

Increasing the Participation and Advancement of Women in Academic Science and Engineering Careers in the United States of America

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Women comprise ~20% of science and engineering faculty in 4-year colleges and universities in the USA, this is true both today and as far back 1900. It is recognized that faculty members and institutions serve as role models that shape the expectations of many prospective scientists and engineers. The under-representation of women faculty members, particularly at the senior levels, is likely to affect women students' critical relationships with mentors, full participation as members of research and education teams, and self-identification as potential researchers. This situation creates a minimizing effect on the number of women choosing to pursue science and engineering careers. The goal of the National Science Foundation pilot program, ADVANCE, is to increase the representation and advancement of women in academic science and engineering careers. To meet this goal, proposals were sought from both women and men in three areas: institutional transformation, leadership and fellows. The anticipated total funding is ~\$19 million.

keywords: retention, academe, university, National Science Foundation, NSF, United States of America, USA

HISTORY IN USA

Women's role in the formation of institutions in the earliest period [1] (1636 to ~1800) in the United States was negligibly small.[2] Only from 1800 to the outbreak of the Civil War, was a modest beginning made in providing higher education for women. Despite the small numbers, significant impact was made. For example, the Oberlin Institute, opened its doors in 1834 to women and blacks as well as men, and soon started to graduate students who became leaders in the women's rights movement, anti-slavery cause and abolitionist movement.[2]

In the post-war era, a burning educational issue, was the admission of both women and men to a single institution. The welcome to women in middle and western universities began with the University of Iowa in 1855; many other universities followed suit: University of Wisconsin, Missouri, Indiana, Michigan and California.[2] Cornell took the lead in private universities by giving women equal status to men in 1872. The university president felt confident in this change, since he had conducted an informal survey and found that co-education did not produce "unmanly" men.[2] When other private eastern universities felt the pressure to admit women, some turned to "joint instruction".[2] E.g. Harvard developed an annex called Radcliffe College (in 1897), Columbia had an adjunct called Barnard

College (1889) and similarly Brown had Pembroke (1887) and Tulane had Sophie Newcombe. By 1898, 53% of the B.A. and Ph.D. degrees awarded by the University of Michigan went to women. At Northwestern University, the percentage of women was so high that an engineering program was instituted primarily in the hope of redressing the balance.[2] In 1899, Stanford adopted a quota system to minimize the number of women and thereby maintain a balance between men and women; (today the numbers are close to 50:50). By 1900, 71% of all American colleges were coeducational, however women were clustered within certain areas such as the liberal arts.

The acceptance of women students occurred simultaneously with rapid changes and growth in educational institutions. In 1890 the census listed approximately a thousand colleges and universities, but this number dropped considerably as a result of the depression in 1893. However, during the same period there was an enormous growth in university size, an emphasis towards research (rather than education) and an increase in number of male faculty by one and a half times, while women faculty increased by only 12% (~500 in number) (Table I). Most women faculty were found in women's colleges and state universities. In the latter institutions, they were usually in the newly created departments of physical education, domestic science and public health.

Although many things have changed in the universities through the last century, the representation of women in faculty positions in science and engineering has not (Table I). As well, the dominance of women in specific areas and their lack in other areas continues in the USA and other G8 countries [6-7] (Table II).[5,8] Overall the representation of women in engineering is significantly lower than that of women in science and engineering. Table II clearly indicates the "leaky pipeline" concept whereby women have a lower representation at higher levels. From the set of data for both 1997 and 1999, it is evident that small increases have been realized in recent years.

Too often, time is quoted as the remedy to the under-representation problem and for this reason, Table III is provided. Therein the assumption is made that a Master's degree takes 2 years, a Doctorate, 5 years, a post-doctoral fellowship, 2 years and then a further 7 years, on average, to obtain the rank of Associate Professor. Clearly, the practices and customs of the last 17 years have not sufficiently fostered the entry and/or retention of women in academic positions.

One of the government foundations that attempts to redress this issue is the National Science Foundation (NSF) and in later years they have, at the express wish of Congress, also kept track of representation of women, minorities and handicapped individuals.[8]

HISTORY OF THE NSF

The NSF, established in 1950, funds research and education in most fields of science and engineering and welcomes proposals from all qualified scientists, engineers and educators.[9-10] The foundation strongly encourages women, minorities and persons with disabilities to compete fully in its programs. In accordance with federal statutes, regulations and NSF policies, no person on grounds of race, color, age, sex, national origin or disability shall be excluded from participation in, be denied the benefits of, or be subjected to discrimination under any program or activity receiving financial assistance from NSF (unless otherwise specified in the eligibility requirements for a particular program).

Table I: Distribution of Faculty by Gender.

Year	Reference	Number (%)	
		Female faculty	Male Faculty
1880	[3]: all disciplines	4,194 (36%)	7,358 (64%)
1900	[3]: all disciplines	4,717 (20%)	19,151 (80%)
1997	[4]: science and engineering	39,800 (22%)	139,400 (78%)
1999	[5]: science and engineering	64,341 (26.5%)	176,459 (73.5%)

Table II. Comparison in Terms of Degrees and Faculty.[4, 5] Numbers indicate % Female.

Level	All disciplines	Science and Engineering	Engineering	Year of Data
Bachelor's Degrees	55.2	47.1	17.9	1996
Master's Degrees	55.9	39.3	17.1	1996
Doctoral Degrees	40.6	32.8	12.3	1997
Post-Doctoral Fellow	—	29.0 (30.1)	11.7 (14.7)	1997 (1999)
Assistant Professor	—	33.0 (37.8)	— (14.8)	1997 (1999)
Associate Professor	—	21.9 (27.3)	— (9.5)	1997 (1999)
Full Professor	—	10.5 (13.9)	— (2.2)	1997 (1999)
Other Academics	—	33.2 (35.9)	— (13.3)	1997 (1999)
All levels of Academics	—	22.2 (26.5)	— (8.0)	1997 (1999)

Table III. A 17-year spread shows a clear drop in the percentage of women [4, 5]

Level	All disciplines	Science and Engineering	Engineering	Year of Data
Bachelor's Degrees	51.0	38.5	12.3	1982
Associate Professor	—	27.3	9.5	1999

Initially NSF-wide efforts to assist women included various programs: Visiting Professorships for Women, Faculty Awards for Women, Research Planning Grants, and Career Advancement Awards Programs.[9] In the mid 1990's a new program, replacing all the others, called "Professional Opportunities for Women in Research and Education" (POWRE) was implemented. The program provided outstanding women with funding opportunities not ordinarily available through regular research and education grants. POWRE aimed to increase the representation of women in the nation's science and engineering workforce and encourage their professional advancement. The major goals of the program included providing opportunities for further career advancement, professional growth, and increased prominence of women in NSF-supported science and engineering disciplines; and encouraging more women to pursue careers in science and engineering by providing greater visibility for women scientists and engineers in academic institutions and industry. The program targeted women scientists and engineers who currently held non-tenured academic or industrial positions, academic tenured or tenure-track positions, or planned to enter or re-enter academia. Three categories were defined: (i) Visiting Professor (activities at a host academic institution for research or education), (ii) Visiting Researcher (activities for academically employed women to conduct research at an industrial or non-federal organization), and (iii) Research/Educational Enhancement (activities at the home institution or at an external site). Further consideration was given to international activities to forge linkages between foreign and U.S. scientists and engineers; to provide access to unique research equipment and facilities; to plan joint seminars and workshops; and to address issues that can benefit from international comparison. The maximum budget amounts were \$150,000 for the first two categories, and \$75,000 for the last category. More than 600 awards were made through the program (Table IV).

Table IV. POWRE Awards.[11]

Starting Year	Number of Awards
1997	37
1998	239
1999	164
2000	177
2001	6
Total	623

These POWRE awards were designed to provide a one-time input of funds at a critical stage in the principal investigator's career, a means by which she can take advantage of an opportunity that will

contribute to a significant, identifiable advance in her career path.

However despite its success, two factors contributed to the demise of this program: (i) at the end of year 2000, positive discrimination was questioned for all under-represented groups: minorities as well as women, and (ii) NSF wanted to attack the problem of under-representation of women on a broader basis. In 2001, a new program, called ADVANCE (for increasing participation and advancement of women in academic science and engineering careers) was spawned.

ADVANCE PROGRAM

NSF recognizes that the pursuit of new scientific and engineering knowledge and its use in service to society requires the talent, perspectives and insight that can only be assured by increasing diversity in the science, engineering and technological workforce. Faculty members and institutions serve as role models that shape the expectations of many prospective scientists and engineers. "The under-representation of senior women faculty members is likely to affect women students' critical relationships with mentors, full participation as members of research and education teams, and self-identification as potential researchers." [10] Currently women make up ~22% of science and engineering faculty in 4-year colleges and universities in the USA (Table I), and hold an even smaller percentage of high-ranked positions (Table II). "This situation creates a minimizing effect on the number of women choosing to pursue science and engineering careers." [10] The goal of NSF's pilot program, ADVANCE, is to increase the representation and advancement of women in academic science and engineering careers.[10]

To meet this goal, creative strategies were sought from men and women under three categories: institutional transformation, leadership and fellows. Institutional transformation awards are to promote the increased participation and advancement of women scientists and engineers in academe. Of the 76 proposals received, 9 (~12%) were selected for awards ranging in size from \$3.1-3.75 million over a 5 year period (Table V).[11-12] Thirteen leadership awards [11] were selected from 49 proposals (~27%) to recognize the outstanding contributions made to date by organizations and/or individuals who have enabled the increased participation and advancement of women in academic science and engineering careers, and to enable awardees to sustain, intensify and initiate new activities designed to make further

progress. These awards range in value from ~\$30,000 to \$230,000 for periods of 1-3 years; the National Institute of Health contributed towards the funding. Many of the leadership awards focus on networking or skill development (Table VI). For example, Mary Anne Holmes and her co-

investigators at the University of Nebraska-Lincoln intend to teach women what they need to know to negotiate salaries and contracts, and tell them how to find out what is required to achieve tenure at their institutions.

Table V: Institutional Transformation Awards in ADVANCE in 2001-2002.[11]

Principal Investigator	Institution	Amount (\$)
Idalia Ramos	University of PR at Humacao	3,108,958
Susan V. Bryant	University of CA Irvine	3,453,391
Patricia Rankin	University of CO Boulder	3,581,254
Lisa Frehill	New Mexico State University	3,687,812
Jean-Lou A. Chameau	GA Tech Research Corp. - GIT	3,702,006
Abigail J. Stewart	University of Michigan	3,748,785
Virginia V. Valian	CUNY Hunter College	3,750,000
Mary Carnes	U of Wisconsin Madison	3,748,973
Denice D. Denton	U of Washington	3,750,000

Table VI: Topics Addressed in Leadership Awards.

Leadership training
 Seminars or workshops
 Written dissemination of information
 Survey of current situation
 Defining needs and demands
 Determining perceptions of barriers
 Identifying and replicating effective structures/systems
 Establishing a database of best practices
 Mentoring
 Assisting with transitions
 Creating linkages to professional science societies
 Demystifying the journal publication process

Fellows awards will enable promising individuals to establish or reestablish full-time independent academic research and education careers in institutions of higher learning. Researchers were permitted to submit proposals independently of any academic institution; this has some interesting implications. A person who normally would not be allowed to submit a proposal from an institution as the primary and only investigator was not blocked. Additionally it enables awardees the option to "shop around" for the best position and/or university after obtaining the award. However, many women, may find themselves restricted geographically for practical reasons. Approximately 150 proposals were received in August 2001 and their review is underway. The review process will proceed in 3 stages: (i) ad hoc mail reviews, (ii) panel review, and (iii) consideration by the ADVANCE implementation committee. The estimated total number of fellows is 20 to 40, bringing the total expenditure for ADVANCE to ~\$19 million.

THOUGHTS AND RECOMMENDATIONS

It is apparent from the numbers presented herein that women are under-represented on faculty in science, engineering and related disciplines. Despite the fact that the competition of NSF's newest program in this area, ADVANCE, is in its first year, a few comments can be provided for change within the program. It might be prudent to run the competitions for the Institutional Transformation competition every two years so that the benefit of the initial grants can be assessed. This delay would also facilitate a higher success rate on incoming proposals. The competition for the fellowships should only be carried out in scientific and engineering programs where there is an under-representation of women on faculty. Biology is likely to be the first discipline to obtain equity, however statistics in psychology departments [13] indicate that ~50% faculty representation should be achieved before the effort in increasing women's roles is labeled successful and is abandoned. Sufficient funds need to be available if success rates in this competition are to be on par with the average within NSF. In short this means that either more funds need to be dedicated to ADVANCE and/or some mechanism should be implemented to convert these proposals into ones attractive for funding outside the fellows competition. Finally, it would be useful for NSF to assist the universities in taking the next step with the most successful of the awardees. NSF could extend the grants by a further two years for the awardees who move into tenure or tenure-track positions.

ACKNOWLEDGEMENTS

Thanks are given to Stanley Johannesen of the Department of History at the University of Waterloo

for encouraging my scholarship. Joan Burrelli of the NSF is gratefully acknowledged for her help in providing statistics and sources for statistics. Thanks are extended to Wendy Fuller-Mora, Alice Hogan and the other members of the ADVANCE implementation committee at NSF for sharing their ideas and perspectives. The critical reading of the manuscript by Erik Svedberg is greatly appreciated.

The views expressed in this article do not necessarily reflect those of the National Science Foundation. The previous section, "Thoughts and Recommendations", presents a viewpoint of the author.

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