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KEY BARRIERS FOR ACADEMIC INSTITUTIONS SEEKING TO RETAIN FEMALE SCIENTISTS AND ENGINEERS: FAMILY-UNFRIENDLY POLICIES, LOW NUMBERS, STEREOTYPES, AND HARASSMENT

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At the end of a special meeting held at the Massachusetts Institute of Technology in January 2001, a statement released on behalf of the most prestigious U.S. research universities suggested that institutional barriers have prevented women from having a level playing field in science and engineering. In 2001, the National Science Foundation initiated a new awards program, ADVANCE, focusing on institutional rather than individual solutions to empower women to participate fully in science and technology. In this study, the authors evaluate survey responses from almost 400 Professional Opportunities for Women in Research and Education awardees from fiscal years 1997 to 2000 to elucidate problems and opportunities identified by female scientists and engineers. Besides other issues, the respondents identified balancing a career and a family as the most significant challenge facing female scientists and engineers today. Institutions must seek to remove or at least lower these and other barriers to attract and retain female scientists and engineers. Grouping the survey responses into four categories forms the basis for four corresponding policy areas, which could be addressed at the institutional level to mitigate the difficulties and challenges currently experienced by female scientists and engineers.

INTRODUCTION

In fiscal year (FY) 2001, the National Science Foundation (NSF) initiated ADVANCE, a new awards program, at a funding level of $19 million, that has two categories to include institutional rather than individual solutions to empower women to participate fully in science and technology. The NSF (2001) encouraged institutional solutions in addition to the individual solution permitted under the category of Fellows Awards because of "increasing recognition that the lack of women's full participation at the senior level of academe is often a systemic consequence of academic culture" (p. 2). Under ADVANCE, Institutional Transformation Awards, ranging up to $750,000 per year for up to 5 years, promote the increased participation and advancement of women; Leadership Awards recognize the work of outstanding organizations of individuals and enable them to sustain, intensify, and initiate new activity (National Science Foundation, 2001).

Several decades of federal funding have supported programs at the K-16 level to attract and retain girls and women in science, mathematics, engineering, and technology, at the NSF (2001) primarily through the Program for Gender Equity. At the graduate level, the NSF targeted fellowships toward women; initiatives such as Faculty Awards for

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Women, Visiting Professorships for Women, Career Advancement Awards, and now Professional Opportunities for Women in Research and Education (POWRE) support the research of individual female scientists at critical junctures during their careers.

Although the numbers of women majoring in scientific and technological fields have increased since the 1960s to 49% in 1998 (National Science Foundation, in press, Table 3.4), the percentages of women in computing, the physical sciences, and engineering remain lower than those of other disciplines. In 1998, women received 74.4% of the bachelor's degrees in psychology, 52.5% in the social sciences, 52.7% in the biological and agricultural sciences, 39% in the physical sciences, and 37% in the geosciences, whereas they received only 18.6% in engineering (National Science Foundation, in press, Table 3.4). The percentage of computer science degrees awarded to women actually dropped from 37% in 1984 to 20% in 1999 (Eisenberg, 2000).

The percentage of graduate degrees in these fields earned by women remained lower. Although women earned 55.5% of the master's degrees in all fields, they earned only 39.3% of the degrees in science and engineering fields. By specific fields, the percentages were as follows: engineering, 17.1%; physical sciences, 33.2%; geosciences, 29.3%; mathematics, 40.2%; computer sciences, 26.9%; biological and agricultural sciences, 49.0%; psychology, 71.9%; and social sciences, 50.2% (National Science Foundation, 2000, Table 43). Women earned 40.6% of the Ph.D. degrees in all fields but only 32.8% of the Ph.D.'s in science and engineering. The specific field percentages included 12.3% in engineering, 22.4% in the physical sciences, 23.7% in the geosciences, 23.4% in mathematics, 16.2% in the computer sciences, 40.7% in the biological and agricultural sciences, 66.6% in psychology, and 58.7% in the social sciences (National Science Foundation, 2000, Tables 4–11).

The small number of women receiving degrees in the sciences and engineering translates to an even smaller percentage of female faculty members in these fields. For example, the NSF reported that only 19.5% of science and engineering faculty members at 4-year colleges and universities are women. Women constitute just 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 (National Science Foundation, 2000, Table 5–15). Although many have read these statistics as suggesting that women will reach parity with men in these fields as they advance through the ranks, other evidence suggests that more substantial changes must occur to foster a more female-friendly climate and retain senior women in these fields. Perhaps it is not surprising that the male dominance in these fields is reflected not only in their statistical majority but also in a continued tradition of male-centered approaches in labs, practices, and cultures. The extent to which these approaches, practices, and cultures present institutional barriers for female scientists and engineers has been underlined through a Massachusetts Institute of Technology (MIT) report released in 1999 and anecdotal reports that some female scientists actively choose to avoid research universities (Schneider, 2000) because of the hostile climate. Recent data document that women make up 40% of tenure-track science faculty members in undergraduate institutions (Curry, 2001, p. A9). Although the bulk of science and technology research occurs at institutions formerly classified as Research I, decreased lab space, lower salaries, and fewer prestigious opportunities exemplify barriers for women endemic to many of these institutions.

A dawning recognition that these barriers are best addressed by institutional rather than individual changes is evident from the statement released after the January 2001 MIT meeting and from the focus of the NSF's ADVANCE initiative. On January 29, 2001, 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 Pennsylvania State University) held a special meeting at MIT. At the close of the meeting, they issued the following statement:

> "Institutions of higher education have an obligation, both for themselves and for the nation, to fully develop and utilize all the creative talent available," the leaders said in a unanimous statement. "We recognize that barriers still exist" for women faculty . . . They agreed:
>
> - To analyze the salaries and proportion of other university resources provided to women faculty
> - To work toward a faculty that reflects the diversity of the student body
> - To reconvene in about a year "to share the specific initiatives we have undertaken to achieve these objectives"
> - To "recognize that this challenge will require significant review of, and potentially significant change in, the procedures within each university, and within the scientific and engineering establishments as a whole." (Campbell, 2001, p. 1)

For the first time, in public and in print, the leaders of the nation's most prestigious research universities suggested that institutional barriers have prevented female scientists and engineers from having a level playing field and that science and engineering might need to change to accommodate women.

Barriers Identified by POWRE Awardees

To be most effective, proposed institutional changes should address institutional barriers identified as most problematic by female scientists and engineers. Data from the almost 400 respondents to an e-mail survey of FYs 1997 to 2000 NSF POWRE awardees reveal the barriers that academic female scientists and engineers identify as most challenging for their careers. Because POWRE was the NSF initiative that ADVANCE replaced in 2001, the quantitative and qualitative data from the entire cohort of POWRE awardees are particularly relevant in exposing the barriers that institutions should change to empower and enable female scientists and engineers.

Established in 1997, the POWRE program stated two main objectives in its attempts to address the need to develop the full use of the nation's human resources for science and engineering:

> to provide opportunities for further career advancement, professional growth, and increased prominence of women in engineering and in the disciplines of science supported by NSF; and to encourage more women to pursue careers in science and engineering by providing greater visibility for women scientists and engineers in academic institutions and in industry. (National Science Foundation, 1997, p. 1)

Female scientists or engineers who were U.S. citizens at any rank in tenured, tenure-track, or non-tenure-track positions at any 4-year college or comprehensive or research university were eligible to apply to POWRE. Although a few tenured, full professors, faculty members from 4-year institutions, and/or non-tenure-track individuals received awards, the vast majority of POWRE awardees were untenured assistant professors in tenure-track

positions at research universities. POWRE awardees represent a relatively successful group of women who hold positions with high potential at good institutions and have received special awards and peer-reviewed funding from a premier governmental, scientific foundation. Issues that POWRE awardees identify as significant barriers for them may be assumed to be equally or more problematic for female scientists and engineers in relatively less successful situations.

METHODS

All POWRE new grant awardees for FYs 1997 to 2000 were sent a questionnaire via e-mail. The questionnaire included the following two questions:

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?

Response rates for the e-mail survey were as follows: 71.6% of the 1997 awardees, 76.6% of the 1998 awardees, 65.5% of the 1999 awardees, and 63.5% of the 2000 awardees. Table 1 shows that the women receiving POWRE awards in all 4 years represented all directorates (see Table 1, footnote a) of NSF disciplines. The success rate (percentage of applicants receiving funding) ranged from 14% to 47% among the seven directorates, and the overall success rate increased from 20% in 1997, 26% in 1998, 27% in 1999, to 33% in 2000.

Sixty-seven of the 96 POWRE awardees for FY 1997, 119 of the 173 awardees for FY 1998, 98 of the 159 awardees for FY 1999, and 105 of the 170 awardees for FY 2000 to whom the e-mail survey was sent responded. The nonresponse rate ranged between 23% and 37% over the 4-year period; some failures to respond were the result of invalid e-mail addresses. In addition to failures to respond, life circumstances prevented acceptance of the award in some cases. For example, in FY 2000, one awardee was killed in an accident, and one responded that personal circumstances surrounding a divorce postponed her acceptance of the award.

As Table 2 shows, 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 (Rosser, 2001).

RESULTS

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

The details of the procedure used to develop the 16 basic categories for responses to Question 1 have been previously published for FY 1997 awardees (see Rosser & Zieseniss,

Table 1. Summary Information for Professional Opportunities for Women in Research and Education (POWRE) Awards for Fiscal Years 1997 to 2000

	FY 1997			FY 1998			FY 1999			FY2000		
Directorate or office[a]	Submitted POWRE proposals	Total FY 1997 grants[b]	Overall success rate	Submitted POWRE proposals	Total FY 1998 grants[c]	Overall success rate	Submitted POWRE proposals	Total FY 1999 grants	Overall success rate	Submitted POWRE proposals	Total FY 2000 grants	Overall success rate
BIO	142	17	12%	214	43	20%	159	36	23%	144	41	28%
CISE	50	10	20%	63	19	30%	43	10	23%	36	11	31%
EHR	12	3	25%	25	7	28%	32	7	22%	24	6	25%
ENG	90	19	21%	118	28	24%	119	30	25%	94	26	28%
GEO	51	10	20%	59	15	25%	50	12	24%	42	17	40%
MPS	100	18	18%	118	34	29%	110	43	39%	94	44	47%
SBE	59	19	32%	104	27	26%	70	21	30%	85	25	29%
Totals[b]	504	96	19%	701	173	25%	583	159	27%	519	170	33%

[a] The National Science Foundation directorates represented in this study include Biological Sciences (BIO); Computer and Information Science and Engineering (CISE); Education and Human Resources (EHR); Engineering (ENG); Geosciences (GEO); Mathematical and Physical Sciences (MPS); and Social, Behavioral, and Economic Sciences (SBE).

[b] This analysis does not include three respondents from the Office of Polar Programs (OPP) directorate for FYs 1997 and 1998 because the total number of respondents was too small to provide meaningful information. Therefore, the totals in this table for each award year do not include the OPP awards.

[c] Some directorates included supplemental grants in their total grants awarded.

Table 2. Numbers and Disciplinary Distribution of Respondents to Questionnaire

Directorate or office[a]	Total FY 1997 grants[b]	Responded to email questions	Total FY 1998 grants[b]	Responded to email questions	Total FY 1999 grants	Responded to email questions	Total FY 2000 grants	Responded to email questions
BIO	17	10	43	27	36	25	41	22
CISE	10	10	19	11	10	6	11	8
EHR	3	3	7	1	7	5	6	3
ENG	19	15	28	23	30	18	26	13
GEO	10	8	15	10	12	8	17	12
MPS	18	9	34	22	43	25	44	28
SBE	19	12	27	22	21	11	25	18
Unknown	n/a	—	n/a	3[c]	n/a	—	n/a	1[c]
Totals[d]	96	67	173	119[e]	159	98[f]	170	105

Note. FY, fiscal year.
N/A = not applicable (i.e., total grants awarded are known for each year of FY 1997–2000.)

[a] The National Science Foundation directorates represented in this study include Biological Sciences (BIO); Computer and Information Science and Engineering (CISE); Education and Human Resources (EHR); Engineering (ENG); Geosciences (GEO); Mathematical and Physical Sciences (MPS); and Social, Behavioral, and Economic Sciences (SBE).

[b] Some directorates included supplemental grants in their total grants awarded.

[c] For three FY 1998 respondents and one FY 2000 respondent, the directorate was not evident from the e-mail address.

[d] This analysis does not include three respondents from the Office of Polar Programs (OPP) directorate for FYs 1997 and 1998 because the total number of respondents was too small to provide meaningful information. Therefore, the totals in this table for each award year do not include the OPP awards.

[e] Three unknown directorates and five late respondents, not included in previous analyses (see Rosser, 2001), were included in this analysis.

[f] One additional respondent, not available in a prior study (Rosser, 2001), was added to the FY 1999 data for this analysis.

2000); the same codes and categories were applied to the responses from FY 1998 to 2000 awardees. 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 clearly emerge when response frequencies are examined.

An overwhelming number of respondents across all 4 years found "balancing work with family responsibilities" (Response 1) to be the most significant challenge facing female scientists and engineers. During all 4 years, large percentages of respondents ranked "time management issues" (Response 2), "isolation and lack of camaraderie," "mentoring due to small numbers" (Response 3), "gaining credibility and respectability from peers" (Response 4), and "two career placements" (Response 5) as major challenges. "Time management

Table 3. Total Responses to Question 1[a]

Category	1997 % of responses	1998 % of responses	1999 % of responses	2000 % 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)
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)
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)
4. Gaining credibility/respectability from peers and administrators	22.4 (15/67)	17.6 (21/119)	19.4 (19/98)	21.9 (23/105)
5. "Two-career" problem (balance with spouse's career)	23.9 (16/67)	10.9 (13/119)	20.4 (20/98)	20.0 (21/105)
6. Lack of funding/inability to get funding	7.5 (5/67)	4.2 (5/119)	10.2 (10/98)	8.6 (9/105)
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)	<1.0 (1/119)	0.0 (0/98)	4.8 (5/105)
9. Affirmative action backlash/ discrimination	6.0 (4/67)	15.1 (18/119)	14.3 (14/98)	12.4 (13/105)
10. Positive: active recruitment of women/more opportunities	6.0 (4/67)	10.1 (12/119)	9.2 (9/98)	14.3 (15/105)
11. Establishing independence	3.0 (2/67)	0.0 (0/119)	6.0 (6/98)	2.9 (3/105)
12. Negative social images	3.0 (2/67)	3.4 (4/119)	2.0 (2/98)	<1.0 (1/105)
13. Trouble gaining access to nonacademic positions	1.5 (1/67)	1.7 (2/119)	1.0 (1/98)	1.9 (2/105)
14. Sexual harassment	1.5 (1/67)	<1.0 (1/119)	2.0 (2/98)	1.9 (2/105)
15. No answer	0.0 (0/67)	<1.0 (1/119)	1.0 (1/98)	1.9 (2/105)
16. Cutthroat competition	— —	— —	1.0 (1/98)	1.9 (2/105)

[a] Question 1: What are the most significant issues/challenges/opportunities facing women scientists today as they plan their careers?

issues" (Response 2) appeared to be less of a problem, whereas "affirmative action/backlash/discrimination" (Response 9) seemed to be more of a problem for 1998 to 2000 awardees. FY 2000 awardees reported "low numbers of women" (Response 3) and "positive responses" (Response 10) at higher rates than awardees in previous years.

Tables 4a, 4b, 5b (see page 175), and 6b (see page 177) show the grouping of the responses to Question 1 into four categories. Adding restrictions because of spousal situations (Responses 5 and 7) to "balancing work with family responsibilities" (Response 1) suggests that Category A, pressures women face in balancing career and family, is the most significant barrier identified by female scientists and engineers regardless of directorate or year of award. A second grouping (Responses 3, 4, 8, 10, and 12) appears to result from the low numbers of female scientists and engineers and consequent stereotypes surrounding expectations about their performance. Isolation and lack of mentoring, as well as gaining credibility and respectability from peers and administrators, typify Category B. Category C (Responses 2, 6, and 16) includes issues faced by both male and female scientists and engineers in the current environment of tight resources that may pose particular difficulties for women, either because of their low numbers or their balancing act between career and family. For example, time management and balancing committee responsibilities with research and teaching (Response 2) can be a problem for both male and female faculty members. However, because of their low numbers in science and engineering, female faculty members are often asked to serve on more committees to meet gender diversity needs, even while they are still junior, and to advise more students, either formally or informally (National Science Foundation, 1997). Cutthroat competition makes it difficult for both men and women to succeed and obtain funding. Gender stereotypes that reinforce women's socialization to be less overtly competitive may make it more difficult for a female scientist or engineer to succeed in a very competitive environment. Category D (Responses 9, 11, 13, and 14) identifies barriers of overt harassment and discrimination faced by female scientists and engineers. Sometimes, even a positive response, such as the active recruitment of women or more opportunities (Response 10), leads to backlash and difficulties in gaining credibility from peers who assume that a woman obtained a position because of affirmative action.

Example quotations from the respondents from all 4 years provide the qualitative context for the categories. The women express the specific barriers for their careers.

Category A (pressures women face in balancing career and family):

> At the risk of stereotyping, I think that women generally struggle more with the daily pull of raising a family or caring for elderly parents, and this obviously puts additional demands on their time. This is true for younger women, who may struggle over the timing of having and raising children, particularly in light of a ticking tenure clock, but also for more senior women, who may be called on to help aging parents (their own or in-laws). Invariably they manage, but not without guilt. (2000 Respondent 63)

> In contrast to other issues related to women choosing careers in science, the two-body problem has received far too little public as well as governmental attention. Universities are basically tackling the problem individually; some act progressively, others don't. The fates of these capable women depend too much on the individual deans or department chairs involved. (1998 Respondent 45)

> Managing dual career families (particularly dual academic careers). Often women take the lesser position in such a situation. Ph.D. women are often married to Ph.D. men. Most Ph.D. men are not married to Ph.D. women. (2000 Respondent 16)

Table 4a. Categorization of Question 1[a] Across Year of Award

Category		Response numbers[b]	Means of responses 1997	1998	1999	2000
A	Pressures women face in balancing career and family	1, 5, 7	31.9%	30.8%	35.0%	32.4%
B[c]	Problems faced by women because of their low numbers and stereotypes held by others regarding gender	3, 4, 8, 10, 12	12.3%	10.1%	9.8%	14.5%
C[c]	Issues faced by both male and female scientists and engineers in the current environment of tight resources, which may pose particular difficulties for women	2, 6, 16	10.0%	4.8%	8.2%	7.9%
D	More overt discrimination and harassment	9, 11, 13, 14	3.0%	4.4%	5.8%	4.8%

Table 4b. Categorization of First Responses to Question 1[a] Across Year of Award

Category		Response numbers[b]	Means of responses 1997	1998	1999	2000
A	Pressures women face in balancing career and family	1, 5, 7	18.4%	22.7%	21.4%	18.1%
B[c]	Problems faced by women because of their low numbers and stereotypes held by others regarding gender	3, 4, 8, 10, 12	4.5%	4.5%	2.9%	4.9%
C[c]	Issues faced by both male and female scientists and engineers in the current environment of tight resources, which may pose particular difficulties for women	2, 6, 16	5.5%	5.5%	3.7%	3.2%
D.	More overt discrimination and harassment	9, 11, 13, 14	1.5%	1.5%	2.6%	2.4%

[a] Question 1: What are the most significant issues/challenges/opportunities facing women scientists today as they plan their careers?

[b] Given the responses from all 4 years, after receiving faculty comments at various presentations of this research, and after working with the data, we exchanged two questions from both Categories B and D to better reflect the response groupings. Specifically, Responses 10 and 12 (considered in Category D in Rosser & Zieseniss, 2000) were moved to Category B. Similarly, Responses 11 and 13 (included in Category B in Rosser & Zieseniss, 2000) were placed into Category D.

[c] The alphabetic designations for Categories B and C have been exchanged, compared with earlier articles (Rosser & Zieseniss, 2000), to present descending response percentages.

Category B (problems faced by women because of their low numbers and stereotypes held by others regarding gender):

> Although possibly less now than before, women scientists still comprise a small proportion of professors in tenure-track positions. Thus, there are few "models" to emulate

and few to get advice/mentoring from. Although men could also mentor, there are unique experiences for women that perhaps can only be felt and shared by other women faculty, particularly in other Ph.D. granting institutions. Some examples of this: a different (i.e., more challenging) treatment by undergraduate and graduate students of women faculty than they would of male faculty; difficulties in dealing with agencies outside of the university who are used to dealing with male professors; difficulties related to managing demands of scholarship and grantsmanship with maternity demands. More women in a department would possibly allow a better environment for new women faculty members to thrive in such a department through advice/mentoring and more awareness of issues facing women faculty members. (2000 Respondent 26)

There remains a disconnect between women faculty and the upper administration of Universities, which is male dominated. The natural tendency to pass on information in casual networks can lead to exclusion of women from the inner circles of information, not necessarily maliciously, but just due to human nature. (2000 Respondent 51)

The biggest challenge that women face in planning a career in science is not being taken seriously. Often women have to go farther, work harder and accomplish more in order to be recognized. (2000 Respondent 21)

In my field . . . women are so poorly represented that being female certainly creates more notice for you and your work, particularly when presenting at conferences. This can be beneficial, as recognition of your research by your peers is important for gaining tenure; it can also add to the already large amount of pressure on new faculty. (2000 Respondent 70)

Category C (issues faced by both male and female scientists and engineers in the current environment of tight resources, which may pose particular difficulties for women):

I have noticed some problems in particular institutions I have visited (or worked at) where women were scarce. As a single woman, I have sometimes been viewed as "available," rather than as a professional co-worker. That can be really, really irritating. I assume that single men working in a location where male workers are scarce can face similar problems. In physics and astronomy, usually the women are more scarce. (1997 Respondent 26)

I still find the strong perception that women should be doing more teaching and service because of the expectation that women are more nurturing. Although research as a priority for women is given a lot of lip service, I've not seen a lot of support for it. (2000 Respondent 1)

Category D (more overt discrimination and/or harassment):

There are almost no women in my field, no senior women, and open harassment and discrimination are very well accepted and have never been discouraged in any instance I am aware of. (1998 Respondent 53)

I have often buffered the bad behavior of my colleagues—and over the years I have handled a number of sexual harassment or "hostile supervision" cases where a more senior person (all of them male) was behaving inappropriately toward a lower social status woman (or in rarer cases a gay man). (1999 Respondent 59)

> The discrimination they continue to face in the workplace. We seem to be making virtually no gains in terms of rates at which women are granted tenure or promotion to full professor. The older I get, the more depressing these statistics become. Women's research is often marginalized. Women's approaches are not recognized. Men scientists want to judge women by "their" standard (i.e. the white male way of doing things!). Most men have no appreciation for the power and privilege of their whiteness and maleness. (1999 Respondent 70)

Comparisons of Responses Among Women from Different Disciplines

Table 5a shows the responses to Question 1 when the data from all 4 years are pooled and the responses are categorized by the NSF directorate of the awardee; this categorization assumes that the NSF directorate granting the POWRE award serves as an indicator of the discipline or field of the awardee. (Note that for data interpretation, Education and Human Resources [EHR] is removed because the numbers are smaller and all awardees come from disciplinary backgrounds included in other NSF directorates). Perhaps the most striking finding is the overall similarity among the directorates. Balancing work with family responsibilities stands out overwhelmingly as the major issue for women from all directorates, just as it did for awardees for all years.

The top six responses were fairly consistent across all directorates, with few exceptions. For Mathematical and Physical Sciences (MPS), Response 3 was lower and Response 10 was higher than for other directorates. This response is curious, given that MPS includes physics, in which low numbers of women have been a problem. However, MPS also includes chemistry and mathematics, fields in which women have increased substantially and job opportunities are plentiful; this may account for the positive response. Both Engineering (ENG) and Geosciences also gave relatively high responses rates to Response 10. Again, this may reflect the positive job opportunities in these fields at the time of the survey, although both of these directorates gave high responses to affirmative action/backlash/discrimination (Response 9). Computer and Information Science and Engineering (CISE) and Biological Sciences awardees also gave a higher Response 9, although a less strong Response 10. Note that when the 16 responses are grouped into the four categories of Table 5b, some of the nuances are lost. For example, Category B includes both Responses 3 and 10, which as noted above are respectively lower and higher for MPS in Table 5a. MPS appears similar to other directorates when Responses 3 and 10 are grouped together in Category B in Table 5b.

Contrary to expectations, the higher frequency of "affirmative action/backlash discrimination" (Response 9) and "positive: active recruitment of women/more opportunities" (Response 10) did not always accompany a higher frequency of "low numbers of women, isolation and lack of camaraderie/mentoring" (Response 3) within a particular directorate group. This suggests that perceptions of both negative discrimination and positive opportunities may not necessarily be correlated with low numbers in a field. This finding contradicts an earlier article (Rosser & Zieseniss, 2000) in which data from only the 1997 awardees were used to compare engineers with scientists:

> The results of this questionnaire reveal that both women scientists and engineers found low numbers/lack of mentoring and gaining credibility/respect to be major issues. However, women engineers listed these issues more frequently than did their scientist

Table 5a. Responses to Question 1[a] According to Directorate

Category	SBE % of responses	MPS % of responses	ENG % of responses	EHR[b] % of responses	CISE % of responses	BIO % of responses	GEO % of responses
1. Balancing work with family responsibilities (children, elderly relatives, etc.)	60.3 (38/63)	77.4 (65/84)	65.2 (45/69)	91.7 (11/12)	60.0 (21/35)	82.4 (70/85)	73.7 (28/38)
2. Time management/balancing committee responsibilities with research and teaching	15.7 (10/63)	13.1 (11/84)	11.6 (8/69)	0.0 (0/12)	17.1 (6/35)	12.9 (11/85)	21.1 (8/38)
3. Low numbers of women, isolation, and lack of camaraderie/mentoring	23.8 (15/63)	11.9 (10/84)	21.7 (15/69)	33.3 (4/12)	31.4 (11/35)	20.0 (17/85)	39.5 (15/38)
4. Gaining credibility/respectability from peers and administrators	17.5 (11/63)	20.2 (17/84)	24.6 (17/69)	25.0 (3/12)	31.4 (11/35)	16.5 (14/85)	13.2 (5/38)
5. Two-career" problem (balance with spouse's career)	14.3 (9/63)	28.6 (24/84)	13.0 (9/69)	16.7 (2/12)	22.9 (8/35)	11.8 (10/85)	21.1 (8/38)
6. Lack of funding/inability to get funding	4.8 (3/63)	7.1 (6/84)	8.7 (6/69)	0.0 (0/12)	5.7 (2/35)	8.2 (7/85)	10.5 (4/38)
7. Job restrictions (location, salaries, etc.)	3.3 (2/63)	7.1 (6/84)	5.8 (4/69)	8.3 (1/12)	5.7 (2/35)	11.8 (10/85)	10.5 (4/38)
8. Networking	1.6 (1/63)	1.2 (1/84)	0.0 (0/69)	8.3 (1/12)	5.7 (2/35)	2.4 (2/85)	5.3 (2/38)
9. Affirmative action backlash/discrimination	7.9 (5/63)	6.0 (5/84)	15.9 (11/69)	8.3 (1/12)	20.0 (7/35)	11.8 (10/85)	23.7 (9/38)
10. Positive: active recruitment of women/ more opportunities	7.9 (5/63)	15.5 (13/84)	13.0 (9/69)	8.3 (1/12)	8.6 (3/35)	3.5 (3/85)	15.8 (6/38)
11. Establishing independence	3.3 (2/63)	4.8 (4/84)	1.4 (1/69)	0.0 (0/12)	2.9 (1/35)	3.5 (3/85)	0.0 (0/38)
12. Negative social images	1.6 (1/63)	2.4 (2/84)	2.9 (2/69)	0.0 (0/12)	5.7 (2/35)	2.4 (2/85)	0.0 (0/38)
13. Trouble gaining access to nonacademic positions	1.6 (1/63)	2.4 (2/84)	0.0 (0/69)	0.0 (0/12)	5.7 (2/35)	1.2 (1/85)	0.0 (0/38)
14. Sexual harassment	3.3 (2/63)	1.2 (1/84)	0.0 (0/69)	0.0 (0/12)	5.7 (2/35)	0.0 (0/85)	2.6 (1/38)
15. No answer	4.8 (3/63)	0.0 (0/84)	1.4 (1/69)	0.0 (0/12)	0.0 (0/35)	0.0 (0/85)	0.0 (0/38)
16. Cutthroat competition	0.0 (0/63)	0.0 (0/84)	0.0 (0/69)	0.0 (0/12)	2.9 (1/35)	1.2 (1/85)	2.6 (1/38)

[a] Question 1: What are the most significant issues/challenges/opportunities facing women scientists today as they plan their careers? SBE, Social, Behavioral, and Economic Sciences; MPS, Mathematical and Physical Sciences; ENG, Engineering; EHR, Education and Human Resources; CISE, Computer and Information Science and Engineering; BIO, Biological Sciences; GEO, Geosciences.

[b] Because of the low numbers of awardees, the EHR directorate should be carefully interpreted here. Many of the women representing this directorate have other disciplinary training and could be classified in other directorates. We have chosen not to interpret the EHR responses as a result.

Table 5b. Categorization of All Responses to Question 1[a] Across Directorates

Category	Response numbers[b]	Means of responses						
		SBE	MPS	ENG	EHR	CISE	BIO	GEO
A Pressures women face in balancing career and family	1, 5, 7	26.0%	37.7%	28.0%	38.9%	29.5%	35.3%	35.1%
B[c] Problems faced by women because of their low numbers and stereotypes held by others regarding gender	3, 4, 8, 10, 12	10.5%	10.2%	12.4%	15.0%	16.6%	9.0%	14.8%
C[c] Issues faced by both male and female scientists and engineers in the current environment of tight resources, which may pose particular difficulties for women	2, 6, 16	6.8%	6.7%	6.8%	0.0%	8.6%	7.4%	11.4%
D More overt discrimination and harassment	9, 11, 13, 14	4.0%	3.6%	4.3%	2.1%	8.6%	4.1%	6.6%

[a] Question 1: What are the most significant issues/challenges/opportunities facing women scientists today as they plan their careers? SBE, Social, Behavioral, and Economic Sciences; MPS, Mathematical and Physical Sciences; ENG, Engineering; EHR, Education and Human Resources; CISE, Computer and Information Science and Engineering; BIO, Biological Sciences; GEO, Geosciences.

[b] Given the responses from all 4 years, after receiving faculty comments at various presentations of this research, and after working with the data, we exchanged two questions from both Categories B and D to better reflect the response groupings. Specifically, Responses 10 and 12 (considered in Category D in Rosser & Zieseniss, 2000) were moved to Category B. Similarly, Responses 11 and 13 (included in Category B in Rosser & Zieseniss, 2000) were placed into Category D.

[c] The alphabetic designation for Categories B and C have been exchanged, compared with earlier articles (Rosser & Zieseniss, 2000), to present descending response percentages.

> colleagues. The women engineers also listed time management and learning the rules of the game to survive in a male-dominated environment as major difficulties.
>
> These differences between women scientists and engineers appear to be directly related to the very small number of women engineers relative to the numbers of women scientists now present in many disciplines. Continuing low numbers provide particular challenges and some opportunities . . . the low numbers that result in active recruitment of women into many areas of science, engineering, and mathematics have both positive and negative consequences. Demand in engineering and computer science gives women starting salaries that are equal to or higher than those of their male counterparts (Vetter, 1996). The recruitment can lead to various forms of backlash for a woman, ranging from overt discrimination to difficulties gaining credibility from peers and administrators who assume she obtained the position to fill a quota. (pp. 17–18)

Analysis of the data from the complete 4-year POWRE cohort does not support the conclusion drawn in the earlier article (Rosser & Zieseniss, 2000), which was based on the more limited data set. In the earlier article, the smaller numbers prohibited comparisons among directorates, so that engineers were compared with all other scientists grouped together, which may partially account for the discrepancy.

Table 6a presents the frequency of the first response for each category for Question 1 for each awardee cohort by year. The data in Table 6a again reinforce that the first six responses, and for 1998 to 20000 awardees, "affirmative action/backlash/discrimination" (Response 9) represents the most frequent response. Table 6b shows the categorization of first response to Question 1 across directorates. Note that when all responses are aggregated across directorate, the percentages are roughly proportional to the mean category responses across award year. However, when only first responses are categorized by directorate, CISE awardees have a lower mean response for Category A and a higher mean response for Category B. This may suggest that women in CISE perceive problems of their low numbers to be of higher priority than the pressure to balance career and family, although both are important issues.

Table 7 presents the frequency of the first response to Question 1 by directorate of awardee, pooled over 4 years. Again, for most directorates, the first six responses plus Response 9 (with the exception of MPS) or Response 10 (in the case of MPS) are the most frequent.

Question 2: How Does the Laboratory Climate Impact Upon the Careers of Women Scientists?

Question 2 of the e-mail survey, "How does the laboratory climate (or its equivalent in your subdiscipline) impact upon the careers of women scientists?" attempted to explore women's perceptions of their work environments. As with Question 1, data from Question 2 are not conducive to standard tests of means for award years and directorates. Although we cannot conclude statistical differences between years or directorates, notable trends do emerge when the frequencies of responses are analyzed by award year and directorate. Across all award years, "balancing career and family/time away from home" (the same response as for Question 1) was an answer given by more respondents than any other. As Table 8 documents, in contrast to Question 1, the responses given to this question reflect less consensus. Awardees from all years, but particularly 1997 awardees, had some difficulty under-

Table 6a. First Response to Question 1[a] by Year of Professional Opportunities for Women in Research and Education Award

Category	1997 % of responses	1998 % of responses	1999 % of responses	2000 % of responses
1. Balancing work with family responsibilities (children, elderly relatives, etc.)	46.3 (31/67)	60.5 (72/119)	54.1 (53/98)	46.7 (49/105)
2. Time management/balancing committee responsibilities with research and teaching	9.0 (6/67)	4.2 (5/119)	6.1 (6/98)	5.7 (6/105)
3. Low numbers of women, isolation, and lack of camaraderie/mentoring	7.5 (5/67)	8.4 (10/119)	9.2 (9/98)	11.4 (12/105)
4. Gaining credibility/respectability from peers and administrators	7.5 (5/67)	5.9 (7/119)	3.1 (3/98)	9.5 (10/105)
5. "Two-career" problem (balance with spouse's career)	7.5 (5/67)	2.5 (3/119)	8.2 (8/98)	7.6 (8/105)
6. Lack of funding/inability to get funding	7.5 (5/67)	1.7 (2/119)	4.1 (4/98)	3.9 (4/105)
7. Job restrictions(location, salaries, etc.)	1.5 (1/67)	5.0 (6/119)	2.0 (2/98)	0.0 (0/105)
8. Networking	3.0 (2/67)	<1.0 (1/119)	0.0 (0/98)	<1.0 (1/105)
9. Affirmative action backlash/ discrimination	1.5 (1/67)	6.7 (8/119)	7.1 (7/98)	7.6 (8/105)
10. Positive: active recruitment of women/more opportunities	1.5 (1/67)	<1.0 (1/119)	1.0 (1/98)	2.9 (3/105)
11. Establishing independence	1.5 (1/67)	0.0 (0/119)	3.1 (3/98)	<1.0 (1/105)
12. Negative social images	3.0 (2/67)	1.7 (2/119)	1.0 (1/98)	0.0 (0/105)
13. Trouble gaining access to nonacademic positions	1.5 (1/67)	<1.0 (1/119)	0.0 (0/98)	<1.0 (1/105)
14. Sexual harassment	1.5 (1/67)	0.0 (0/119)	0.0 (0/98)	0.0 (0/105)
15. No answer	0.0 (0/67)	<1.0 (1/119)	1.0 (1/98)	1.9 (2/105)
16. Cutthroat competition	— —	— —	1.0 (1/98)	0.0 (0/105)

[a] Question 1: What are the most significant issues/challenges/opportunities facing women scientists today as they plan their careers?

standing the question. Although many women did not mention problems in either their laboratory or work environment related to gender issues (Responses 3, 4, and 9), the largest number of responses did suggest that to some degree, their gender led to their being perceived as a problem, anomaly, or deviant in the laboratory or work environment. Awardees from 1998 and 1999 ranked "hostile or intimidating environment" (Response 7) higher than 1997 and 2000 awardees. Awardees from 1999 ranked the "boys club atmosphere" (Response 6), "lack of numbers/networking" (Response 11), and "lack of funding" (Response 16) as more problematic than 1997, 1998, or 2000 awardees. In contrast, 1998 awardees ranked "have not experienced problems" (Response 3) and "positive impact" (Response 10) higher than either 1997 or 1999 awardees. Awardees from 2000 ranked "positive impact" (Response 10) and "lack of camaraderie/communications and isolation"

Table 6b. Categorization of First Responses to Question 1[a] Across Directorates

Category		Response numbers[b]	Means of responses						
			SBE	MPS	ENG	EHR	CISE	BIO	GEO
A	Pressures women face in balancing career and family	1, 5, 7	19.1%	23.8%	20.3%	22.2%	12.4%	21.2%	20.2%
B[c]	Problems faced by women because of their low numbers and stereotypes held by others regarding gender	3, 4, 8, 10, 12	3.5%	3.6%	4.3%	6.7%	7.4%	2.6%	3.1%
C[c]	Issues faced by both male and female scientists and engineers in the current environment of tight resources, which may pose particular difficulties for women	2, 6, 16	3.7%	2.4%	2.4%	0.0%	2.9%	4.3%	5.3%
D	More overt discrimination and harassment	9, 11, 13, 14	2.4%	0.9%	2.2%	0.0%	4.3%	2.7%	2.0%

[a] Question 1: What are the most significant issues/challenges/opportunities facing women scientists today as they plan their careers? SBE, Social, Behavioral, and Economic Sciences; MPS, Mathematical and Physical Sciences; ENG, Engineering; EHR, Education and Human Resources; CISE, Computer and Information Science and Engineering; BIO, Biological Sciences; GEO, Geosciences.

[b] Given the responses from all 4 years, after receiving faculty comments at various presentations of this research, and after working with the data, we exchanged two questions from both Categories B and D to better reflect the response groupings. Specifically, Responses 10 and 12 (considered in Category D in Rosser & Zieseniss, 2000) were moved to Category B. Similarly, Responses 11 and 13 (included in Category B in Rosser & Zieseniss, 2000) were placed into Category D.

[c] The alphabetic designation for Categories B and C have been exchanged, compared with earlier articles (Rosser & Zieseniss, 2000) to present descending response percentages.

Table 7. First Response to Question 1[a] According to Directorate

Category	SBE % of responses	MPS % of responses	ENG % of responses	EHR[b] % of responsesa	CISE % of responses	BIO % of responses	GEO % of responses
1. Balancing work with family responsibilities (children, elderly relatives, etc.)	50.8 (32/63)	60.7 (51/84)	50.7 (35/69)	58.3 (7/12)	31.4 (11/35)	57.6 (49/85)	50.0 (19/38)
2. Time management/balancing committee responsibilities with research and teaching	6.3 (4/63)	4.8 (4/84)	4.3 (3/69)	0.0 (0/12)	5.7 (2/35)	7.1 (6/85)	10.5 (4/38)
3. Low numbers of women, isolation, and lack of camaraderie/mentoring	11.1 (7/63)	2.4 (2/84)	11.6 (8/69)	16.7 (2/12)	17.1 (6/35)	7.1 (6/85)	10.5 (4/38)
4. Gaining credibility/respectability from peers and administrators	3.2 (2/63)	9.5 (8/84)	7.2 (5/69)	8.3 (1/12)	14.3 (5/35)	3.5 (3/85)	2.6 (1/38)
5. "Two-career" problem (balance with spouse's career)	4.8 (3/63)	10.7 (9/84)	7.2 (5/69)	8.3 (1/12)	5.7 (2/35)	1.2 (1/85)	7.9 (3/38)
6. Lack of funding/inability to get funding	4.8 (3/63)	2.4 (2/84)	2.9 (2/69)	0.0 (0/12)	2.9 (1/35)	5.9 (5/85)	5.3 (2/38)
7. Job restrictions (location, salaries, etc.)	1.6 (1/63)	0.0 (0/84)	2.9 (2/69)	0.0 (0/12)	0.0 (0/35)	4.7 (4/85)	2.6 (1/38)
8. Networking	1.6 (1/63)	1.2 (1/84)	0.0 (0/69)	0.0 (0/12)	2.9 (1/35)	0.0 (0/85)	2.6 (1/38)
9. Affirmative action backlash/discrimination	4.8 (3/63)	0.0 (0/84)	8.7 (6/69)	0.0 (0/12)	14.3 (5/35)	8.2 (7/85)	7.9 (3/38)
10. Positive: active recruitment of women/ more opportunities	0.0 (0/63)	3.6 (3/84)	0.0 (0/69)	8.3 (1/12)	2.9 (1/35)	1.2 (1/85)	0.0 (0/38)
11. Establishing independence	3.2 (2/63)	1.2 (1/84)	0.0 (0/69)	0.0 (0/12)	2.9 (1/35)	1.2 (1/85)	0.0 (0/38)
12. Negative social images	1.6 (1/63)	1.2 (1/84)	2.9 (2/69)	0.0 (0/12)	0.0 (0/35)	1.2 (1/85)	0.0 (0/38)
13. Trouble gaining access to nonacademic positions	1.6 (1/63)	1.2 (1/84)	0.0 (0/69)	0.0 (0/12)	0.0 (0/35)	1.2 (1/85)	0.0 (0/38)
14. Sexual harassment	0.0 (0/63)	1.2 (1/84)	0.0 (0/69)	0.0 (0/12)	0.0 (0/35)	0.0 (0/85)	0.0 (0/38)
15. No answer	4.8 (3/63)	0.0 (0/84)	1.4 (1/69)	0.0 (0/12)	0.0 (0/35)	0.0 (0/85)	0.0 (0/38)
16. Cutthroat competition	0.0 (0/63)	0.0 (0/84)	0.0 (0/69)	0.0 (0/12)	0.0 (0/35)	0.0 (0/85)	0.0 (1/38)

[a] Question 1: What are the most significant issues/challenges/opportunities facing women scientists today as they plan their careers? SBE, Social, Behavioral, and Economic Sciences; MPS, Mathematical and Physical Sciences; ENG, Engineering; EHR, Education and Human Resources; CISE, Computer and Information Science and Engineering; BIO, Biological Sciences; GEO, Geosciences.

[b] Because of the low numbers of awardees, the EHR directorate should be carefully interpreted here. Many of the women representing this directorate have other disciplinary training and could be classified in other directorates. We have chosen not to interpret the EHR responses as a result.

(Response 5) higher than any of the previous three years' awardees. Awardees from 1999 and 2000 also mentioned new issues not articulated by 1997 or 1998 awardees, such as "space" (Response 21), "cultural/national stereotypes for women" (Response 20), and "department doesn't get basic issues" (Response 19).

Table 9 shows the responses to Question 2 when the data from all 4 years are pooled and categorized by the NSF directorate of the awardee. As with Question 1, the most strik-

Table 8. Total Responses to Question 2[a]

Category	1997 % of responses	1998 % of responses	1999 % of responses	2000 % of responses
1. Don't know/question unclear	16.4 (11/67)	4.2 (5/119)	7.1 (7/98)	5.7 (6/105)
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)
3. Have not experienced problems	11.9 (8/67)	16.8 (20/119)	10.2 (10/98)	9.5 (10/105)
4. Not in lab atmosphere/can't answer	11.9 (8/67)	5.9 (7/119)	1.0 (1/98)	8.6 (9/105)
5. Lack of camaraderie/communications and isolation	9.0 (6/67)	11.8 (14/119)	9.2 (9/98)	14.3 (15/105)
6. "Boys club" atmosphere	9.0 (6/67)	9.2 (11/119)	18.4 (18/98)	9.5 (10/105)
7. Hostile environment/intimidating/lack of authority	9.0 (6/67)	14.3 (17/119)	15.3 (15/98)	8.6 (9/105)
8. Establishing respectability/credibility	9.0 (6/67)	10.9 (13/119)	10.2 (10/98)	3.8 (4/105)
9. No answer	7.5 (5/67)	6.7 (8/119)	5.1 (5/98)	<1.0 (1/105)
10. Positive impact	6.0 (4/67)	10.1 (12/119)	6.1 (6/98)	11.4 (12/105)
11. Lack of numbering/networking	4.5 (3/67)	6.7 (8/119)	12.2 (12/98)	4.8 (5/105)
12. General problem with time management	4.5 (3/67)	1.7 (2/119)	5.1 (5/98)	3.8 (4/105)
13. Safety concerns/presence of toxic substances (health concerns)	3.0 (2/67)	0.0 (0/119)	4.1 (4/98)	1.9 (2/105)
14. Benefit by working with peers	3.0 (2/67)	2.5 (3/119)	3.1 (3/98)	5.7 (6/105)
15. Problem of wanting research independence	3.0 (2/67)	0.0 (0/119)	1.0 (1/98)	<1.0 (1/105)
16. Lack of funding	1.5 (1/67)	<1.0 (1/119)	5.1 (5/98)	<1.0 (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)
18. Did not answer	0.0 (0/67)	0.0 (0/119)	3.1 (3/98)	0.0 (0/105)
19. Department doesn't understand basic issues	—	—	—	<1.0 (1/105)
20. Cultural/national stereotypes for women	—	—	—	6.7 (7/105)
21. Space	—	—	1.0 (1/98)	0.0 (0/105)
22. Better bathroom facilities	—	—	—	<1.0 (1/105)

[a] Question 2: How does the laboratory climate (or its equivalent in your subdiscipline) impact upon the careers of women scientists?

ing finding is the similarity of responses among the awardees from different directorates. However, some differences in responses emerge, which might be predicted, based on the discipline. (Note that for this analysis, EHR is removed because the numbers are small and the awardees come from different disciplinary backgrounds.) For example, large numbers of awardees from the Social, Behavioral, and Economic Sciences and CISE indicated that they are "not in lab atmosphere/can't answer" (Response 4) or gave "no answer" (Response 9). Some responses seem peculiar, or even contradictory. For example, awardees from ENG give the highest response rates both to "have not experienced problems" (Response 3) and to "hostile environment/intimidating/lack of authority" (Response 7). MPS awardees give high response rates to "lack of camaraderie/communications and isolation" (Response 5) and "lack of numbers/networking" (Response 11). Although this response to Question 2 is internally consistent, it contradicts the response of MPS awardees to Question 1, to which they gave a relatively low response rate to "low numbers of women, isolation and lack of camaraderie/mentoring" (see Table 5, Response 3).

Table 10 presents the frequency of the first response for each category for Question 2. With a few notable exceptions (Response 4 for 1999 awardees and Response 14 for 2000 awardees), overall, the responses are more evenly distributed among the first 12 categories during all 4 years than they were for Question 1.

Table 11, which sorts the frequency of first responses by the directorate of awardee and pools them over the 4 years, reveals more variation in responses to some categories by directorate. Not surprisingly, the results in Table 11 mirror closely those in Table 9. This mirroring reflects that the first response was often the sole response to Question 2.

Again, the quotations from the responses of the female scientists and engineers explain the context and provide specific illustrations of the problems and difficulties that affect their careers:

> There is little recognition of the contradiction that researchers are expected to spend personal time in the lab doing research, when especially women are expected to spend their personal time for family obligations. (2000 Respondent 1)

> The laboratory climate in my field negatively impacts the careers of women scientists. Many of my colleagues are foreign males who do not take females seriously and do not collaborate with them. (2000 Respondent 62)

> We do a lot of work with agencies outside of the university that are predominantly dominated by men (police, courts, correctional agencies, legislators). These agencies have also been used to dealing with male professors. Thus, it is difficult for women to establish links and work with these agencies—I am still working on establishing ties with agencies around my area, working closely with other established women and men faculty members. (2000 Respondent 26)

In contrast to the quotations above, some female scientists and engineers, as suggested by Responses 10, 14, and 17, find the laboratory environment extremely positive and productive.

Because many women have life experiences that differ from those of their male colleagues, these experiences may lead female scientists and engineers to different approaches, interests, and questions to their research than those traditionally used by men (Keller, 1983; Rosser, 1990, 1997). As in identifying the difficulties, the words of the respondents themselves provide the most convincing evidence for the potential of new ideas and approaches women can contribute to science and engineering:

Table 9. Responses to Question 2[a] According to Directorate

Category	SBE % of responses	MPS % of responses	ENG % of responses	EHR[b] % of responsesa	CISE % of responses	BIO % of responses	GEO % of responses
1. Don't know/question unclear	9.5 (6/63)	6.0 (5/84)	10.1 (7/69)	8.3 (1/12)	5.7 (2/35)	7.1 (6/85)	5.3 (2/38)
2. Balancing career and family/time away from home	11.1 (7/63)	14.3 (12/84)	10.1 (7/69)	16.7 (2/12)	8.6 (3/35)	28.2 (24/85)	18.4 (7/38)
3. Have not experienced problems	14.3 (9/63)	7.1 (6/84)	18.8 (13/69)	8.3 (1/12)	11.4 (4/35)	8.2 (7/85)	18.4 (7/38)
4. Not in lab atmosphere/can't answer	19.0 (12/63)	4.8 (4/84)	1.4 (1/69)	8.3 (1/12)	17.1 (6/35)	0.0 (0/85)	2.6 (1/38)
5. Lack of camaraderie/communications and isolation	4.8 (3/63)	20.2 (17/84)	11.6 (8/69)	33.3 (4/12)	5.7 (2/35)	9.4 (8/85)	5.3 (2/38)
6. "Boys club" atmosphere	7.9 (5/63)	14.3 (12/84)	10.1 (7/69)	25.0 (3/12)	8.6 (3/35)	12.9 (11/85)	10.5 (4/38)
7. Hostile environment/intimidating/ lack of authority	4.8 (3/63)	16.7 (14/84)	18.8 (13/69)	0.0 (0/12)	14.3 (5/35)	11.8 (10/85)	5.3 (2/38)
8. Establishing respectability/ credibility	9.5 (6/63)	9.5 (8/84)	7.2 (5/69)	8.3 (1/12)	8.6 (3/35)	8.2 (7/85)	5.3 (2/38)
9. No answer	11.1 (7/63)	3.6 (3/84)	4.3 (3/69)	8.3 (1/12)	11.4 (4/35)	1.2 (1/85)	0.0 (0/38)
10. Positive impact	3.2 (2/63)	6.0 (5/84)	7.2 (5/69)	16.7 (2/12)	2.9 (1/35)	12.9 (11/85)	21.1 (8/38)
11. Lack of numbering/networking	7.9 (5/63)	11.9 (10/84)	5.8 (4/69)	8.3 (1/12)	2.9 (1/35)	7.1 (6/85)	0.0 (0/38)
12. General problem with time management	1.6 (1/63)	3.6 (3/84)	2.9 (2/69)	0.0 (0/12)	5.7 (2/35)	5.9 (5/85)	2.6 (1/38)
13. Safety concerns/presence of toxic substances (health concerns)	1.6 (1/63)	3.6 (3/84)	2.9 (2/69)	0.0 (0/12)	0.0 (0/35)	2.4 (2/85)	0.0 (0/38)

(continues on next page)

Category	SBE % of responses	MPS % of responses	ENG % of responses	EHR[b] % of responsesa	CISE % of responses	BIO % of responses	GEO % of responses
14. Benefit by working with peers	4.8 (3/63)	1.2 (1/84)	2.9 (2/69)	0.0 (0/12)	2.9 (1/35)	4.7 (4/85)	7.9 (3/38)
15. Problem of wanting research independence	1.6 (1/63)	0.0 (0/84)	1.4 (1/69)	0.0 (0/12)	0.0 (0/35)	1.2 (1/85)	2.6 (1/38)
16. Lack of funding	0.0 (0/63)	1.2 (1/84)	0.0 (0/69)	0.0 (0/12)	0.0 (0/35)	3.5 (3/85)	10.5 (4/38)
17. Benefit from time flexibility/determine own lab hours	3.2 (2/63)	1.2 (1/84)	1.4 (1/69)	0.0 (0/12)	0.0 (0/35)	3.5 (3/85)	5.3 (2/38)
18. Did not answer	0.0 (0/63)	2.4 (2/84)	1.4 (1/69)	0.0 (0/12)	0.0 (0/35)	0.0 (0/85)	0.0 (0/38)
19. Department doesn't understand basic issues	0.0 (0/63)	1.2 (1/84)	0.0 (0/69)	0.0 (0/12)	0.0 (0/35)	0.0 (0/85)	0.0 (0/38)
20. Cultural/national stereotypes for women	1.6 (1/63)	2.4 (2/84)	1.4 (1/69)	0.0 (0/12)	5.7 (2/35)	1.2 (1/85)	0.0 (0/38)
21. Space	1.6 (1/63)	0.0 (0/84)	0.0 (0/69)	0.0 (0/12)	0.0 (0/35)	0.0 (0/85)	0.0 (0/38)
22. Better bathroom facilities	0.0 (0/63)	1.2 (1/84)	0.0 (0/69)	0.0 (0/12)	0.0 (0/35)	0.0 (0/85)	0.0 (0/38)

[a] Question 2: How does the laboratory climate (or its equivalent in your subdiscipline) impact upon the careers of women scientists? SBE, Social, Behavioral, and Economic Sciences; MPS, Mathematical and Physical Sciences; ENG, Engineering; EHR, Education and Human Resources; CISE, Computer and Information Science and Engineering; BIO, Biological Sciences; GEO, Geosciences.

[b] Because of the low numbers of awardees, the EHR directorate should be carefully interpreted here. Many of the women representing this directorate have other disciplinary training and could be classified in other directorates. We have chosen not to interpret the EHR responses as a result.

Table 10. First Response to Question 2[a] by Year of Professional Opportunities for Women in Research and Education Award

Category	1997 % of responses	1998 % of responses	1999 % of responses	2000 % of responses
1. Don't know/question unclear	16.4 (11/67)	4.2 (5/119)	6.1 (6/98)	5.7 (6/105)
2. Balancing career and family/time away from home	9.0 (6/67)	11.8 (14/119)	10.2 (10/98)	11.4 (12/105)
3. Have not experienced problems	11.9 (8/67)	16.8 (20/119)	10.2 (10/98)	9.5 (10/105)
4. Not in lab atmosphere/ can't answer	11.9 (8/67)	5.9 (7/119)	1.0 (1/98)	8.6 (9/105)
5. Lack of camaraderie/ communications and isolation	4.5 (3/67)	10.1 (12/119)	7.1 (7/98)	13.3 (14/105)
6. "Boys club" atmosphere	7.5 (5/67)	9.2 (11/119)	13.3 (13/98)	6.7 (7/105)
7. Hostile environment/ intimidating/lack of authority	6.0 (4/67)	11.8 (14/119)	13.3 (13/98)	7.6 (8/105)
8. Establishing respectability/ credibility	9.0 (6/67)	6.7 (8/119)	5.1 (5/98)	1.9 (2/105)
9. No answer	7.5 (5/67)	6.7 (8/119)	5.1 (5/98)	<1.0 (1/105)
10. Positive impact	4.5 (3/67)	6.7 (8/119)	6.1 (6/98)	10.5 (11/105)
11. Lack of numbering/networking	1.5 (1/67)	4.2 (5/119)	6.1 (6/98)	4.8 (5/105)
12. General problem with time management	1.5 (1/67)	1.7 (2/119)	4.1 (4/98)	3.8 (4/105)
13. Safety concerns/presence of toxic substances (health concerns)	3.0 (2/67)	0.0 (0/119)	3.1 (3/98)	1.9 (2/105)
14. Benefit by working with peers	1.5 (1/67)	1.7 (2/119)	1.0 (1/98)	4.8 (5/105)
15. Problem of wanting research independence	1.5 (1/67)	0.0 (0/119)	1.0 (1/98)	0.0 (0/105)
16. Lack of funding	0.0 (0/67)	<1.0 (1/119)	2.0 (2/98)	<1.0 (1/105)
17. Benefit from time flexibility/ determine own lab hours	1.5 (1/67)	1.7 (2/119)	2.0 (2/98)	1.9 (2/105)
18. Did not answer	0.0 (0/67)	0.0 (0/119)	3.1 (3/98)	0.0 (0/105)
19. Department doesn't understand basic issues	— —	— —	— —	0.0 (0/105)
20. Cultural/national stereotypes for women	— —	— —	— —	4.8 (5/105)
21. Space	— —	— —	0.0 (0/98)	0.0 (0/105)
22. Better bathroom facilities	— —	— —	— —	<1.0 (1/105)

[a] Question 2: How does the laboratory climate (or its equivalent in your subdiscipline) impact upon the careers of women scientists?

> The most significant challenge I face is favoring "hacker" experience. In the computer science discipline in which I work, respect is conferred on those who possess knowledge obtained primarily through countless hours investigating the nuances of hardware and operating systems. To many in my peer group, this is a relaxing hobby and way of life. Though I learn these nuances as I need them for my research outside of my work, I read literature, am deeply interested in social issues and am committed to being involved in my child's life. I see this alternate experience base as an asset to my field. As Rob Pike of

> C language fame recently said, "Narrowness of experience leads to narrowness of imagination." But for now, the perception is still tilted against me. (1999 Respondent 68)

> I've built a project and a lab with a group of female scientists. It was a mere coincidence (or was it?) to form an interdisciplinary research visualization group in applied medicine (e.g. virtual surgical training, teaching anatomy via 3D visualization, at [my university's] medical school). Because our group consists of computer scientists, computational linguists, cognitive psychologists, anatomists, we had to establish communication between these disciplines . . . somehow we managed to develop an amazing climate to collaborate and also attract female graduate students to do research with us. (1998 Respondent 50)

> I find the laboratory climate more liberal than, say, the "office climate." I also feel autonomous, powerful and free in this environment (maybe it's because I get to use power tools?) In the laboratory climate, I am able to create and build. I am also able to ask for help and delegate responsibility. Sometimes my colleagues ask me for help. There is a hierarchical structure at the laboratory in which I work, but it is more fluid, roles switch as projects come through. Sometimes I will take the lead and other times I will follow. In terms of my career, working in a laboratory offers a fantastic opportunity to work alone, work with a large group and manage a project, offer support to a colleague, and to build a small community. (1997 Respondent 27)

DISCUSSION AND POLICY CONSIDERATIONS

Data from the almost 400 awardees from FYs 1997 to 2000 who responded to an e-mail questionnaire provide insights into barriers that institutions must seek to remove or at least lower to increase the retention of female scientists and engineers and to attract more women to the disciplines. The experiences of the POWRE awardees and the outcomes of this research suggest various policy considerations for removing the institutional barriers that prevent women from being full participants in science and technology disciplines. On the basis of the findings presented in this article, we observe at least four distinct policy issues that emerge from the POWRE responses. We organize our discussion and recommendations around the four response categories, which evolved from grouping together similar responses across all 4 years of the study.

Balancing Career and Family

The most pressing, immediate concern that institutions must alleviate is the difficulty women face in balancing family and career. Although this issue affects many women (and increasingly men also), it is particularly challenging for women in competitive fields such as science and engineering (Wasserman, 2000). The balancing act extends beyond the scenario of a woman juggling children and her job; it also affects a woman's decision on when (or whether) to have children. For many women, the decision affects their likelihood of getting tenure (Cook, 2001). Family-friendly policies that stop the tenure clock, provide on-site day care, and facilitate dual-career hires should help both male and female faculty members (Wenniger, 2001; Wilson, 2001). The policy of the American Association of University Professors is to stop the tenure clock for parental leave (available to men or

Table 11. First Response to Question 2[a] According to Directorate

Category	SBE % of responses	MPS % of responses	ENG % of responses	EHR[b] % of responsesa	CISE % of responses	BIO % of responses	GEO % of responses
1. Don't know/question unclear	9.5 (6/63)	6.0 (5/84)	8.7 (6/69)	8.3 (1/12)	5.7 (2/35)	7.1 (6/85)	5.3 (2/38)
2. Balancing career and family/time away from home	9.5 (6/63)	7.1 (6/84)	8.7 (6/69)	16.7 (2/12)	8.6 (3/35)	17.6 (15/85)	10.5 (4/38)
3. Have not experienced problems	14.3 (9/63)	7.1 (6/84)	18.8 (13/69)	8.3 (1/12)	11.4 (4/35)	8.2 (7/85)	18.4 (7/38)
4. Not in lab atmosphere/can't answer	19.0 (12/63)	4.8 (4/84)	1.4 (1/69)	8.3 (1/12)	17.1 (6/35)	0.0 (0/85)	2.6 (1/38)
5. Lack of camaraderie/communications and isolation	1.6 (1/63)	16.7 (14/84)	11.6 (8/69)	25.0 (3/12)	5.7 (2/35)	7.1 (6/85)	5.3 (2/38)
6. "Boys club" atmosphere	7.9 (5/63)	10.7 (9/84)	7.2 (5/69)	16.7 (2/12)	8.6 (3/35)	10.6 (9/85)	7.9 (3/38)
7. Hostile environment/intimidating/ lack of authority	4.8 (3/63)	11.9 (10/84)	14.5 (10/69)	0.0 (0/12)	11.4 (4/35)	10.6 (9/85)	5.3 (2/38)
8. Establishing respectability/credibility	3.2 (2/63)	7.1 (6/84)	7.2 (5/69)	0.0 (0/12)	2.9 (1/35)	5.9 (5/85)	2.6 (1/38)
9. No answer	11.1 (7/63)	3.6 (3/84)	4.3 (3/69)	8.3 (1/12)	11.4 (4/35)	1.2 (1/85)	0.0 (0/38)
10. Positive impact	3.2 (2/63)	4.8 (4/84)	4.3 (3/69)	0.0 (0/12)	2.9 (1/35)	11.8 (10/85)	21.1 (8/38)
11. Lack of numbering/networking	7.9 (5/63)	6.0 (5/84)	2.9 (2/69)	8.3 (1/12)	2.9 (1/35)	3.5 (3/85)	0.0 (0/38)
12. General problem with time management	0.0 (0/63)	2.4 (2/84)	1.4 (1/69)	0.0 (0/12)	5.7 (2/35)	5.9 (5/85)	2.6 (1/38)
13. Safety concerns/presence of toxic substances (health concerns)	0.0 (0/63)	3.6 (3/84)	2.9 (2/69)	0.0 (0/12)	0.0 (0/35)	2.4 (2/85)	0.0 (0/38)

(continues on next page)

Category	SBE % of responses	MPS % of responses	ENG % of responses	EHR[b] % of responsesa	CISE % of responses	BIO % of responses	GEO % of responses
14. Benefit by working with peers	4.8 (3/63)	1.2 (1/84)	1.4 (1/69)	0.0 (0/12)	2.9 (1/35)	1.2 (1/85)	5.3 (2/38)
15. Problem of wanting research independence	0.0 (0/63)	0.0 (0/84)	1.4 (1/69)	0.0 (0/12)	0.0 (0/35)	0.0 (0/85)	2.6 (1/38)
16. Lack of funding	0.0 (0/63)	0.0 (0/84)	0.0 (0/69)	0.0 (0/12)	0.0 (0/35)	3.5 (3/85)	2.6 (1/38)
17. Benefit from time flexibility/determine own lab hours	1.6 (1/63)	1.2 (1/84)	1.4 (1/69)	0.0 (0/12)	0.0 (0/35)	2.4 (2/85)	5.3 (2/38)
18. Did not answer	0.0 (0/63)	2.4 (2/84)	1.4 (1/69)	0.0 (0/12)	0.0 (0/35)	0.0 (0/85)	0.0 (0/38)
19. Department doesn't understand basic issues	0.0 (0/63)	0.0 (0/84)	0.0 (0/69)	0.0 (0/12)	0.0 (0/35)	0.0 (0/85)	0.0 (0/38)
20. Cultural/national stereotypes for women	1.6 (1/63)	2.4 (2/84)	0.0 (0/69)	0.0 (0/12)	2.9 (1/35)	1.2 (1/85)	0.0 (0/38)
21. Space	0.0 (0/63)	0.0 (0/84)	0.0 (0/69)	0.0 (0/12)	0.0 (0/35)	0.0 (0/85)	0.0 (0/38)
22. Better bathroom facilities	0.0 (0/63)	1.2 (1/84)	0.0 (0/69)	0.0 (0/12)	0.0 (0/35)	0.0 (0/85)	0.0 (0/38)

[a] Question 2: How does the laboratory climate (or its equivalent in your subdiscipline) impact upon the careers of women scientists? SBE, Social, Behavioral, and Economic Sciences; MPS, Mathematical and Physical Sciences; ENG, Engineering; EHR, Education and Human Resources; CISE, Computer and Information Science and Engineering; BIO, Biological Sciences; GEO, Geosciences.

[b] Because of the low numbers of awardees, the EHR directorate should be carefully interpreted here. Many of the women representing this directorate have other disciplinary training and could be classified in other directorates. We have chosen not to interpret the EHR responses as a result.

women), postponing the time faculty members come up for tenure. The University of California's systemwide policy offers faculty members an option called active service-modified duties that permits a parent, spouse, or partner with substantial responsibilities caring for a young child to request a quarter or semester of active service-modified duties around the time of birth or adoption (Cook, 2001). Because balancing the tenure clock with the biological clock challenges female scientists and engineers who want to become biological mothers in ways never faced by men, such policies will benefit women more.

In a similar fashion, because most (62%) female scientists and engineers are also married to male scientists or engineers, who are also often in the same field, such women experience more problems with the two-career issue (Williams, 2001) than their male colleagues, most of whom are married, but not to female scientists or engineers (Sonnert & Holton, 1995). Although "balancing career with family" and "dual-career" relationships appear at first blush to be the result of the individual choices made by women alone and/or in conjunction with their spouses or partners, the predominance of these responses by awardees from all 4 years in response to an open-ended question suggests that addressing the problem at the level of the individual proves inadequate. Institutional responses are needed to resolve these family-centered issues identified by overwhelming numbers of POWRE awardees each year.

A few institutions have begun to formalize policies to facilitate partner hires (Wilson, 2001). The University of Arizona, for example, has taken a proactive stance by negotiating a set of guidelines for partnership hires as a means to attract and retain couples; these guidelines include provisions such as the provost or vice president paying up to one third of a partner's salary for 3 years, when funds are available (Riley, 2001).

Low Numbers of Women and Stereotyping

Problems resulting from low numbers of women in science and engineering can lead to stereotypes surrounding their performance, isolation, lack of mentoring, and difficulty gaining credibility among their peers and administrators. Such problems become increasingly complex to address at the institutional level because of the considerable variations among fields. As the numbers of women have increased quite markedly in some disciplines (psychology, sociology) and begun to approach parity in others (life sciences) while remaining relatively small in others (engineering and computer science), it may be important to focus on differences women face in different disciplines. Small numbers make women very visible; visibility draws attention to successful performance, but it also spotlights errors. The variance in numbers from field to field suggests that institutions may need to establish different priorities and policies for women in different disciplines in sciences and engineering. For example, a one-size-fits-all policy may not work equally well for women in engineering compared to their counterparts in biology. The MIT report and the statement issued at the end of the January 29, 2001, meeting have resulted in several institutions, such as the University of Arizona and the Georgia Institute of Technology (Riley, 2001) in addition to the nine institutions present at the meeting, undertaking studies of salaries, space, and other resources provided to female scientists and engineers on their campuses.

Continuing low numbers provide particular challenges and some opportunities. Because the unwritten rules of academia often go unlearned by women in academia until professional disaster strikes (Aisenberg & Harrington, 1988), increasing the number of women in science and engineering becomes even more critical to ensuring that such rules

are learned. Low numbers mean that a woman often serves as the first or one of few women in her department or college. She may have no senior female colleagues to act as role models and serve as mentors to provide her access to networks of necessary professional information. These low numbers also lead to being asked to serve on more committees (even at the junior level) and to advise more students. Although these service activities provide opportunities for women to be visible and experience leadership and administration at an early stage in their careers, they may not be valued by the institution for promotion and tenure and may lead to difficulties with time management. Thus, it is crucial for the former Research I institutions to ensure either that junior female faculty members are not given extra teaching and service or that the tenure and promotion committees recognize and validate such work to compensate for lost research time and focus.

Overt Discrimination and Harassment

The low numbers that result in the active recruitment of women into many areas may have both positive and negative consequences. Demand may give female engineers starting salaries that are equal to or higher than those of their male counterparts (Vetter, 1996). The negative perception of affirmative action policies and active recruitment of women can lead to various forms of backlash, ranging from overt discrimination to difficulties gaining credibility from peers and administrators who assume that a woman obtained a position to fill a quota.

The situations that women encounter of overt and subtler harassment must be dealt with at the institutional level. Institutions and professional societies need to establish policies against sexual harassment and gender discrimination, including against pregnant faculty members in hiring, promotion, and tenure if such policies do not exist (Elliott, 2001). Flexibility and acceptance of differences between men and women may not only be crucial for retaining and advancing the numbers of women and careers of individual women in sciences and engineering but may also serve as the key for new approaches to collaboration and creative generativity.

Institutional policies against sexual harassment and gender discrimination must be implemented and enforced. Senior administrators play critical roles in terms of allocation of human, financial, physical, and time rewards for those who enforce such policies. For example, giving an outstanding research award from a university and/or providing a research sabbatical are not appropriate for a documented harasser as mechanisms to get him out of a problem situation. On rare occasions in which a senior administrator is a harasser, an institution must be particularly responsible to ensure that action is taken. Indiana University South Bend demoted Daniel Cohen from his position as chancellor after he lost a sexual harassment suit. When the faculty voted not to censure him, current chancellor Kenneth Perrin banned Cohen from campus (Wenninger, 2001). In many fields, sexual harassment and gender discrimination workshops should include substantial focus on cultural and national differences regarding gender roles and expectations in U.S. universities for appropriate professional behavior, including collaboration with female colleagues.

Decreased Funding Issues

The recent trend toward tightening the federal budget for research and the resulting competitive environment affects both male and female scientists and engineers. However,

women may face a disproportionate disadvantage in this area because of issues related to their low numbers and family balancing act. Women also tend to work in teams more than men. Although a recent trend is toward more collaborative research, the need to establish oneself as an independent researcher is critical to securing grants and funding; thus, women may actually be less successful if they tend to collaborate. Women are also socialized to be less overtly competitive, a trait often associated with success, which may increase their difficulty for success in a highly competitive environment. Thus, the lack of social and professional connections available to most women in academic science and engineering departments, overt and covert gender bias, and differences in socialization create special and unique problems for women (Fox, 2001). To enhance funding opportunities, academic departments can develop grant-writing seminars for new and even existing faculty members or encourage faculty members to attend existing seminars offered through campus offices of sponsored research. Although collaboration should be encouraged for all faculty members when research topics deem it appropriate, institutions must also foster women's independent research. The retention of the Fellows Awards category within ADVANCE continues the opportunity provided by POWRE for women to receive support for their independent research initiatives after their careers have been interrupted (National Science Foundation, 2001).

CONCLUSIONS

Recognition of these policy issues is only a first step in overcoming the institutional barriers that keep women from fully participating in science and technology. The POWRE data provide important information for policy makers at the institutional level to identify and implement appropriate interventions; they suggest that unleashing the talent within female scientists and engineers is advanced by institutional policies and guidelines such as those offered above. A tremendous love for science and technology and extreme dedication to their research and profession strongly characterize the responses of the overwhelming majority of POWRE awardees in all 4 years. Most seek to have the barriers removed so that they can be productive researchers who take creative approaches to the physical, natural world.

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