AC 2011-335: USING AN EXTENSION SERVICES MODEL TO INCREASE GENDER EQUITY IN ENGINEERING

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Didion served as Executive Director for the Association for Women in Science (AWIS) for fourteen years (1990 to 2004). During tenure AWIS was awarded the U.S. Presidential Award for Excellence in Science, Mathematics, and Engineering Mentoring and she was the principle investigator for 17 government and foundation grants. Didion has presented testimony before the United States Congress and U.S. federal agencies and she was the editor for Women in Science Column for the Journal of College Science Teaching from 1993-2002. Didion has extensive experience on Capitol Hill including staff positions at the U.S. Senate Commerce, Science, and Transportation Committee, Office of Senator Robert Packwood (R-Oregon), the Senate Computer Center, and the Senate Press Gallery.

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Using an Extension Services Model to Increase Gender Equity in Engineering

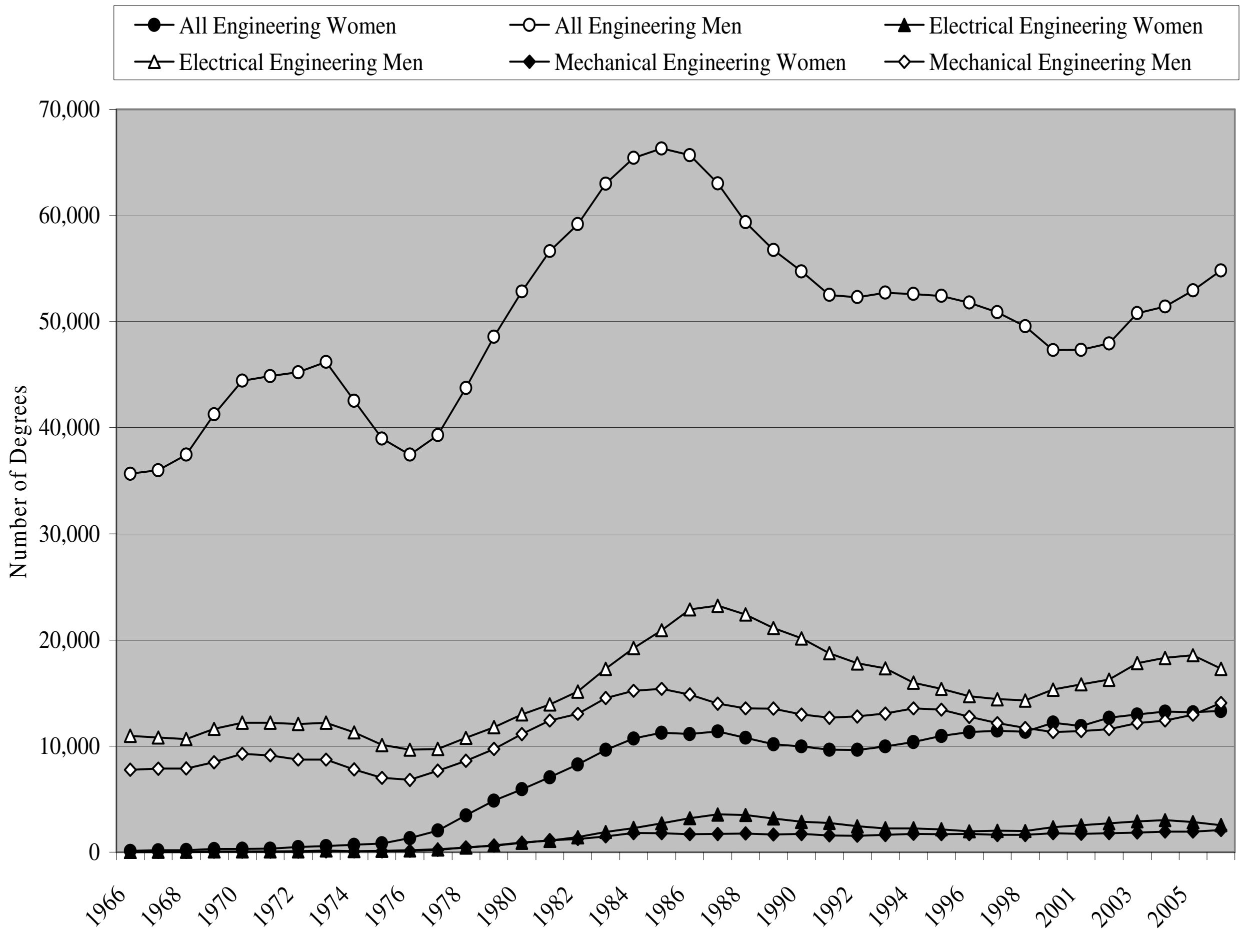
The Engineering Equity Extension Services (EEES) developed a research-based approach to encouraging more gender equity in engineering, specifically in the mechanical and electrical fields, with the ultimate goal of increasing the number of women attaining baccalaureate degrees in these fields. We envisioned a "train-the-trainer" project based on an extension services model, with our Experts providing research-based guidance on practice to Extension Agents who provide practical guidance of "gender-friendly" instructional and outreach practices, informed by research on engineering education and project management, to teachers, faculty, and outreach volunteers. Over the 5-year course of the Project, the original plan evolved into one employing Expert consultants both to give advice to the original Extension Agents as well as to work directly with faculty members in mechanical and electrical engineering departments on projects aimed at both K-12 and undergraduate students. Our website serves as a clearinghouse for resources developed during the Project as well as relevant research-based resources on gender equity, engineering education, and project management. This paper describes lessons learned over the course of the project, the resources that were developed, and the application of these lessons and resources to other efforts to encourage diverse students to study engineering.

Introduction

Between 1966 and 2006, the percentage of women attaining bachelor's degrees in all fields increased from 42.6% to 57.8%, with women receiving approximately 851,824 degrees and men receiving approximately 621,911 degrees in 2006[1]. During that time the percentage of women receiving bachelor's degrees in science and engineering (S & E) fields increased from 24.8% to 50.5%, and the number of women earning S & E degrees increased from 45,634 to 239,273 in that time. However, the percentage of women with bachelor's degrees in engineering was 19.5% in 2006, although that is an increase from 0.4% in 1966 and represents an increase in total number of women's degrees from 146 in 1966 to 13,300 in 2006. Certain engineering fields have even lower numbers and percentages of women graduates. For example, the percentage of women attaining electrical or mechanical engineering bachelor's degrees increased from less than 1% to 13% over that time frame, with women earning 41 bachelor's degrees in those two disciplines combined in 1966 and obtaining 2,571 electrical and 2,107 mechanical degrees in 2006. Because those two disciplines have historically made up over half of the engineering degrees and in 2006 comprised 36,026 (53%) of the total engineering bachelor's degrees[1], this indicates a serious problem in recruiting, retaining, and advancing girls and women in these fields. See Figure 1 for number of bachelor's degrees earned by women and men in engineering, electrical engineering, and mechanical engineering for the years 1966 to 2006 (Note that no data was available for 1999).

Although women's underrepresentation in science and engineering has long been an issue, with the recent focus on how the United States will compete in a global economy, many agree that better educating K-12 students in science, technology, engineering, and mathematics (STEM) is crucial, although engineering has not been a traditional secondary school option. However, even as some schools have incorporated engineering courses, they struggle with a lack of standards, leadership, and learning assessments [2]. Although exact numbers are not known, Katehi et al.[2]

Figure 1: Engineering degrees by field and gender, 1966 – 2006 (data obtained from[1])



estimate that in the approximately 15 years since engineering coursework entered K-12 schools only 6 million students have participated, a small number considering total enrollment has increased from just under 50 million to over 55 million students in that timeframe[3]. In addition, in that time fewer than 20,000 K-12 teachers have completed professional development programs related to teaching engineering. This represents a small percentage of the approximately 550,000 middle and high school science, math, and technology education teachers[2]. However, because engineering courses are increasingly becoming part of secondary school courses, an increase in students exposed to engineering could lead to an increased enrollment in engineering[2].

Given the current low involvement of elementary and secondary school teachers in teaching engineering, formal professional development activities that provide guidance to teachers and faculty on effective instructional strategies are an important step in recruiting more students into, and retaining more students within, engineering. However, these activities must include information on changing the prevalent perceptions of engineers and engineering in the U.S. For example, many people focus on engineers' need for strong math and science background rather than the actual creative work of engineers. In addition, engineering is often viewed as a maleoriented field[4]. Thus, changing the perceptions of teachers is crucial to encouraging more girls and women to enter engineering fields. Simple professional development activities, such as researching and presenting information about successful female engineers, can increase the likelihood that teachers will view engineering as a career for women[5]. In addition, using consistent, positive messages about engineering and engineers will help change any negative perceptions that teachers might bring to the classroom[4].

Outside the classroom, camps or other informal educational experiences can increase knowledge of and intent to major in engineering. Ryerson Polytechnic University in Toronto has operated several activities, including a week-long summer camp, to introduce middle and high school students to engineering, and results from their follow-up surveys showed that interest in engineering or science increased immediately following camp and that camp attendees who went on to major in engineering were influenced at least in part by their experience[6]. However, the same respondents indicated that they relied on hard work and resolve to push past barriers they encountered in their educational path, which suggests that programs to build self-efficacy, metacognition, or motivation would be a valuable addition to pre-college engineering.

In addition to individual traits, the environment of an engineering classroom or department affects whether women feel comfortable and welcome. In one study, upper-level female engineering students experienced decreased comfort and increased vigilance when viewing a video of a scientific conference with a 3:1 male-to-female ratio as compared to their responses to a gender balanced video. Although males did not differ in their responses to the videos, both women and men stated a preference to attend the gender balanced conference, indicating that increasing the number of women in STEM fields will encourage men as well[7]. The effect of environment extends to classrooms and labs as well, and in one study environments viewed as stereotypically male led to women experiencing less feeling of belonging and less interest in the field of computer science[8].

In addition to programs that increase recruitment of girls and women into engineering, programs exist to improve the retention of women once they begin engineering majors. Fox, Sonnert, and Nikiforova[9]correlated specific elements of Women In Science and Engineering (WISE) programs on 45 different campuses with the proportion of women receiving bachelor's degrees in science or engineering over a 15 year period. The programs associated with the most increase in women's bachelor's degrees tended to focus on changing the institutional context, while the programs associated with the lowest increase focused more on supporting individual women but not connecting them to the broader institutional community. The most successful programs also combined a variety of activities, such as bridge programs, mentoring, and research opportunities, while the least successful programs emphasized peer mentoring over other activities. The program directors who saw the most increase in women's degrees also talked of initiating an even wider range of activities if they could, while directors with low-performing programs discussed continuing and expanding the same activities they were already carrying out. These findings suggest that successful retention of women in engineering is aided by programs that work within the institutional context and provide a wide range of support and community programs for students[9].

Although successful programs exist to increase the number of women engineering graduates by reducing the attrition rate of women students, given the low numbers of women entering engineering programs recruiting should also be a focus [10]. The current project addresses both issues and tries to improve recruitment and retention of female students in mechanical and electrical engineering, which are two of the largest engineering disciplines with the lowest percentages of women (see Figure 1). EEES worked through various Extension Agents at the Collaborating Organizations (e.g., American Society of Mechanical Engineers [ASME], Institute of Electrical and Electronics Engineers [IEEE], and Project Lead the Way [PLTW]), that chose a targeted population for training (the Clients), including mechanical engineering faculty, K-12 outreach volunteers, and high school teachers. EEES also partnered with university departments of mechanical and electrical/computer engineering to support their gender equity projects aimed at faculty members, undergraduate students, and/or K-12 students.

Current Project

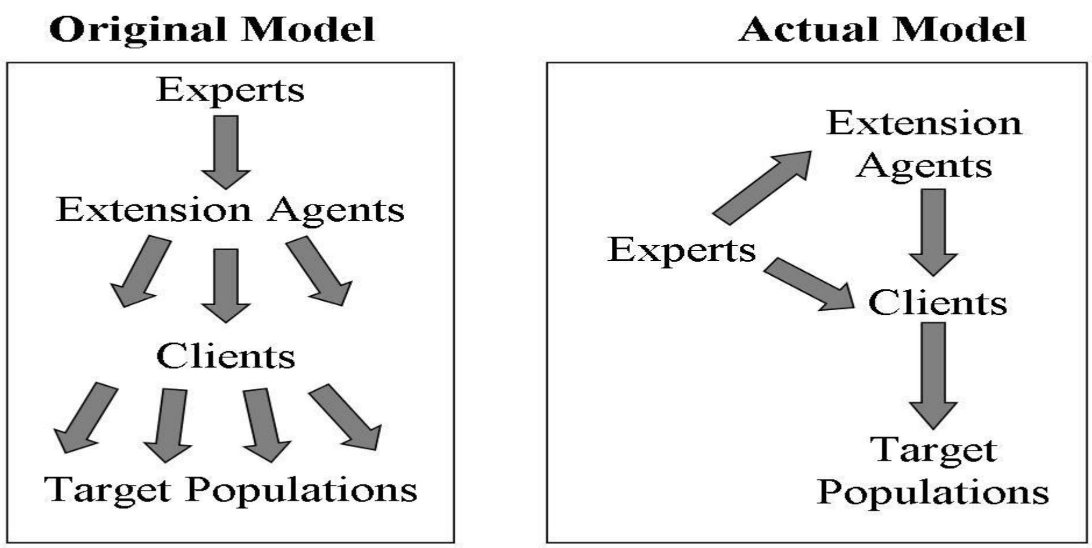
Begun in 2005 at the Center for the Advancement of Scholarship on Engineering Education (CASEE) of the National Academy of Engineering (NAE), the EEES Project developed a research-based approach to encouraging more gender equity in engineering, specifically in the mechanical and electrical fields, with the ultimate goal of increasing the number of women attaining baccalaureate degrees in these fields. Using an extension services model, we envisioned a “train-the-trainer” program, with consultants (Experts) providing research-based guidance on practice to individuals (Extension Agents) who provide professional development workshops and seminars translating research on gender equity, engineering education and project management into practical guidance for teachers, faculty, and outreach volunteers (Clients). The Experts translated research results from the fields of gender equity, engineering education, and project management into practical advice for the Extension Agents and, later, the Clients. Ultimately, the Clients were responsible for implementing the knowledge they gained from the professional development activities offered by the Extension Agents in their local programs. At the outset we also developed a list of exemplar programs, all of which had been successful in implementing an intervention that improved recruitment, retention, or advancement of girls and women in STEM, with the intent that the Experts would draw on these identified best practices in their advice to the Extension Agents. However, the Experts instead drew on their own knowledge and experience, and throughout the course of the project our experts developed sets of formalized resources (see below) for use by extension agents and clients.

Work began by conducting needs assessment surveys with the members of the Collaborating Organizations to determine how to best focus resources and efforts. Originally, one of the associations focused on undergraduate retention and faculty development, one association focused on K-12 outreach and training volunteers, and one association focused on K-12 pre-engineering and engineering courses and training teachers. In addition, the original plan called for a secure electronic network to link the Experts, representatives from the engineering associations (Extension Agents), and EEES Project staff. This website combined communications aspects such as blogging, email, and poll capability with a secure site for posting electronic versions of the resources developed by the project.

Over the 5-year course of the Project, the original plan evolved from a "train-the-trainer" approach to one employing consultants to give both advice to the original Extension Agents who provide faculty and teacher development as well as to work directly with engineering faculty members on projects aimed at both K-12 and undergraduate students. See Figure 2 for the evolution of the EEES model.

In addition, the originally-envisioned integrated electronic network did not work as well as a combination of (1) a publicly-accessible website of resources (http://www.nae.edu/casee-equity) that includes resources developed during the Project as well as relevant research-based resources on gender equity, engineering education, and project management, and (2) direct email communication between stakeholders.

Figure 2: The EEES Original and Actual Models.



Project Resources

The human resources of the project, in addition to staff, included the 35 extension agents who were associated with one of the collaborating organizations. Their work was supported by 15 experts who provided more than 400 hours per year of consultation on instructional materials development, resource development, assessment and assessment materials, and program and materials review. In particular, the extension agents associated with the 16 university departments developed a variety of projects that were supported by both consultations and mini-grants.

Ten departments largely focused on organizing outreach activities for pre-college students. Approximately 925 students in grades K-12 participated in activities ranging from one-day events to longer camps. Approximately 75% of those students were female, and many indicated an interest in becoming an engineer following their participation. Nine institutions targeted undergraduate retention through engaging students in social activities, peer mentoring and serving as role models and mentors for pre-college students, and faculty role modeling. These women also took leadership positions for several of these activities and in many cases became more involved in departmental activities as a result. Approximately 140 students, about half of them women, participated in these activities.

Three departments held faculty workshops, and faculty members also served as mentors for both retention and recruiting activities. In all, approximately 70 faculty members participated in the project. Parents and high school teachers were involved or observed several of the outreach projects. In addition, 3 institutions revised recruiting or course materials. As these materials are disseminated to students, parents, and faculty, it is unknown how many individuals will see the revised material. Most of these revisions involved including more gender-neutral descriptions and pictures as well as describing student projects that appeal to a wide range of students. These revisions were encouraged by the expert consultants who worked with the department faculty.

In addition to the projects completed by the extension agents, the EEES project created an extensive set of materials and tools for use by engineering departments, faculty members, and outreach volunteers including the following. Unless otherwise noted, the resources can be found at http://www.nae.edu/casee-equity.

a) guide books and videos highlighting research based practices for enhancing awareness by girls and women for engineering careers, retention strategies, and academic advancement strategies (available at http://www.caseeconduit.org/ndeeindex.html),
b) climate assessment tools,
c) curriculum equity review tools,
d) peer-reviewed short summaries, one-pagers, and full-papers on gender equity research findings and their implications for practice (available at http://www.engr.psu.edu/awe/ARPResources.aspx),
e) one-pagers on academic and climate change strategies to enhance the academic performance of women students in engineering (available at http://www.nae.edu/Activities/Projects20676/CASEE/26338/35823/EEESHome/EEESPremierProducts.aspx#change),
f) research to practice briefs, drawing on the engineering education research base and the social science research base, targeted to teachers, faculty, and academic administrators (available at http://www.nae.edu/Activities/Projects20676/CASEE/26338/35823/EEESHome/EEESPremierProducts.aspx#rps),
g) short video simulations summarizing key research to practice findings,
h) tutorials on effective practices for outreach volunteers (available at http://www.ieee.org/education_careers/education/preuniversity/train_the_trainer.html),
i) links to scholarly resources to enhance knowledge on gender equity,
j) links to practical resources for enhancing academic and social equity environments,
k) equity case study videos, and
l) a proposal writing and project management guide, available at http://www.lulu.com/product/paperback/eees-proposal-writing-and-project-management-guide/5377747.

During the five year life of the project, representatives of the original three EEES collaborating organizations reported tangible and substantial evolutions in their organizations' understandings of (a) the importance of addressing gender equity in engineering, (b) the necessity of comprehensive approaches that address organizational environments and not just student preparation or resilience, (c) the harm caused by well-meaning, but uninformed actions to address gender inequities, and (d) the need to involve all parts of an organization and not simply the "diversity staff."

As the EEES Project ended, all individuals who had participated in any way in the activities were asked to complete an evaluation survey conducted by our external evaluator. Overall, those who responded indicated satisfaction with their experiences and beliefs that project goals were met. In particular, the extension agents and clients valued the resources developed or gathered on the EEES website, and the consultants viewed their advice as appreciated by the extension agents. Finally, survey respondents indicated increased personal knowledge of gender equity, engineering education, and project management as well as positive experiences in working with the other organizations.

Lessons Learned

Over the course of the project, several lessons came to light. First, our experts were uncomfortable using exemplar resources developed by others. Whether this was professional chauvinism or simply a discomfort in advising others to use materials for which the detailed conditions of development and limitations in application were unknown is unclear. Furthermore, although the resources developed by EEES experts were enthusiastically received by all the stakeholders, widespread and effective adoption of the practical tips in them requires some training on how to easily and effectively use them in the classroom. In addition, although a secure website to use as both a communication hub and a resource clearinghouse seemed to be the most efficient way to maintain stakeholder connections, the individuals involved were much happier with traditional email and/or teleconferences as their communication method coupled with a website for posting EEES resources that can be accessed by Experts, Extension Agents, Clients, and the broader engineering education community. The change in web platforms allowed EEES to more widely disseminate resources.

Second, the extension services (i.e. train-the-trainers) model works best with a strong focus on a few key topics rather than with a wide variety of topics. This concentration brings focus to all project materials and communications and helps to align stakeholders with movement toward the common goal. This movement allows for short term successes for all stakeholders, such as an increase in female enrollment in a departmental outreach effort or an invitation from the leadership of a Collaborating Organization to present information on improving gender equity organization-wide. These intermediate achievements improve engagement and allow for later expansion of EEES focus. Finally, institutions or societies planning to adopt this model must choose their organizational partners very carefully to ensure common focus, efficiency, and engagement.

Acknowledgement

This work was supported by the National Science Foundation via grant HRD- 0533520. Opinions expressed by the authors are their own and do not necessarily reflect the policies of the National Science Foundation.

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