The National Science Foundation As a Catalyst for Systemic Change in Higher Education Related to Women in Engineering*

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A fairly frequent topic these days is "systemic change". For years change has focused on women engineering students and women engineers as somehow deficient—needing to alter themselves to fit existing structures and adapt to environments which were less than encouraging, individuals and organizations are finally beginning to investigate how the institutions themselves, and the environment in which engineering is learned and practiced, might accommodate a more diverse group of students and practitioners. The National Science Foundation is committed to serving as a catalyst for this type of systemic change.

Defining Systemic Change in Higher Education

In this paper systemic change will be defined as *"change to an entire system—its policies and practices"*. This definition allows us to focus on changes that would allow the abilities of women to flourish in engineering education rather than to consider only how the women themselves can better survive the existing situation. Some measure of whether or not systemic change has occurred, would include evidence of more inclusive teaching styles among faculty and teaching assistants; a change of attitude among engineering faculty and staff whereby women would feel valued for the abilities they bring to engineering; and the existence of policies that facilitate the successful progress of women in engineering education.

The least effective type of reform is that which impacts only one discipline (e.g. engineering) within one institution. Only slightly better would be reform resulting in change across several disciplines within one institution. Another, perhaps more promising method of systemic change is that which reforms one discipline across multiple institutions of higher education. Examples of this are the calculus or chemistry reform projects funded in the past by the Division of Undergraduate Education at NSF or the Engineering Education Coalitions sponsored by the Engineering Directorate at NSF. The best case scenario for women in engineering would see NSF acting as a catalyst for the inclusion of gender issues in reform efforts across all science, engineering, and mathematics disciplines at institutions throughout the United States.

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Various Agents of Systemic Change

For systemic change related to women in engineering at colleges and universities there are several potential agents of change. University presidents and engineering deans can become strong advocates for systemic change within their own institution. However, several criteria are critical to their individual effectiveness including personal charisma, the respect they command from the faculty, and the value systems operating in their particular institution. Recommendations of a professional organization are probably the most palatable catalyst for change among faculty. Public awareness is another potential source of pressure to reform.

If the factors which discourage young women from pursuing careers in engineering can be well identified and brought to the attention of the general public, pressure can come from many sides to encourage reform in engineering education. An example of this at the pre-college level lies in the recent publicity related to the American Association of University Women's study defining *How Schools Shortchange Girls*. Although the information in this publication has been well known by gender equity experts for many years, these individuals have been unable to bring about significant changes in the K-12 arena. However, since becoming the focus of several television shows during prime time, the issue is receiving quite a bit of attention and consideration from teachers, parents, and the general public. Hopefully this will result in efforts to change the existing practices which permit differential treatment, or equal treatment resulting in differential outcomes, to continue.

Finally, one can consider the appropriateness of private and public foundations as agents of systemic change. Foundations control the distribution of considerable funds relevant to engineering education and as such have considerable control over the establishment of specially targeted programs for females, as well as over the accountability of faculty and administrators to establish educational environments which are more appropriate for an increasingly diverse group of students.

Why NSF?

There are many reasons why NSF should be considered as an appropriate agent of change. Section 33 of NSF's statutory authority (P.L. 100-570, 102 Stat. 2865) currently authorizes NSF to pursue 11 defined areas of gender-specific activities in order to fulfill "the policy of the United States to encourage men and women, equally, of all ethnic, racial, and economic backgrounds to acquire skills in science, engineering, and mathematics, to have equal opportunity in education, training, and employment in scientific and engineering fields, and thereby to promote scientific and engineering literacy and the full use of the human resources of the Nation in science and engineering."

Proposals submitted to the NSF are peer reviewed using four criteria: Research performance competence, intrinsic merit of the research, utility or relevance of the research and *"Effect of the research on the infrastructure of science and engineering—Potential of the proposed research (project) to contribute to better understanding or improvement of the quality, distribution or effectiveness of the Nation's scientific and engineering research, education, and human resources base."* Criterion four provides NSF with one avenue of authority to serve as a catalyst for systemic change which could help reverse the current under representation of women in engineering. If several proposals are equally qualified for funding based on the first three criteria, program officers can use the relevant impact on the human resource data base as a deciding factor. Projects with the potential to increase the representation of women in the human resource data base would receive priority over those which do not. A low rating on this criterion from

reviewers who are sensitive to the under representation of women could result in a low enough overall rating that the project would not be considered worthy of funding.

NSF is an appropriate catalyst for systemic change because of the unique position it holds to impact multiple levels of education and careers, across all science, engineering, and mathematics disciplines. Women in Engineering Programs in colleges and universities would have limited success in achieving systemic change without complementary changes occurring at the elementary, secondary, informal, and employment levels. Also, systemic change in engineering curricula and pedagogy would be seriously hindered without accompanying changes occurring in calculus, chemistry, and physics.

Another reason NSF is in a appropriate position to serve as a catalyst for systemic change is due to its peer review system and advisory panels. NSF's programs and practices (including funding decisions) relevant to increasing the representation of women in engineering are more acceptable to scientists, engineers and their respective organizations because they are based in the recommendations of colleagues. Finally, due to the respect and influence NSF holds among scientists and engineers, it is in a unique position to serve as a catalyst for systemic change.

NSF's Multiple Strategies for Creating Systemic Change

Targeted Programs

NSF Programs for Women and Girls in the Human Resource Development division include *Experimental Projects for Women and Girls* which have a goal of permanent, or at least long term, change to the climate. No longer is funding limited to projects which focus on overcoming deficiencies in the young women themselves so that they will be more successful in science, engineering, and mathematics. The goal of Experimental Projects is to fund projects which will create real change to the systems in which science and engineering exist.

Individual Program Requirements and Reporting Procedures

Several divisions and directorates within NSF have included statements in their program announcements which encourage systemic change by advising all proposal submitters to be cognizant of the under representation of certain groups, including women, and ensure that they are included. For example, the program announcement for Conferences, Workshops and Special Years in the Mathematical Sciences states: *Conference proposals which contribute to the Foundation's effort to enlarge the science personnel base of the nation by including (where feasible) students and recent doctoral recipients, women, minorities and persons with disabilities among the invited speakers and/or participants will be given a higher priority than otherwise equally meritorious proposals which do not.*

Official NSF project reports require principle investigators to report on the inclusion of senior staff, other staff, post docs, graduate students, and participants by gender, ethnicity, and citizenship. Such reports could be used as evidence of researchers who are furthering the goals of NSF in relation to the inclusion of under represented populations. Researchers who have a consistent record of ignoring this important NSF goal could be considered less competitive for future proposals when program officers must rate "prior NSF work".

Modeling

As a microcosm of the scientific and technological community, NSF serves as a model for institutional change. NSF is conscientiously striving to increase the representation of women in all of its "systems"—permanent staff, rotators, the review process, advisory boards, publications, conferences, etc. Dr. Neal Lane, Director of NSF has made a commitment to the inclusion of women throughout NSF and to give attention to gender issues as they impact NSF programs, policies, and practices.

Conclusion

Although NSF has been involved in systemic reform for a relatively short period of time, it is in a strong position to serve in the role of instigator, change agent, model, and advocate. It is evident that NSF is willing to serve in this capacity and continue to increase its role in this regard.