students have researching with me will be only positive. I want them to experience the excitement and potential fulfillment of this pursuit so that they might choose or at least consider it as a career for themselves. (Respondent 20)

When she was interviewed for this project, biologist Annelise Swinton talked about hiring female students for her lab as a way to encourage female undergraduates in science:

Annelise Swinton never had any female mentors, although all of her male mentors proved extremely supportive of women. Enduring the struggles that all female scientists experience was possible because her parents encouraged her to do what she wanted. Because she did well in school, the faculty pushed her toward becoming a physician. In college, she realized that she liked science but did not wish to become a physician.

An excellent professor and mentor invited Annelise to work in his lab and sent her to Africa. The level of confidence that he demonstrated in her as an undergraduate encouraged her to go to graduate school. She attended a university in the mid-South, working with an advisor she met via her undergraduate mentor. He also went out of his way to support women and diversity, as well as to socialize individuals to the professions of physiology and endocrinology.

Annelise obtained her first job at a private liberal arts institution in the Midwest right out of graduate school. For the first time, she enjoyed being in a department with more women than men. Although she liked her 5 years there, she jumped at a position at a private liberal arts institution in her home state in New England.

The CBL Professorship has encouraged the institution to hire women in science. With only one tenured woman out of a science faculty of 40, the CBL influence seems critical to attracting and retaining women in science. Because Annelise hires female students to work in her lab, it also encourages female undergraduates.

The absence of senior women in science to serve as mentors becomes a substantial barrier for junior women. This absence becomes further complicated by the dearth of women in senior administrative positions and/or holding endowed chairs. Few individuals in leadership positions understand the subtle aspects of gender bias, such as those that emerge from student evaluations of teaching, that may negatively affect women's salaries and standing. Annelise feels that the overall climate for women in biology, however, has really improved because of increasing numbers of women and willingness to collaborate.

Although small, private colleges, with their emphases on teaching, may provide more supportive atmospheres for female students, the notion that they provide more time and less pressure than research institutions for female faculty members may be an illusion. Typically, the teaching load at a small liberal arts college is higher than that at a major research institution. The pressures and time demands of the types of institutions may differ, while remaining intense at both. For example, as suggested in the interview with Swinton, at institutions at which teaching takes priority over research for promotion and tenure, as well as salary decisions, pressures erupt from subtle gender bias in teaching evaluations or negative perceptions from colleagues about too much course buyout. The expectations from smaller, private institutions for all faculty members to attend ceremonies and other events, such as

parents' weekends, may make time demands similar in amounts to those expected for faculty members at research institutions to spend on secondary research-related activities.

Similarly, the absence of graduate students and postdocs at small liberal arts colleges means that faculty members must prepare and teach all the laboratories, as well as the lecture courses. Faculty members in these institutions have only undergraduates to assist with their research. Using undergraduates in research provides students with excellent experience, now documented as one of the most, if not the most, significant factor for attracting them to pursue graduate studies in science and technology (Astin & Sax, 1996; National Science Foundation, 2003). However, undergraduate students do not and cannot further the research agenda of faculty members in ways that technicians, graduate students, and postdocs found in laboratories of most research institutions can.

As the following quotations from the e-mail questionnaire suggest, reliance on undergraduate students to pursue research agendas tends to decrease the research productivity of faculty members in these 4-year institutions:

> I need technical assistance with my research so that I can supervise students and my own research program more effectively. I need to hire a technician, but the CBL program does not fund support staff. I am finding, as time goes on, that I cannot give my research and student advising the attention they deserve without some extra help with day-to-day running of laboratory and field operations. Most funding agencies do not support technical staff. (Respondent 38)

> With our campus culture, it is difficult to make use of student stipends during the semester. Typically, a student who works for credit will be able to devote more hours to research than a student who works for pay. Funds allocated to a part-time technician would probably be more beneficial, both for me and for students doing independent study or honors projects. (Respondent 7)

> Most problematic: The funds could be more flexible regarding international travel, student stipends, and general allocations. For example, I find that hiring students during the academic year is an inefficient use of funds; students become very busy, and they tend to focus instead on coursework or laboratory work for academic credit. That money could be better used if dedicated to research expenses, or if we were given flexibility in its use. (Respondent 5)

Small liberal arts colleges do not necessarily provide the most conducive environments for a productive research career. The combination of higher teaching loads with the dearth of graduate students and postdocs means that faculty members in these small liberal arts colleges often must prepare and teach laboratory courses (a function typically carried out by graduate students at research institutions) as well as run their own research labs (a function often left to postdocs at research institutions). This combination often results in less time for writing grants, producing research results, and publication. Ultimately, research slows or may stop entirely, because without funds, research in most science and engineering disciplines, unlike that in the humanities and some areas of the social sciences, is not possible. This in turn has implications for maintaining the pipeline for women in science, because female faculty members are important for attracting female graduate students. Responding to and realizing a national crisis of the shortage of women scientists and engineers, particularly exacerbated in the wake of 9/11, Senator Wyden (an Oregon

Democrat) and others have recognized the loss of brainpower by the attrition of women from the science and engineering pipeline. They have suggested using Title IX legislation to affect this underrepresentation (Rolison, 2003).

CONCLUSIONS: POLICY RECOMMENDATIONS AND CONSIDERATIONS

This study, comparing the responses of POWRE awardees (most at research institutions) with those of CBL Professorship recipients (many at small liberal arts colleges and faith-based institutions) helps in understanding the experiences of pretenure female faculty members across a broad spectrum of academic settings. This understanding points toward institutional policies or practices that could increase the satisfaction, retention, and success of female faculty members in fields in which they are least well represented. Such positive changes should have a ripple effect on female graduate and undergraduate students as they consider the wisdom of choosing careers in academia.

Moving Toward Balance

The issue of balance—whether pertaining to the tension between personal responsibilities and the demands of work or among competing demands within the work environment—surfaces time and again as an impediment to the attraction and advancement of women in the sciences and engineering. The combined responses of POWRE awardees and CBL Professorship recipients leave no doubt that the issue of balancing work with family responsibilities is the most pervasive and persistent challenge facing female science and engineering faculty members, spanning the variables of time, type of institution, and discipline. The conflicting demands of work and personal responsibilities are likely exacerbated for female science and engineering faculty members because of the competitiveness and inflexibility characteristics of these fields. Engineering in particular, with its foundation in the military (Cockburn, 1983; Hacker, 1989), often perpetuates its hierarchical nature and cutthroat competitiveness.

A burden experienced by female faculty members in general is the competition between the biological clock and the tenure clock, if women have postponed childbearing until after graduate school and postdoctoral experiences. An additional challenge makes this situation more problematic for female faculty members in the sciences and engineering, because most of them (62%) are married to scientists or engineers who also have unreasonable demands on their time (Sonnert & Holton, 1995). Although most of their male colleagues are also married, few are married to scientists or engineers.

The issues of balancing work and family may seem to be a result of personal choice and individual circumstances; however, individual solutions have proved inadequate. Successful institutional solutions, on the other hand, appear promising. Such solutions cluster around two issues: increased flexibility for individual faculty members and the distribution of control from the institution or administration to the individual. Flexibility evident in work hours, benefits, and telecommuting and the distribution of control to individuals through a cafeteria system of benefits or in a startup package that includes a professional development account available until tenure (hallmark of the CBL Professorships) exemplify such institutional solutions.

Several institutions have developed cafeterias of benefits that provide important flexibility across the span of faculty members' careers. Childcare or elder care benefits may take the form of financial assistance, information and the assessment of available services, or the convenience of on-site facilities. An example of this type of flexibility exists at Iowa State University, at which on-site child care for infants through kindergartners has a sliding scale of fees; a cafeteria of benefits allows any benefit dollars that remain after selection to be moved to a flexible spending account for medical expenses or childcare expenses, departmental assistance for spousal hires, and lactation rooms for nursing women.

Institutional policies that address the issue of balance would likely have a positive impact on the recruitment and retention of female undergraduate and graduate students, as well. The perception that success in the sciences and engineering requires an unbalanced, intense focus on inanimate objects for prolonged periods of time is a significant deterrent to women selecting those fields for lifelong careers (Margolis & Fisher, 2002).

Widening Paths to Success

The small number of women in most areas of the sciences and engineering can impede or, worse yet, end the career of an outstanding female scientist or engineer. A lack of role models, feelings of isolation, and stereotyping are all barriers caused by low numbers. Interventions at the precollege, college, and graduate school levels increase numbers slowly; institutions can be proactive in offsetting the consequences of low numbers.

Understanding specific characteristics of gender differences at each institution and within individual departments provides a first step to widening paths. Do paths narrow in certain places (departments), at critical junctures (recruitment, tenure, promotion to full professor, prestigious awards, influential committees), or over specific issues (salary, space, graduate student assignment)? For example, a study of faculty members hired as assistant professors or instructors at the University of Michigan between 1982 and 1988 revealed that 53% of male assistant professors and 24% of male instructors but only 43% of female assistant professors and 10% of female instructors received tenure (Hollenshead, 2003). Surveys such as the ones conducted at MIT (Hopkins, Bailyn, Gibson, & Hammonds, 2002) identified sources of inequity that further restrict the already narrow paths to successful advancement and recognition for female faculty members.

Creating additional, equally valued paths to success also widens career opportunities. A brainstorming meeting or survey of beginning faculty members and graduate students provides alternatives to the traditional procedures for advancement and recognition that may be more effective for future faculty members. Alternate paths to success must be seen by the academic community as equally prestigious and attractive to faculty members regardless of gender, age, race, or ethnicity.

Providing more structure and transparency to the advancement and recognition practices in individual departments also widens paths. Negative forms of discrimination are less likely to occur if the paths to academic advancement and recognition are clearly understood by both the beginning faculty members who must negotiate them and the senior faculty members responsible for their implementation (Fox, 1995). Examples of such transparency include a panel of newly tenured faculty members speaking to new faculty members or an effective 3rd-year review process that identifies potential weaknesses in an untenured faculty member and provides a plan for addressing those weaknesses.

Improving the Environment

Words describing the environment encountered by female faculty members in science and engineering departments include *chilly*, *masculine*, *exclusionary*, *elitist*, and *hostile*. The differences between the availability of female Ph.D.'s and actual proportions on faculties varies considerably, depending on the discipline, with especially large discrepancies in chemistry and mathematics (Hornig, 2003). Is it any wonder that even in fields such as chemistry, in which the proportion of women completing Ph.D.'s has been above 20% since 1985, (American Chemical Society, 1999) the proportion of those choosing to return to the inhospitable environments that educated them is closer to 12% at the top 50 universities ("Women Still Lag," 2002)? An in-depth interview study with female faculty members who left the University of Michigan "voluntarily" uncovered the extent to which the women "cited lack of respect by their colleagues as figuring in their decision" to leave the institution (Hollenshead, 2003, p. 219).

A lack of collegiality and difficulty in gaining credibility among their peers in science and engineering departments exemplify a characteristic of a negative environment identified by the research on POWRE awardees. The prestigious nature of the CBL Professorship mitigates this somewhat. POWRE awardees found that their peers viewed a "women's award" as less prestigious. In fact, these awards were smaller in size and less competitive than most NSF research awards. The CBL Professorship recipients commented on the opposite effect. A "named" professorship that provided full salary support for 5 years, augmented by a sizable and very flexible career development fund, enhanced women's credibility, was perceived by peers and senior faculty members as prestigious, provided experience administering a research account, and set high expectations for excellence among recipients' peers.

Wadsworth (2002) suggested other ways of improving the environment in *Giving Much, Gaining More*. The book describes the personal impact of mentoring programs developed at Purdue University in the 1990s that successfully used positive actions to offset the negative characteristics of engineering departments: welcoming versus excluding, communicating versus bickering, trusting versus doubting, accepting versus rejecting, and affirming versus ridiculing. If such positive actions become the "norm" in science and engineering departments, the need for such supplemental, support programs for women will eventually disappear.

The relatively new ADVANCE program (institutional transformation component) at the NSF (2001) funded nine universities beginning in fiscal year 2001 and funded that many again in fiscal year 2002 to develop model policies and practices to address institutional barriers and discouragements faced by female science, technology, engineering, and mathematics faculty members. The results of ADVANCE will provide a variety of models for improving the environment in academic science and engineering departments and transform faculty careers to be more attractive and supportive of all men and women, particularly those from previously underrepresented populations. Some recommendations are already posted to project Web sites of each of the nine fiscal year 2001 institutions (the Georgia Institute of Technology; Hunter College; New Mexico State University; the University of California, Irvine; the University of Colorado–Boulder; the University of Michigan; the University of Puerto Rico–Hamaco; the University of Washington; and the University of Wisconsin).

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