

WOMEN IN ENGINEERING PROGRAMS: NO LONGER A QUESTION OF EFFECTIVENESS

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Two significant studies about Women in Engineering Programs were conducted this year. Both studies will add critical information to the knowledge base regarding the effectiveness of interventions focused on increasing the participation of women in engineering. The two studies were: *A National Evaluation of Existing Women in Engineering Programs* by Suzanne G. Brainard, Ph.D. at the University of Washington and *The 1991 National Survey of Women in Engineering Programs* by Emily M. Wadsworth, Ph.D. at Purdue University.

The purpose of this paper is to provide an overview of both studies and to examine the differences and commonalities. First, with respect to the differences, the purpose of *1991 National Survey* was to investigate relationships between enrollments and degrees granted to women in engineering at institutions with *activities* for women in engineering. Some of those institutions had formal Women in Engineering Programs; others did not. In this case, the definition of a *formal* Women in Engineering Program is one in which a director is designated for at least 50% time. On the other hand, the *National Evaluation* assessed the effectiveness of existing *formal* Women in Engineering Programs; that is, programs with a designated 50% time administrator.

And, second, in both studies, the focus was on the outcome or results of *formal* Women in Engineering Programs or *activities* directed at increasing the enrollment and degrees granted to women. Both studies found that WIEP administrators with degrees in non-engineering fields had higher percentages of female engineering students graduating from their institutions. In light of the controversy regarding the type of individual who should be managing a Women in Engineering Program, this finding clearly suggests that non-engineering majors are more successful administrators of Women in Engineering Programs.

Wadsworth found a significant relationship between the topics of retention (e.g., careers) activities and enrollment, while Brainard found a significant relationship between the number of enrollment and retention activities and the numbers of degrees granted. Further, Wadsworth found a significant relationship between institutional funding of a WIEP and enrollment, and Brainard found a significant relationship between number of degrees granted and size of an annual WIEP budget, fundraising assistance to the administrator, and evaluation. Both studies found that faculty support, institutional commitment, and student involvement and participation in Women in Engineering Programs were significant.

In conclusion, the findings from both studies demonstrate that institutions with *formal Women in Engineering Programs* or institutions with a significant number of activities for female engineering students tend to have higher numbers of females enrolled and granted degrees in engineering. A synopsis of each study follows.

Suzanne G. Brainard, Ph.D. and Jamie Kelley.

A National Evaluation of 1991 Women in Engineering Programs: An Overview

The goal of this study was to conduct a national evaluation of existing Women in Engineering Programs in the United States in 1991. Thirty-one institutions were initially identified as having formal Women in Engineering Programs; upon closer examination, only 26 formal Women in Engineering Programs existed. A survey was designed to gather information regarding the following generic topics: 1) program objectives; 2) target populations; 3) years in operation; 4) organizational structure; 5) budget; and 6) enrollment and degrees earned. Within each of the above topical areas, the questions were designed to ascertain the following: 1) commitment of the engineering dean; 2) skills and experience of the designated director of the program; 3) adequacy of the budget; 4) scope of and assistance with fundraising; 5) student participation or involvement in the program; 6) faculty involvement, and 7) system of accountability or evaluation procedures.

The findings revealed that Women in Engineering Programs are having an impact on increasing the number of women receiving undergraduate degrees in engineering. In addition, the study found that there are six prerequisite conditions for successful Women in Engineering Programs and six criteria to be used for evaluation purposes. Finally, six institutional Women in Engineering Programs are highlighted for excellence.

Significant Relationships

Statistical analyses revealed that there were several significant relationships between variables. Specifically, positive relationships were found between: a) percent of undergraduate engineering degrees awarded to women and the size of the annual Women in Engineering budget; b) director's scope of fundraising responsibilities and size of the annual Women in Engineering budget; c) fundraising assistance and size of the annual Women in Engineering budget; d) use of evaluation and size of the annual Women in Engineering budget, and e) major discipline of the director and the percentage of undergraduate engineering degrees awarded to women.

Because the sample size included only 26 institutions, many relationships were not statistically significant. However, several were very close ($p > .06$ or $p < .086$) and would probably have been significant with a larger sample size. The magnitude of the difference was meaningful and consistent with expectations. Examples of these include: a) positive relationship between the number of retention programs at the university-level and number of undergraduate engineering degrees granted to women; b) positive relationship between the age of a Women in Engineering Program and the size of the annual budget; and c) positive relationship between faculty support and size of the annual Women in Engineering Program budget.

Indicators of Success

Given these findings, it was reasonable to conclude that indicators of a successful Women in Engineering Program include:

- . percent of undergraduate degrees awarded to women;
- . the size of the annual Women in Engineering budget;
- . fundraising assistance for the program;
- . fundraising responsibility of the director;
- . use of evaluation, and
- . major discipline of the director of the Women in Engineering Program.

Neither student involvement nor enrollment statistics were found significant indicators of success. With respect to student involvement, everyone responding to the survey indicated student involvement; consequently, the measure was not fine enough to detect differences in degree of involvement. On the other hand, the small sample size probably accounts for the reason that enrollment did not appear as a significant indicator of success.

As a practical application, these findings provide the criteria for evaluating the effectiveness of existing Women in Engineering Programs. As an example, the criteria could be used by either internal or external reviewers, including Deans as internal reviewers or federal agencies as external reviewers. However, one should be cautious when applying these criteria without consideration to the climate for women in engineering at an institution.

Prerequisite Conditions for Success

Another aspect of the study was to investigate the hypothesis made by Brainard in 1989 that certain conditions needed to exist at an institution *prior to the establishment and during the operation* of a Women in Engineering Program. She proposed seven prerequisite conditions for successful programs. By using factor analysis, six prerequisite conditions, each with a set of defining factors, were revealed.

Factor analysis made it possible to look for significant associations between multiple (more than two) variables. As a result, the original number of variables were reduced to a series of two or more factors under each of the six underlying constructs. The sets of factors within each underlying construct made intuitive sense.

The findings revealed that the following underlying constructs or prerequisite conditions for a successful Women in Engineering Program were meaningful:

- . Commitment from the top/Dean;
- . A full time program director;
- . Annual WIE budget;
- . Faculty involvement in WIE;
- . Student involvement in the design and operation of a WIE program; and,
- . Program evaluation.

Each of these conditions of success were defined by a series of factors, as discussed in the previous section. One can envision each of the factors as being a definition of that construct. For example, the construct Commitment of the Dean is defined by size of budget, fundraising assistance, evaluation of the program by the Dean, presence of study centers and university-level programs, salary of the Director, and membership and training in WEPAN (Women in Engineering Program Advocates Network). In other words, the definition of Commitment from the Dean makes it possible to more clearly articulate and measure exactly what commitment means for a Women in Engineering Program.

Programs of Excellence

By applying the prerequisite conditions of success and the criteria of success to the data, we were able to identify six innovative programs of excellence. The institutions are listed in alphabetical order, not by ranking:

Cornell University	University (undergraduate)
Purdue University	Pre-College & University (undergraduate)
Douglass College (Rutgers)*	Pre-College & University (undergraduate)
Stevens Institute of Technology	Pre-College
University of Ohio, Dayton	Pre-College
University of Washington	University (undergraduate & graduate)

Limitations of the study included a small sample size ($n = 26$) and respondents' incomplete answers to questions related to enrollments, degrees granted and annual WIEP budgets. The small sample size decreased the likelihood of more statistically significant results. Further, data on enrollment and degrees granted for each institution was ultimately obtained from EMC's 1991 Annual Report because of missing data on the surveys. Finally, when reviewing the list of programs of excellence, it should be reemphasized that this study was conducted in 1991 using 1991 data. Since that time several new Women in Engineering Programs have been established or expanded, and as would be expected, the list of programs of excellence would expand.

Conclusion

In conclusion, the findings of this study strongly suggest that Women in Engineering Programs are having an impact on increasing the number of women receiving undergraduate degrees in engineering. The study found that there are six prerequisite conditions for successful programs and six criteria of success to be used for evaluation purposes. It also pointed out that commitment from the Dean, a designated full-time director, a Women in Engineering Program budget, faculty and student involvement, and program evaluation were critical components of a successful Women in Engineering Program.

The primary limitation of the study was the small sample size. It is important to repeat the study again in 1993-94. As a result of the national technical assistance and training offered through WEPAN, the numbers of Women in Engineering

*Douglass College is recognized as a prototype of programs for women in science; its programs for women in engineering are limited at this time.

Programs have increased significantly throughout the U.S. A larger sample size of Women in Engineering Programs would provide the opportunity to confirm the findings of this study, and to investigate other relationships such as type and size of institution with other variables.

Finally, the findings in this study are important to a number of audiences: 1) provides deans with guidelines for the conditions that are needed to establish a successful Women in Engineering Program; 2) provides directors of Women in Engineering Programs with strategies to make the program successful; 3) provides funders with measures for evaluating success; and 4) provides policy makers with indicators of successful intervention programs, as well as a perspective on the national need to increase the number of women pursuing careers in engineering.

Emily M. Wadsworth, Ph.D..

Synopsis of a Final Report: 1991 National Survey of Women in Engineering Programs

Introduction

Periodic surveys of Women in Engineering Program(s) [WIEP(s)] have been conducted under the auspices of the American Society for Engineering Education. The 1991 National Survey of WIEP(s) was five pages long and 33 items were selected to provide specific information about nine WIEP factors that could influence women in engineering. The nine factors were: institutions; programs; administrators; fundings and expenditures; printed and visual materials; pre-college recruitment activities; college retention activities; professional networks; and prevalent issues. Surveys were returned by 186 out of 293 schools resulting in a 63% response rate.

Three of the five primary purposes of the final report were to: 1) determine needs for an additional research study using the 1991 survey data; 2) examine results of tests exploring relationships between the 1991 WIEP factors and 1991 enrollments and degrees granted for women engineering students; and, 3) draw conclusions about this research study.

Research Study

Initial findings from analyses of the 1991 WIEP(s) survey indicated that percentage of women receiving B.S. engineering degrees was positively related to mean scope of WIEP activities, mean number of women awarded B.S. engineering degrees, and mean percent of African American women awarded B.S. degrees per institution. What we needed was additional knowledge about factors such as: types of institutions offering activities for women in engineering; gender and degree fields for WIEP administrators; financial sources for and costs of WIEP(s); specific conditions for recruitment and retention activities offered by WIEP(s); and existence of professional organizations on campuses with WIEP(s). However, we also wanted to discover if these factors were related to percentages of enrollments and degrees for women engineering students. Therefore, additional research was required and the present study was instigated.

This study focused on institutions, programs, administrators, fundings and expenditures, publications, precollege activities, college activities, professional

networks, and prevalent issues. We examined four areas, first year enrollments, undergraduate enrollments, B.S. Degrees and graduate enrollments. Within each of these four areas, engineering schools were placed into three groups according to whether they had a low (L), middle (M) or high (H) percentage of women enrolled as first year students (1stY.), enrolled as undergraduate students (UnG.), graduating with B.S. Degrees (B.S.) or enrolled as graduate students (Grad.) Thus, percentages in each of the groupings, within each of the areas, fluctuated somewhat. The four areas, three groups and their percentages are as follows:

1stY. Enrollments: Low (0-13.62%); Middle (13.63-21.58%); High (21.59% - up)

UnG. Enrollments: Low (0-13.19%); Middle (13.20-15.52%); High (15.53% - up)

B.S. Degrees: Low (0-11.46%); Middle (11.47-19.17%); High (19.18% - up)

Grad. Enrollments: Low(0-8.14%); Middle (8.15-15.22%); High (15.23% - up)

Chi-Square tests were conducted in order to determine if there were significant differences among the Low, Middle and High groups. All relationships were significant at the $p < .05$, $p < .01$ or $p < .001$ levels. These levels were selected due to the exploratory nature of the study.

There are some limitations in this study. The first is that the 1991 sample did not contain all engineering institutions in the United States that enrolled women students. However, institutions comprising the sample did award the majority of 1991 baccalaureate engineering degrees to women. Second, since the entire population of engineering schools was not included in the study, we cannot generalize findings to all engineering colleges and/or universities. Also, survey respondents might have interpreted the same question differently, which would decrease reliability of research findings. Further investigations need to be conducted in order to validate study results.

Results

Statistically significant differences among the Low, Middle and High groups were found in relation to six factors (institutions, administrators, fundings and expenditures, recruitment activities, retention activities and professional networks). Findings indicate the following:

- **Institutions:** Private institutions tend to have both high and low percentages of women enrolled as undergraduate engineering student whereas public institutions are apt to be at mid range for percentages of undergraduate women engineering students.
- **Administrators:** Institutions that had female administrators for their WIEP(s), with advanced degrees in non-engineering fields and academic experience, had high percentages of women engineering students enrolled at and/or graduating with B.S. engineering degrees from their schools.
- **Fundings and Expenditures:** Schools with fundings from their own institution for WIEP activities were likely to be at mid range when looking at percentages of women enrolled as graduate students in engineering.
- **Recruitment Activities:** Schools with WIEP activities that focused on engineering as the topic and involved college students during their recruitment events had low percentages of women enrolled as undergraduate engineering students.

- **Retention Activities:** Schools with WIEP activities that involved college students and faculty in their retention events, had high percentages of women enrolled as first year engineering students.
- **Professional Networks:** Institutions with NSBE and SWE organizations existing on their campuses that supplied student volunteers for WIEP events and administered their own activities, had high percentages of women engineers enrolled at and graduating from their schools.

Conclusions

The *Final Report of the 1992 National Survey of Women in Engineering Programs* documents the dramatic changes that have taken place in the participation of women in engineering during the past two decades. In 1975, only half of the U.S. engineering institutions enrolled and/or graduated women engineering students, now; virtually all (94%) do so. These changes have come about not only due to the women's movement and national policies regarding equity and affirmative action, but, also the significant increase in efforts of WIEP administrators to recruit and retain women students through special activities. Financial and personal resources include not only internal support within educational institutions, but also support from industries, foundations, and the government. The scope and nature of expanding networks focuses on women in engineering, on other equity-related partnerships, as well as on women in the allied fields of science and technology.

Deans of engineering institutions might consider the results of this final report when establishing Women in Engineering Program(s), hiring administrators for programs, funding activities, planning recruitment and/or retention events, and facilitating national organizations that support women engineers.

Although undergraduate engineering enrollments and degrees have increased only slightly in recent years, graduate enrollments continue to rise and promise to provide not only industrial and governmental leadership, but, the academic and intellectual leadership that full participation of women in engineering requires.

