Res High Educ (2009) 50:333–353
DOI 10.1007/s11162-009-9120-4

Successful Programs for Undergraduate Women in Science and Engineering: *Adapting* versus *Adopting* the Institutional Environment

Mary Frank Fox · Gerhard Sonnert · Irina Nikiforova

Received: 18 October 2007 / Published online: 28 January 2009

Abstract This article focuses upon programs for undergraduate women in science and engineering, which are a strategic research site in the study of gender, science, and higher education. The design involves both quantitative and qualitative approaches, linking theory, method, questions, and analyses in ways not undertaken previously. Using a comprehensive, quantitative, cross-institutional, and longitudinal method, two extreme groups of programs are distinguished: those associated with the "most successful" and "least successful" outcomes in undergraduate degrees awarded to women in science and engineering. Qualitative analyses of interview data with key players in the programs in these two groups point to ways in which definitions of issues, problems, and solutions diverge (as well as converge), and thus to conceptual underpinnings that have important real-life consequences in these organizational settings of higher education. The programs that regard issues, problems, and solutions of women in science and engineering as rooted in "institutional/structural-centered," as opposed to "individual/student-centered," perspectives are associated with the most positive outcomes in undergraduate degrees awarded to women in science and engineering.

Keywords Women · Gender · Science · Engineering · Undergraduate education · Programs

M. F. Fox (✉)
School of Public Policy, Georgia Institute of Technology, 307 DM Smith Building, Atlanta 30332-0345, GA, USA
e-mail: mary.fox@gatech.edu

G. Sonnert
Harvard University, Cambridge, MA, USA

I. Nikiforova
School of History, Technology, and Society, Georgia Institute of Technology, Atlanta 30332-0345, GA, USA

Introduction: Focus and Objectives

Since the early 1970s, the under-representation of women in scientific and engineering education and careers has been considered a pressing national issue for at least two reasons: (1) the potential contribution of women to the size, creativity, and diversity of the scientific and engineering workforce, and (2) the principle of social equity, expressed in the belief that scientific careers should be "open to talent," and not governed or constrained by personal factors, such as race and gender (Long and Fox 1995; Merton 1973a; Pearson and Fechter 1994).

Challenges in the representation of women in undergraduate education vary by field. In the recent (2003/2004) period, women represented 57% of undergraduate degrees awarded across all fields in higher education; but only 25.1% in computer and information sciences, 21.4% in physics, and 20.5% in engineering (Commission on Professionals in Science and Technology (CPST) 2006, Tables 3–02 and 3–51).

Efforts to open educational pathways for women (and other under-represented groups) in science and engineering frequently take the form of programs or sets of activities thought to affect the targeted group positively (Clewell and Ficklen 1986, p. 6; Matyas 1991, p. 67; Matyas and Dix 1992). Such programs usually consist of activities that are organized responses to perceived issues of, and perceived barriers to, the representation, participation, or performance of a targeted group (Clewell et al. 1992, pp. 95, 134).

In the study of gender and higher education, programs targeted to women in science and engineering are "strategic research sites"[1] for three reasons. First, a central claim of programs is that they have a positive effect upon outcomes for women in science and engineering—and systematic, quantitative evidence can be brought to bear on this claim. Second, programs embody the organizers' and sponsors' conceptions (Stage 1992, pp. 16–17), as well as cultural assumptions (Lagesen 2007), of what is "wrong" or at issue for women in science and engineering, *and* of what can be done to improve the participation and performance of women in these fields. In other words, these programs encompass a "diagnosis" of the root problem that needs to be addressed: for example, women students' attitudes and skills, faculty bias, the structure of undergraduate education, or the culture of departments. The programs also encompass proposed "solutions" to the problem through, for example, mentoring, bridge programs, peer tutoring, or curricular reform. Third, the conceptions of what is wrong or at issue for women in science and engineering, which underlie the programs, illustrate the extent to which two major ways of scholarly thinking about women in science and engineering—an individual versus an institutional/structural approach (described below)—are linked to concrete social and institutional action in higher education, that is, to specific programmatic activities implemented for women. These conceptions of "what is at issue" for undergraduate women in science and engineering potentially have important, real-life consequences for women's recruitment and retention within these critical fields of higher education.

In the most basic formulation, the two ways of thinking about women in science and engineering can be described as a matter of "individual issues" versus "institutional issues" and may be summarized in the following manner. From the individual perspective, the status of women in science and engineering is attributed to, or thought to

[1] A "strategic research site" refers to a research site that exhibits, to advantage and in an accessible form, the phenomena to be explained or interpreted (Merton 1973b).

correspond to, women's individual characteristics. These individual characteristics include attitudes, behaviors, aptitudes, skills, and experience of women that may affect their participation and performance in science (Astin and Sax 1996; Cronin and Roger 1999; Fox 1998; Ong 2005; Sonnert and Holton 1995a, b). For example, women's lower level of self-confidence in mathematics and lower internal sense of ability or potential for scientific achievement can be seen as barriers to pursuing careers in these fields (Astin and Sax 1996). Likewise, levels of motivation to perform in scientific areas may be regarded as supports or barriers to pursuing scientific careers. From the institutional or structural perspective, the status of women in science and engineering is more strongly attributed to factors beyond individual characteristics, that is, to features of the settings in which women are educated and in which they work. These factors may include, for example, patterns of inclusion or exclusion in research groups, selective access to human and material resources, and different practices and standards of evaluation that may operate for women compared to men (Astin and Sax 1996; Cronin and Roger 1999; Fox 1995, 1996, 1998, 2001; Frehill 1997; Robinson and McIlwee 1989; Seymour and Hewitt 1997; Sonnert and Holton 1995a, b). From this structural perspective, factors also include science and engineering teaching environments that may isolate students from social concerns (Rosser 1993), portray science and engineering as highly competitive, masculine domains (Margolis and Fisher 2002), and tend to "weed-out" students in the curricular process (Seymour and Hewitt 1997).

The distinction between individualistic and institutional/structural perspectives or explanations for the status of women in science and engineering is important. This is because a long-standing and controversial debate exists about the extent to which it is the women or the social systems of education and work that need to be "fixed" to improve the participation and performance of women in these fields (Fox 1998; Sturm 2006). Further, although social scientists who have studied the phenomenon have tended increasingly to lean to the structural perspective, natural scientists and engineers themselves typically leave unexamined the structures in which students are educated (and work), and expect students to "shape themselves" to prevailing environments (see Sonnert and Holton 1995a, b; Sturm 2006).

Programs that exist at institutions of higher education in support of women represent a real-life embodiment of these theoretical perspectives, exhibiting conceptions of what is "at issue" for the status of undergraduate women in science and engineering. Thus, some programs are based on the premise that women students, as individuals, need to be given special support to succeed in their courses of study, resulting in programmatic activities such as extra study groups for women. Other programs consider structural factors to be crucial for the participation and performance of women students, and therefore attempt organizational reforms such as creating links between the program and faculty members in science and engineering. Furthermore, any empirical link between the perspectives of programs (individual vs. structural) and outcomes for women in science and engineering would point to potential relationships between social theory and social consequences in higher education. In other words, such a link between theory and consequences would mean that the debate about the relative importance of individual and structural factors in determining women's participation in undergraduate science and engineering is not only of interest to social scientists, but also has practical implications. A program's exercise of one, compared to the other, of these theoretical orientations potentially influences success for women in scientific fields.

This article addresses these issues of gender, science, and higher education (outlined above) by reporting analyses from an important phase of a large, national study of

programs for undergraduate women in science and engineering[2]—site visits, including interviews with directors (and others) associated with programs, in two contrasting groups, those associated with the "most successful" and "least successful" outcomes in terms of undergraduate degrees awarded to women in science and engineering. The measure of success was based upon the difference between pre- and post-program rates of growth of the percentage of women among recipients of bachelor's degrees in science and engineering fields, as explained in the section on Method.

This outcome of "degrees awarded" has conceptual and practical validity. The indicator has been endorsed by national evaluation studies assessing the efficacy and effectiveness of women in engineering programs (Brainard et al. 1993). Correspondingly, for continued administrative support by the universities in which they are located, programs often need to reference "degrees awarded to women." Although alternate definitions of "success" exist,[3] the particular measure of degrees awarded to women is organizationally significant in the higher education settings of programs for women in science and engineering.

The focus upon women at the undergraduate level, in particular, is critical to understanding and improving gender equity in science and engineering for two related reasons. First, in order to pursue advanced education in science and engineering, one usually needs to have had undergraduate preparation in these fields (Hanson 1996). Second, the undergraduate level of education is acknowledged to be the "latest point" for a standard entry into science and engineering fields (Xie and Shauman 2003, p. 96). This contrasts with fields outside of science, which may, on average, be entered and pursued from both a wider range of educational backgrounds, and at later stages in a life course.

With our analyses of interview data from programs for undergraduate women in science and engineering, our aims are to: (1) improve the understanding of what major players consider to be "at issue" about the condition of women in science and engineering; (2) identify the range and complexity of "solutions" posed to the perceived problem/issues of undergraduate women in these fields; (3) foster the understanding of programs as organizational phenomena, pointing to both the potential for, and limits of, programs in

[2] The study included three phases. The first phase involved analyses of institutional-level data collected through IPEDS and a survey of 499 institutions-45 with programs, and 454 control institutions without programs, which were matched to institutions with programs on the basis of the earlier Carnegie classification (in place in 2000), similarity in institutional control (public/private), and the level of urbanization (large city/midsize city/small town) of the community in which the institution was located. More specifically, the institutions included in the survey were selected according to the following plan. All institutions in the "Research I," "Research II," "Doctoral I," and "Doctoral II" categories of the Carnegie Classification in use before 2000 were included. Within the large Masters Degree Granting ("MAI") and Associate Degree Granting ("AA") categories, the selection procedure was based on the existence of programs for undergraduate women students in science and engineering. In these categories of the Carnegie classification, we matched the institutions with programs to institutions that were similar in institutional control (public/private) and urbanization (large city/midsize city/small town) of the community in which the institution was located. If the categories thus determined were still too large to survey them fully—which occurred in the public/midsize, private/midsize, and public/small town groups—we selected the 40 institutions that matched the target program institution most closely in size of student population. The second phase was a survey of directors in the universe of programs for undergraduate women in science and engineering within the United States. Third were the site visits to ten (10) programs associated with "most" and "least" successful outcomes.

[3] Other outcome variables at the level of faculty and administrators (compared to students who are at focus in the present study), may include, for example, proportions of faculty, chairs, and others who are female, over time.

relationship to the institutional environments of higher education in which they exist; and (4) identify patterns of programs associated with most (compared to least) positive outcomes—with implications for understanding the participation and performance of undergraduate women in science and engineering, and for potential supportive practices and policies in higher education.

Previous studies of programs for women in science and engineering in the US[4] have tended to focus upon a single institution, describing features of particular programs (Brainard 1993; Muller 1992), or analyzing ways in which initiatives of a local program (especially residential, living-learning programs) are associated with students' retention and grade-point-averages (Allen 1999; Brainard and Carlin 1998; Fisher et al. 2000; Hathaway et al. 2001). Cross-institutional studies are exceptional and include Brainard's et al. (1993) evaluation of women in engineering programs, which gathered information on features such as program objectives, target populations, years in operation, and budget-levels; Knight and Cunningham's (2004) description of what a "typical women in engineering program might look like" and "directors' advice for people who may be interested in learning more about women in engineering programs" (p. 4); as well as the *Final Report of the Women's Experience in College Engineering (WECE) Project* (2002) that includes findings on reports by directors of women in engineering programs about "effective ways to retain female engineering students." Studies of programs for women in science and engineering have been characterized as failing to "situate the study or its potential findings within a framework or theory," and as having only "weak links between questions, theory, methods, and data analysis plans" (Dietz et al. 2002, p. 400).[5]

Our research goes beyond the restrictions and limitations of previous studies in both methods and its attention to conceptual frameworks. The study uses longitudinal institutional data in the assessment of "success," and employs a comprehensive scope that includes all (49) existing programs for undergraduate women in science and engineering in the US, identifying those programs that are "most" and "least" successful. The analysis of these programs is essential in disseminating academic organizational strategies and programmatic activities linked with visible success. Through interviews with program directors (and others), the study explicitly links conceptual frameworks of women in science and engineering, that is, individual versus institutional/structural perspectives, to real-life definitions of issues, problems, and solutions, and to most or least successful outcomes. The study also illustrates the complex relationship between programs and the institutional environments of higher education in which they exist. Finally, by advancing the understanding of women, science, and organizational environments of higher education, this study has the potential to enhance strategic policy-making to improve the condition of women in these fields.

[4] A recent investigation in a Norwegian setting (Lagesen 2007) is a case study of a initiative within a single university, addressing strategies that were implemented and successful for recruitment of women students into computer science in this university. Efforts to redefine computer science as symbolically more "feminine" were not successful for recruitment; rather, the successful strategy was the use of a quota for recruiting, combined with efforts to make women students feel "welcome and appreciated."

[5] Further, for understanding of women and science, it is important to undertake a systematic, empirical and theoretically-grounded study of programs, because often programs disseminate their methods through relatively narrow and pragmatic outlets, such as workshops, training programs, technical assistance, and materials development (Clewell et al. 1992, p. 165). This leaves unmet the need for scholarly and broadly communicated studies of programs.

Method

Data and Outcome Measure

We began with the universe of (49) programs for undergraduate women in science and engineering existing, nation-wide, within the United States in 2000/2001. These programs were located at (45) institutions (because four institutions had two programs, each). The data on outcomes-proportions of women among bachelor's degrees recipients, over time (1984–2001), within institutions in which programs are situated-were obtained on-line through the Integrated Postsecondary Education Data System (IPEDS) and, for years not available on-line, through a survey of registrars.[6]

We selected ten (10) programs for more detailed analyses through interviews and site visits. These programs were chosen for maximum contrast between programs associated with "most successful" and "least successful" outcomes in terms of the proportion of degrees awarded to women. Our measure for identifying these programs was the difference between the pre- and post-program rates of growth in the percentage of women among bachelor's degree recipients. To obtain this for each institution with a program, two regressions were estimated, one for the years leading up to the year when the program was created, and the other for the following years.[7] In these regressions, the dependent variable was the percentage of women among bachelor degree recipients (in engineering, in the biological and physical sciences, or in all three areas of engineering, biology, and physical sciences—depending upon whether the program was one for women in engineering, women in sciences, or women in science and engineering). The independent variable was years. Our measure indicated whether initiation of a program had an effect—positive or negative—in the rate of change in the percentage of women among bachelor's degree recipients in the relevant fields. A positive difference between the "post-" and "pre-" slopes signifies that the percentage of women among bachelor degree recipients grew more strongly after the start of the program than before the founding of the program. The slope differences allowed us to identify the (5) "most successful" and the (5) "least successful" programs.

The success of programs, as defined by this method, was not simply a function of the programs' age. The average founding years for the "most successful" and "least successful" programs were quite similar (1993 and 1994, respectively). Furthermore, the composition of the two groups of programs was similar, overall, in the broad types of institutions in which they were located. Of the (5) most successful programs, three were at Research I institutions, according to the old Carnegie classification, and two were at Research II institutions. Of the (5) least successful programs, two were at Research I institutions, two at Research II institutions, and one at a Masters-level institution. Moreover, all (10) programs in both groups were at public institutions. The "starting points" for the two groups—in the percentage of women among the bachelor degree recipients at the inception of the programs—were also similar, as explained in Appendix 1.

The focus upon the extremes ("most" and "least" successful) allows for analyses of maximum contrast, and thus presents the best opportunity to identify features of programs

[6] At the time these data were collected in 2000/01, on-line data were available for the numbers of male and female students completing undergraduate degrees 1989–1990 through 1998–1999.

[7] Not all institutions had at least four time points each of data on the percentage of women among bachelor's degree recipients, pre- and post-program initiation. Those with fewer data-points were dropped from consideration. To estimate the regressions, PROC AUTOREG in the SAS statistical package was used because we were dealing with time-series data.

that may relate to the outcomes. The longitudinal approach is keyed to trajectories of institutional trends, and how they change before and after initiation of a program. The data on slope differences for programs in both groups ("most" and "least" successful) and additional methodological details appear in Appendix 1.

Inspection of the national time trends in the women's percentage among undergraduate degree recipients in the disciplines examined (biology, physical sciences, engineering) revealed that, over the study period, the trends for all fields were remarkably linear and showed steady increases, albeit at different levels. Hence, even though the representation of women varied markedly by field, the respective growth trajectories did not. Our analysis took a longitudinal approach for each institution (which, in turn, controls for a great deal of institutional background factors) and determined if a "kink" in the growth trajectory was associated with a program, that is, if the growth in the percentage of women among degree recipients accelerated, remained the same, or even slowed down once the program came into existence.

Interviews: Process, Rationale, and Questions

Because each program consists of a program director and in some cases, an assistant or associate director, interviews were arranged by email with the program directors. The program directors were also asked if interviews could be arranged with an assistant or associate director (if one existed), and with the person to whom the program reports (if that person was available).[8] For all ten programs, the program directors were interviewed; for seven programs, interviews also took place with the persons to whom the program reports, and in some cases with associate directors as well. In seven of the cases (out of ten), the interviews were part of site visits to programs/universities that lasted a half to a whole day. In three cases, interviews with the program directors took place by phone. The interviews were conducted in the winter, spring, and summer of 2004.

The focus here is largely upon interviews with program directors, specifically, for the following reasons. First, each program has a director, and the position has shared meaning across cases. Further, interviews with program directors, who are regarded as the "backbone of a program" (Knight and Cunningham 2002, p. 2), may be considered a reliable source of information, and they provide a focal comparative set of responses across programs. The program directors typically are most knowledgeable about a given program. Their statements about the program's underlying concepts have great real-life validity because it is the director's views that ultimately tend to matter most as they plan and coordinate the program's activities. Tellingly, program directors referred to their role, variously, as "I am the program" or "It's me," and in one written instance, as the "best job on campus [working with] students, faculty, and industry representatives every day."

The interview questions followed a semi-structured protocol (Platt 2002) including (1) definitions of what is "at issue" for the participation/performance of undergraduate women as majors in science and engineering; (2) solutions represented by activities undertaken in the program; (3) perceptions about what is important for a director of a program, in personal characteristics and educational background; (4) linkages between the program and the broader environment (institution, administration, faculty communities) in which it exists; and (5) aspirations and directions for the future of the program. Data were coded for responses to each question for respondents/participants interviewed within each program.

[8] For a large proportion of interviews and site visits, conducted during the late spring and summer, student participants were not available for interviews.

Data were then analyzed by contrasting the two groups of sites (those with the "most" successful and "least" successful outcomes) and determining different types and patterns of responses in these two groups.

These interviews were an important element of this study because (1) they provided detail and richness beyond that of the quantitative indicators in the survey; (2) they helped address the phenomenon of "women and science and engineering" in real-life educational settings; and (3) they helped elucidate organizational definitions of problems, perspectives, and solutions for undergraduate women in science and engineering. While the issues of women in science and in engineering were not the same, many overlapped at the undergraduate level. In these three ways, the interviews were critical in our study of programs for women in science and engineering as a strategic research site for the understanding of key issues of gender, science, and higher education.

In addition to interviews, we analyzed printed and on-line documents that were available for all of the programs. The documents were most likely to contain statements of the programs' missions and a record of programmatic activities, aimed at recruiting participants for the program. Data from documents are reported in the following section for the cases in which they highlight findings.

Findings

Although each program had unique features, similarities and patterns emerged within the two categories of programs that congealed into Weberian ideal types[9] (Weber 1947) of the most successful and least successful programs. These ideal types to a considerable extent were aligned, respectively, with the institutional/structural and individualistic perspectives discussed earlier. The focal findings are described below according to the questions/issues addressed in the interviews.[10] (For a summary table, see Appendix 2.)

1. The definition of the problem: In the view or orientation of the program, what is the major issue or problem of women undergraduate majors in science and engineering? What is "the issue"?

These questions address the definition of the issue and, in turn, factors that motivate the existence of a particular program. Programs in the most successful group defined the problem/issue of undergraduate majors in science and engineering more comprehensively, with greater awareness of the structural antecedents of the under-representation of women (Table 1). The problems reported by the directors of these programs were not only the limited "numbers of women" recruited and enrolled, but also involved a broader range of environmental issues including: faculty and classroom bias against under-represented groups; grading systems that function to "weed-out" students; and a "pipeline of support" for continued (graduate) study that is less helpful to women than to men undergraduates.

A program director in the most successful group described the weed-out mechanism this way: "Women are top students in high school. They make a 'C' in college and begin to

[9] In Weber's conceptualization, an ideal type is formed from characteristics of a class of given phenomena, but a particular case within this class does not correspond exactly, in all its features, to the ideal type. Rather, an ideal type emphasizes elements that are common to most cases of this class of phenomena. Ideal types are especially useful in comparative analyses, as in the "most successful" and "least successful" programs in this study.

[10] The findings contain responses from all (10) program directors. Additionally, the responses of seven (7) other persons associated with directors and the programs appear in the findings.

Table 1 Programs by definition of problem

Focal areas	Most successful	Least successful
Definition of problem	Under-representation and being a minority, and faculty issues, including "weed-out" orientation and lack of "pipeline of support"	Numbers of women participating, and retention

question whether they should remain." Another posed the issue as the faculty being "still very male oriented." A third director expressed a similar view: "There are not a lot of women in engineering. They [female students] don't have role models and sometimes don't think they can do it."

Programs in the least successful group have less explicit definitions of the problem; or tend not to see the issue/problem of women as undergraduate majors as subject to "solutions" (Table 1). Directors of programs in this group tend to define the problem more narrowly as one of "recruitment and retention," with a focus upon the students themselves. As one program director summarized, "our goal is to increase recruitment and retention of women and minority students in science, technology, and engineering." Another director defined the problem as seeking "to bring a few women together to provide a support system." A third remarked, "retention is the biggest problem." Some program directors in this category expressed awareness of a range of factors negatively affecting women as undergraduate majors in science and engineering; yet, they saw the bigger problems as "beyond [their] control" in their roles as program directors.

The interviews with programs' associate directors and administrators to whom the program directors report also revealed a range of perspectives on what is "at issue." The administrators to whom the programs report generally corroborated the issues specified by the directors, with the difference being a shallower depth (at least as expressed) in understanding the actual problems. This was revealed when administrators tried to locate issues in a larger social context and had to rely on their personal experiences to understand factors that impede the participation of women. An administrator from one of the least successful programs, for example, described the importance of communication for women, "My wife talks on the phone for hours. It used to drive me crazy. But now I see that women need to communicate." Even then, however, administrators from the most successful schools were more likely to identify external factors, such as that women "lack information and connections" and access to projects that "emphasize social aspects of engineering." The administrators in the least successful schools were more likely to mention small numbers of women in classrooms and retention problems, and to express the prevalent view that women "need a community," an "ongoing structure of support," and "a push because of the past" and because they "tend not to be 'tough-minded.'"

This difference in perspectives—focusing on external/structural factors compared to personal or historical gender deficiencies—was revealed also in the documents communicating the programs' missions. In the most successful programs, the mission expressed was to encourage women to pursue degrees in science and engineering and to offer activities to reinforce and enhance students' interests. The documents frequently stressed the goal of supporting the recruitment, retention, and success of women in science and engineering disciplines, but also talked about *creating* an equitable environment for men and women, and integrating three spheres—academic, professional and social. In contrast, the documents from least successful programs pointed to a mission to "attract, recruit and retain women" in the science and engineering fields, with strategies of "outreach" (often to

Table 2 Programs by solution and new initiatives

Focal areas	Most successful	Least successful
Solution	Early start ("bridge") programs, residence hall clusters, broad mentoring	Peer tutoring/mentoring, early start ("bridge") programs
New initiatives	Student research programs, hands-on research experience, faculty buy-in and involvement	Expand mentoring, expand early start programs

K-12) and mentoring. Thus, in these cases, recruitment and individual support were perceived as a means of addressing the historically disadvantaged position of women.

2. Solutions and new initiatives: (a) What are the major activities of the program—"solutions" of the program posed for undergraduate women in science and engineering? (b) If you could pick any new initiative or activity for the program, what might it be?

Directors of programs in the most successful group emphasized a broad range of activities, of which the most common and well developed were: bridge programs between high school and the start of college, living/learning residence halls, and mentoring (Table 2). Directors of programs in the least successful category also mentioned bridge programs, but overwhelmingly focused on a particular activity as most important: peer mentoring. This activity rests with the students and their support of each other—without emphasis upon initiatives geared more directly to the institutional and environmental conditions in which students live and learn. As one director in that group put it, "What we hear from kids, what is important, is camaraderie. They find other women in sciences by being in these programs. They can find people who they can form friendships with and work academically. Peer support is very important." Similarly, another director in the least successful category said, "The role model aspect is important. The first two years are also considered boring and hard. Students need to learn that there is so much more to engineering than physics and calculus. Women like the communication and [like] to feel needed." Again, the focus is on students, and specifically, on the support of students, and students' reinforcement of each other.

Relatedly, when asked what "new initiative" they would like to undertake, directors of programs in the most successful group pointed to a range of activities, specifically: "faculty buy-in" through workshops with faculty, undergraduate research projects with faculty, and "hands-on experiences for students geared to taking their careers in science and engineering." One director asserted, "I would pick hands-on experience, showing students how the practice comes together." The reason, she continued, is that you want to "show what happens when you pull mechanical and intellectual components together." For example, she explained, female students could learn to put together a personal computer since "women don't get [to do] that." Another director stated that as a new initiative she would focus on "faculty buy-in and their awareness of why [to have] women's programs and what makes a difference." The initiative could be in the form of faculty learning project since "what changes faculty opinions are peers" and "faculty will change themselves based on peer opinion and perception."

In response to the question about a new initiative, directors of the programs in the least successful group said, in contrast, that by and large they would do more of the same, that is, "expand mentoring" (Table 2). "Truly, if I could, I would expand the individual mentoring program, [and] add bodies [staff members]," said one of the program directors.

In both the most successful and least successful groups, the administrative persons to whom programs report expressed a relatively narrow conception of appropriate activities. While naming important activities, they echoed the activities presently undertaken and pointed out that the programs would be doomed without the particular, current highlights of the programs. For the administrators in the most successful group, such activities were early start ("bridge") programs and workshops; for administrators in the least successful group, they were pro-active mentoring and study halls.

3. Leadership characteristics needed: (a) What are the most important characteristics needed for being an effective program director? (b) How important do you think it is for a director to have a degree in a science or engineering field? (c) How important is it for a director to have an advanced (doctoral) degree?

Directors of programs in both the most successful and least successful groups believed that "the personality of a director" is a very important, even essential, aspect of the program. But when asked "which aspects of personality" are important and "why," the directors diverged (Table 3).

Directors of programs in the least successful group emphasized the importance of characteristics that relate, as they expressed variously, to "communication," "being approachable, positive, empathetic, and encouraging," "counseling students," and even to acting as "parents" with students. The emphasis upon interpersonal interaction, communication, and counseling corresponds to a "student services" model. "We are like moms and dads," said one program director. Another described that "kids come to me; they know I will deal with a problem; I will go with them through [the] process." A third director told students in the program to come by if they needed someone to cheer them up, calm them down, listen to them, or let them brag about a grade.

In contrast, directors of programs in the most successful group believed that interpersonal communication with students is important—but in *combination with* "resourcefulness," "collaboration," and "outreach" that connect the program with administrators and others in the environment beyond the students. Exemplifying this view, one program director said "most of the time, [you] want to engage in conversation, want to be able to get ideas across, want to be able to get support, keep promises, and be able to deliver."

Directors were also asked about the importance for a director to have a degree in a science or engineering. Directors of programs in both the "most" and "least" categories reported that having a degree is science or engineering is important—but they differed in their reasons of *why* it may be important (Table 3).

Those in the least successful category regarded the degree as important to understanding the students, their issues, and the fields in which they are taking their degrees. The director of a program in this category said: "When you do not have a degree in science or

Table 3 Programs by director's personality and leadership characteristics

Focal area	Most successful	Least successful
Director's leadership, characteristics needed	Person and organizationally-oriented: collaborative, resourceful, network-oriented	Person-oriented: approachable, nurturing, mentoring, warm, encouraging, interactive
	Science/engineering degree important: in relationship to college/institutions/ faculty	Science/engineering degree important: for understanding students

engineering, this issue is raised. There are pros to having been through the experience, having taken the classes."

In the most successful category, directors tended to regard the degree as important, more broadly, in relationship to their institutions. They noted, for example, that science and engineering fields are "high in the pecking order of the faculty," and that a degree in these fields is a "means to respect" within the institution.

Additionally, when asked about the importance of having an advanced (doctoral) degree, directors of programs in the most successful category were also more likely to relate an advanced degree to the institutional environment of their programs, emphasizing that "credibility" and "professional recognition" accrue from having a doctoral degree. "When you are in higher education, everyone needs an advanced degree," remarked one program director.

Administrators' responses about the most important characteristics for a program director revealed that they saw directors mainly as "student counselors." In both the most successful and least successful groups, administrators to whom the programs report identified as most important the personal characteristics of directors that would make them "able to work with students." Those from the most successful group responded variously that it was "definitely helpful to be approachable and neutral," that one needs "to understand the people they [directors] are working with," and that it is important to be "nurturing, mentoring and pro-active" in relating to young people. As one administrator in the most successful group put it, "students need to know this person cares about them and will give them more than the time of day." The administrators in the least successful group pointed to the importance of counseling and people skills, charisma of the director, and the need to be "outgoing, very positive, and good." As one administrator put it, "if you don't have students coming in constantly, you aren't doing your job." In these ways, the expectations of the administrators to whom program directors report tended to confine the role of directors to that of student counselors—across most and least successful groups.

When asked whether the directors needed a degree in science or engineering or an advanced degree, administrators from both groups listed advantages and limitations of having and not having such degrees. Their actual choice about the field of the degree depended on the nature of the work in which the director was engaged, administrative or content-driven work. For those who viewed the work of the program director as administrative, a representative response was that "none of the directors have had one [a degree in science or engineering] and they all did a really good job." Those who viewed the work of the program director as more content-driven pointed out that a degree in science or engineering, and even an advanced degree, would broaden the type of work the director could do. A director with such a degree would be able to teach and have an easier time communicating with faculty. Administrators in both the most and least successful categories reported that to perform the job of program director, science or engineering degrees were "not required"; but degrees in these fields were typically described as "helpful" in the case of least successful programs and as "critical" in the case of the most successful ones. This suggests that the administrators in the most successful category were more concerned with the authority and legitimacy of the program director's position in academic settings.

4. Linkages/relationship to institutional context: (a) Does it matter to which level/unit a program reports? (b) Does the program have links with administrators in colleges and departments and with faculty?

When asked about whether it mattered to which level/unit (e.g., provost, dean, associate dean, or other) the program reports, directors of programs in both categories agreed that it did matter, but they differed in their explanations of why (Table 4).

Table 4 Programs by relationship to institutional context

Focal area	Most successful	Least successful
Relationship to context	Link with administration: issues of visibility, impact, and connection	Link with administration: issues of resources
	Link with faculty: difficult—and more "critical" stance to faculty	Link with faculty: difficult—and more "distant" stance
	Environment ↔ program	Environment → program

Those in the least successful category responded in terms of dependency upon material resources, and upon having the goals of their programs "understood" by the person/level to which the program reports. As one of the directors in this category said," It matters who you report to, in what you are able to do. The people above you need to have passion."

In the most successful category, directors were more likely to report a need or aspiration for the program to have, in words of directors, an "academic connection," "visibility," and "impact" in linkages to the administration. In the most successful category, awareness of the environment, its networks, and an active role within them, were more heightened and pronounced. "It is the position that is important," stated one director of a successful program, "but at the same time, the person is important, [the person] needs to promote you."

Overall, directors reported that program activities involving faculty were the greatest challenge for the programs. In both categories of programs, the most and least successful, the participation of faculty was reported to be "low," "limited," or always from "the same group of faculty supporters." When asked what "accounts for" the limited participation of faculty, directors in both categories of programs pointed to "time pressures upon faculty" and "lack of rewards to faculty" for participating in the programs. The directors thus pointed to some of the structural disincentives for faculty members to become active and engage in women's programs, that is, the conventional reward systems in institutions of higher education and underlying normative notions of what counts as legitimate inquiry and valid use of a professor's time. However, when asked further about the particular difficulties of getting faculty to participate, directors in the two categories evidenced different patterns of response (Table 4). Directors of programs in the least successful category were less critical about the limited involvement of faculty; they saw themselves and their programs as relatively "distant" from faculty, and were less willing and able to be pro-active toward faculty involvement in the program. When faculty members did participate, they were described by directors in the least successful programs variously, as "core," "key faculty members," or "faculty who are good with students." But in each of these cases, the faculty members were regarded as "apart" from the program and the director, and the low, overall participation of the faculty was regarded relatively uncritically.

In the most successful category, directors were more critical, saying, for example, "I don't think that they [the faculty] care" or "participation of faculty is not in their own interest." Directors in the most successful category also saw a need to be pro-active in getting faculty involved. As one program director in this category put it, "you have to ask them, develop the relationship, sit in on faculty meetings"—with a sense, in turn, that faculty are not so distant from the program as they are thought to be the least successful category.

When asked about linkages to colleges, departments, and other initiatives on campus for under-represented groups in science and engineering, only some of the most successful programs reported ongoing relations with programs for women such as "women's resource centers," the minority center, and the college of engineering, for examples. The least

Table 5 Programs by aspirations and/or directions

Focal areas	Most successful	Least successful
Aspirations/ directions	Expand range of scope: Form partnerships with faculty, and undertake proposals and external funding	Increase magnitude of present emphases: More students, more retention, more bridge programs, more scholarships

successful programs had little or nothing to report about linkages. Some directors of the least successful programs commented that there were questions of "whether there should be linkages," and that "linkages to students are number one." Further examination confirmed that the least successful programs were slightly at a distance from the students' academic life. Most successful programs, on the other hand, more strongly related to students academically through being involved in the curriculum by offering a course, academic success workshops, study-help, and/or living-learning, residential clusters. Further, with respect to linkages, some programs were able to forge strategic alliances with industry and alumnae, which provided funding opportunities and a broader group with stakes in the program. This was explicitly acknowledged in one of the publications stating that external sponsors were the reason "we can build an effective network of services for women."

5. Directions/aspirations: What are the most important directions—aspirations—for the program's future?

Asked about directions and aspirations for the program's future, responses diverged again in a similar way (Table 5). Directors of programs in the most successful category strove for more visibility and aspired to make strides in the scope and range of activities, particularly those that involve partnerships and involvement with faculty, development of research proposals and external funding, frequently in concert with faculty, and career development for students that also provides them with tools and opportunities for "navigating the university." One director elaborated, "I would like mentoring-partnerships formed with faculty to build a relationship, so students can rely upon faculty member over time. It supports [the] academic mission, connects people, supports relationships academic[ally] and personally." Another director expressed the need and urgency to "do grant writing and research" since the dean encourages "grants and engaging with faculty and faculty funding through grants."

In contrast, in the least successful category, programs reported to aspire to simply "more" of their present activities/goals, expressed variously as "more women, more degrees"; "more confidence within the students"; "more scholarships and recruiting"; "more extra schooling in summer programs"; and "more retention of the students" in science and engineering majors (Table 5).

Discussion and Conclusions

Programs in the most successful and least successful categories differ in ways in which issues of undergraduate women in science and engineering are defined and in ways in which these issues are approached and tackled. As these differences are associated with the respective growth trajectories in the percentage of degrees awarded to undergraduate women in science and engineering, the results may hold useful lessons for making future efforts more successful. In this study, two different types of programs emerged: "institutional/structural-centered" and "individual/student-centered" programs. The most

successful programs focused to a greater degree upon institutional structures—that is, characteristics and features of the institution and its units—both in perceiving the issues/problems and in addressing them. The least successful programs focused more on addressing women as individuals and on helping women students cope.

The "student-centered" programs tend to *adopt* the goals of the institution insofar as these institutional goals support the recruitment and retention of women undergraduate students in science and engineering fields. In doing so, these programs take a stance of "standing along side of" the institution and supporting the students—without challenging the ways in which the institution is organized and the ways in which education is conducted. In many cases, the rationale for the existence of a "student centered" program came down to maintaining a status quo: the program reflects well on the university and contributes to the recruitment and retention of students. This is in keeping with the organizational argument that institutional products, services, and programs can function as "powerful myths" as well as practical activities (Meyer and Rowan 1977).

The more structural-centered programs take a more active stance vis-à-vis the institutional environment, seeking broader scope, broader associations, and more extensive links and networks with faculty and administrators. Directors of programs in the most successful group were more likely to mention challenging, and even negative, aspects of their work, expressing accumulated frustration in attempts to alter faculty attitudes that may be biased against under-represented persons and groups. A key, however, is that these programs in the most successful group attempt to *adapt* the institutional environment to broader programmatic aspirations involving students' research activities, faculty "buy-in" for the program, and greater involvement in funded research. As stated above, the programs in the least successful group, in contrast, are more likely to *adopt* the institution's goals, by simply emphasizing recruitment and retention of women students. Thus, we found an interesting pattern reversal, rooted in views about women in academic science and engineering. The least successful programs were connected to their institutions by goal conformity, but they did not play a very active role within the organizational structure. The most successful programs, by contrast, were more critical of the institutional goals—and exhibited some goal divergence—but they were more active players within the organizational structure of higher education institutions.

The programs in the most successful category were more likely to regard public relations and collaboration with others as an important part of a director's job. "Communication comes in so strongly," pointed out one director, "because you must be able to engage in resistance" to the low participation of women in certain fields. The necessity of resistance was most commonly felt around issues of institutional support and collaboration with faculty. We observed particularly high frustration levels among the program directors in the most successful group with the most ambitious goals. Program directors in the most successful group expressed a deep concern with faculty interest and engagement in the program. Perceiving that increasing faculty involvement is an effective strategy for a program, those in the most successful category expressed that they wanted to "get to [the] faculty" by educating them about the program and by promoting faculty-student research.

A "critical stance" toward institutional structures sometimes came about through an evolution in programmatic focus. In a few cases, program directors in the most successful category acknowledged that through years of logistics and fundraising, their focus had changed from student-centered to structural-centered: "At first the focus was on helping the women cope. Then [we] realized the women were not the problem, the system was. This was an evolution in thought. We were scared, it felt overwhelming [to have] to

challenge [our] home base." It is also the case that directors in the most successful group of programs had higher average time (seniority) in the position: an average of 7.2 years in the most successful and an average of 2.4 years in the least successful group (even though the average starting year of the programs did not differ markedly between the two groups—1993 for the most, and 1994 for the least, successful programs). Thus, personnel continuity at the director level was associated with success, and one might consider it either a contributing factor to, or an effect of, that success. On the one hand, a longer-serving director could be assumed to accumulate relevant knowledge, expertise, and connections that might help the program flourish, whereas changes at the director position might lead to a certain amount of disruption and uncertainty. On the other hand, a program that is successful might create strong incentives for the director to stay with it and for the institution to keep the director, whereas a program with a problematic performance might constitute the opposite incentive.

Our results suggest that a key ingredient of successful programs is that they consciously and strategically position themselves within the structure of their institution and work toward systemic transformation and change. Simply constituting a type of programmatic support group for women, within existing structures, was not associated with success. Further, the environment surrounding programs for women in science and engineering is "layered" and not necessarily "friendly." Programs exist in a social and organizational context consisting of multiple tiers of departments, colleges, and universities, and a regional locale (Fox 1998, p. 218). Programs in the most successful group tended to have some relationship to or presence in a student's academic education and, hence, to departments. However, the programs were not necessarily popular among the academic scientists as seen from low participation rates of faculty and faculty's relative "detachment" from the goals of the programs. In addition, the broader university community often perceived programs skeptically. In the words of one director in the most successful group, people think, "you [the director] are promoting quotas," "you are the agitator," "[you are] seen as 'being in a niche'—not seen as part of a team in a broad institutional way." In these regards, the environment surrounding programs is "challenging," even for those in the most successful group.

The majority of the programs also communicated the need to assess their effectiveness. With the tightening of funding, the need to quantify the results becomes even more urgent. "The program needs to do a lot of documenting successes," noted one of the directors. "The Dean is an economic man. He likes to see numbers," explained another program director. In fact, almost all of the programs reporting to Deans or Provosts mentioned the importance of conducting studies and collecting statistics; and those programs in the most compared to least successful categories were more likely to report to the level of a dean or higher. Interestingly, while these programs were more likely to aspire to "adapt" (rather than to "adopt") features of their organizational environments, accountability through reporting was heightened among the most successful group.

In these ways, then, programs that focused on helping female students succeed within the existing institutional structure did not appear to contribute to raising the percentage of women among bachelor degree recipients. In contrast, an emphasis upon more structural or institutional features appears to have a positive effect on the women's proportion of undergraduate degrees in science and engineering. Structure-based approaches include the awareness of and attention to institutional climates, links between the program and other units within the institution, and the educational experiences relevant to students in sciences and engineering. The approaches of successful programs have implications, in turn, for potential strategies of programs, including the following recommendations:

(1) Redefining a program's issues, problems, and solutions in organizational terms: Some individually-based activities, such as peer-mentoring, may make women feel comfortable, but keep them isolated. Activities that focus upon building an integrative environment for women students, connecting them to continuing training and careers, may be the route to the students' successful persistence in scientific and engineering majors.
(2) Building supportive programs that connect the students to the larger environment and involve collaboration and alliances: Strategic alliances for programs involve partnerships with industry and alumnae that provide financial support and connections to continuing opportunities for women students. Other strategic alliances of the programs involve teaming with administrators and other persons and units in the institutions, such as centers for career development. Potentially important as well are student-faculty research and interaction, and courses offered on gender, culture, and science, and on mechanical devices and other "hands-on" engineering or technological activities.
(3) Assessing effectiveness to ensure accountability and documentation of the success of the program: Deans and administrators often seek justification that the program's operation makes a difference. Such inquiries put pressure on program directors to identify and select effective activities that are able to deliver positive results. The survival of a program may indeed depend on its ability to demonstrate its impact.

A potential consideration for our methodological approach of identifying most successful and least successful programs is that the trajectories of women's percentages might merely reflect random fluctuations and that, hence, particular programs have no influence on them. In that case, however, the two groups, most successful and least successful, would be populated by random programs, and there would be no reason to expect systematic differences between the two groups of programs. The fact that our findings did reveal meaningful differences suggests that the trajectories were not entirely random, and that differences in outcomes were indeed associated with the differences found between programs.

Yet, as always in correlational studies such as ours, no unequivocal inference of causality is possible. Successful programs may be successful because of some of the characteristics that they share; but, conversely, success might stimulate programs to develop certain characteristics. Lastly, it may also be the case that certain environmental and institutional conditions beneficial for women students in science and engineering, such as institutional leadership, both led to an accelerated growth in the percentage of women students and favored the creation of a certain type of program and certain ways of conceptualizing and tackling the issues. We surely recognize that the programs for undergraduate women did not originate or exist in a structural vacuum. The small number of cases also puts limits upon the generalizability of our findings. On the other hand, the ten (10) cases examined constitute about 20% of the total number of programs for undergraduate women in science and engineering in existence at the time of the study. Furthermore, the systematic selection of the two contrasting groups of most successful and least successful programs makes the contrasts discovered more consequential.

Thus, a prime conclusion that derives from the findings is that, for programs for undergraduate women in science and engineering, a more structure-based approach to the definition of the problem and to solutions posed appears to correspond with success. Positive outcomes, in increased growth in the percentage of undergraduate degrees awarded to women in science and engineering fields, were more likely to be associated with programs that regard issues, problems, and solutions of women in science and engineering as rooted in

features of the settings in which women are educated. For future research on programs for women in higher education, a continuing challenge is the identification and evaluation of particular structural/institutional reforms that hold the promise of boosting undergraduate women's participation and performance in science and engineering fields.

Acknowledgements The research reported here was supported by a grant from the National Science Foundation (SES-0080638). For research assistance, we thank especially Rachel Patterson.

Appendix 1

Differences Between the Post- and Pre-Program Slopes of the Percentage of Women Among Bachelor Degree Recipients Per Year

As explained in the "Method" section, our measure for identifying the five (5) "most successful" program institutions and the five (5) "least successful" program institutions was the difference between the pre- and post-program annual rates of growth in the percentage of women among bachelor's degree recipients. The following tables display the difference between post-program and pre-program regression slopes in the selected institutions (Because we were dealing with time-series data, PROC AUTOREG of the SAS statistical program was used to estimate the slopes). A difference of 1.4, for instance, means that the annual increase in the percentage of women degree recipients was 1.4 percentage points higher after the implementation of the program than before (e.g., 0.8% before and 2.2% after).

Table 6 Most successful programs

University	Difference between slopes
A University	3.73004
B University	2.1502
C University	1.44361
D University	1.37819
E University	1.36852

Table 7 Least successful programs

University	Difference between slopes
V University	−0.04722
W University	−0.11392
X University	−0.15799
Y University	−0.27214
Z University	−0.73427

A potential argument against the chosen measure of success might be that it would be distorted by some kind of a "ceiling effect." Thus, if programs are started when a large percentage of women is already present, one might suspect that the post-program growth rates could not greatly exceed the pre-program growth rates simply because the percentage of women cannot grow without bounds. However, a "ceiling effect" may be largely ruled

out for the following reasons. First, in our larger study of 499 institutions, we found linearly increasing percentages of women bachelor degree recipients in all fields during the study period—with ample room to grow and no sign of a collective ceiling effect. More specifically, we compared the strength of women's representation at the "most successful" and "least successful" institutions when their respective programs were started. In doing so, we used the residuals of regressions, for each field, of the percentage of women bachelor degree recipients on years (taking the average of all three fields for Women in Science and Engineering programs, the average of the two science fields for Women in Science programs, and the engineering residuals for Women in Engineering programs). By averaging the residuals for the year of program implementation and the year preceding it, we found that the average residual for the "least successful" institutions was −0.1 and for the "most successful" institutions, it was −2.2. This suggests that a ceiling effect was not a major factor for these institutions' ensuing trajectories. The "least successful" institutions were very close to average in terms of the percentage of women bachelor degree recipients and thus had ample room to grow; and the "most successful" institutions were slightly below average, but not to an extent that would, by itself, make plausible their following increases in the rates of women's percentages.

Appendix 2

Table 8 Summary of focal areas: emphases of the most successful and least successful programs for undergraduate women in science/engineering

Focal areas	Most successful	Least successful
Definition of problem	Under-representation and being a minority	Numbers of women participating
	Faculty issues, including "weed-out" orientation and lack of "pipeline of support"	Retention
Solution	Early start ("bridge") programs	Peer tutoring/mentoring
	Residence hall clusters, broad mentoring	Early start ("bridge") programs
New initiatives	Student research programs, hands-on research experience	Expand mentoring
		Expand early start programs
	Faculty buy-in and involvement	
Director's leadership characteristics needed	Person and organizationally-oriented: collaborative, resourceful, network-oriented	Person-oriented: approachable, nurturing, mentoring, warm, encouraging, interactive
	Science/engineering degree important: in relationship to college/institutions/ faculty	Science/engineering degree important: for understanding students
Relationship to context	Link with administration: issues of visibility, impact, and connection	Link with administration: issues of resources
	Link with faculty: difficult—and more "critical" stance to faculty	Link with faculty: difficult—and more "distant" stance
	Environment ↔ program	Environment → program
Aspirations/ directions	Expand range of scope: Form partnerships with faculty, undertake proposals and external funding	Increase magnitude of present emphases: More students, more retention, more bridge programs, more scholarships

References

Allen, C. (1999). Wiser women: Fostering undergraduate success in science and engineering with a residential program. *Journal of Women and Minorities in Science and Engineering, 5*, 266–277.

Astin, H. S., & Sax, L. J. (1996). Developing talent in undergraduate women. In C. S. Davis, A. Ginorio, C. Hollenshead, B. Lazarus, & P. Rayman (Eds.), *The equity equation: Fostering the advancement of women in the sciences, mathematics, and engineering*. San Francisco: Jossey-Bass.

Brainard, S. (1993). Student ownership: The key to successful invention programs. *Initiatives, 53*, 23–30.

Brainard, S., & Carlin, L. (1998). A six year longitudinal study of undergraduate women in science and engineering. *Journal of Engineering Education, 87*, 369–375.

Brainard, S., Kelly, J., & Wahl, P. (1993). National evaluation of existing women in engineering programs. Women in Engineering Program Advocates Network, Working paper 93–92.

Clewell, B. C., Anderson, B. T., & Thorpe, M. (1992). *Breaking the barriers: Helping female and minority students to succeed in mathematics and science*. San Francisco: Jossey-Bass.

Clewell, B., & Ficklen, M. (1986). *Improving minority retention in higher education: A search for effective institutional practices*. Princeton, NJ: Educational Testing Service.

Commission on Professionals in Science and Technology (CPST). (2006). *Professional women and minorities: A total human resources data compendium*. Washington, D.C.: CPST.

Cronin, C., & Roger, A. (1999). Theorizing progress: Women in science, engineering and technology in higher education. *Journal of Research in Science Teaching, 36*, 637–661.

Dietz, J. S., Anderson, B., & Katzenmeyer, C. (2002). Women and the crossroads of science: Thoughts on policy, research, and evaluation. *Journal of Women and Minorities in Science and Engineering, 8*, 395–408.

Fisher, J., Young, J., & Hein, J. (2000). Retaining women in the sciences: Evidence from Douglass College's project SUPER. *Journal of Women and Minorities in Science and Engineering, 6*, 349–372.

Fox, M. F. (1995). Women and scientific careers. In S. Jasanoff, G. Markle, J. Petersen, & T. Pinch (Eds.), *Handbook of science and technology studies*. In cooperation with the Society for Social Studies of Science. Newbury Park, California: Sage Publications.

Fox, M. F. (1996). Women, academia, and careers in science and engineering. In C. S. Davis, A. Ginorio, C. Hollenshead, B. Lazarus, & P. Rayman (Eds.), *The equity equation: Fostering the advancement of women in science, mathematics, and engineering*. A book supported by the Alfred Sloan Foundation. San Francisco, California: Jossey-Bass.

Fox, M. F. (1998). Women in science and engineering: Theory, practice, and policy in programs. *Signs: Journal of Women in Culture and Society, 24*(Autumn), 201–223.

Fox, M. F. (2001). Women, science, and academia: Graduate education and careers. *Gender & Society, 15*(October), 654–666.

Frehill, L. (1997). Education and occupational sex segregation: The decision to major in engineering. *The Sociological Quarterly, 38*, 225–249.

Goodman Research Group. (2002, April). *Final report of the women's experiences in college engineering (WECE) project*. Cambridge, Mass.

Hanson, S. (1996). *Lost talent: Women in the sciences*. Philadelphia: Temple University Press.

Knight, M. T., & Cunningham, C. (2004). Building a structure of support: An inside look at the structure of women in engineering programs. *Journal of Women and Minorities in Science and Engineering, 10*, 1–20.

Lagesen, V. A. (2007). The strength of numbers: Strategies to include women into computer science. *Social Studies of Science, 37/1*(February), 67–92.

Long, J. S., & Fox, M. F. (1995). Scientific careers: Universalism and particulularism. *Annual Review of Sociology, 21*, 45–71.

Margolis, J., & Fisher, A. (2002). *Unlocking the clubhouse: Women in computing*. Cambridge, Mass: MIT Press.

Matyas, M. L. (1991). Programs for women and minorities. In M. L. Matyas & S. M. Malcolm (Eds.), *Investing in human potential: Science and engineering at the crossroads* (pp. 67–96). Washington, D.C.: American Association for the Advancement of Science.

Matyas, M. L., & Dix, L. S. (Eds.). (1992). *Science and engineering programs: On target for women?*. Washington, D.C.: National Academy Press.

Merton, R. K. (1973a). The normative structure of science. In N. W. Storer (Ed.), *The sociology of science: Theoretical and empirical investigations* (pp. 267–278). Chicago: University of Chicago Press.

Merton, R. K. (1973b). Multiple discoveries as strategic research site. In N. W. Storer (Ed.), *The sociology of science: Theoretical and empirical investigations* (pp. 371–382). Chicago: University of Chicago Press.

Meyer, J. W., & Rowan, B. (1977). Institutionalized organizations: Formal structure as myth and ceremony. *American Journal of Sociology, 83*(Sept), 340–363.
Muller, C. (1992). The women in science project at Dartmouth. *Initiatives, 53*(Fall), 39–47.
Ong, M. (2005). Body projects of young women of color in physics: Intersections of gender, race, and science. *Social Problems, 52*, 593–617.
Pearson, W., & Fechter, A. (Eds.). (1994). *Who will do science? Educating the next generation*. Baltimore: Johns Hopkins University Press.
Platt, J. (2002). The history of the interview. In J. Gurbrium & J. A. Holstein (Eds.), *Handbook of interview research*. Thousand Oaks, California: Sage Publications.
Robinson, J. G., & McIlwee, J. (1989). Women in engineering: A promise unfulfilled? *Social Problems, 36*(December), 455–472.
Rosser, S. (1993). Female friendly science: Including women in curricular content and pedagogy. *Journal of General Education, 42*(1993), 190–220.
Seymour, E., & Hewitt, N. M. (1997). *Talking about leaving: Why undergraduates leave the sciences*. Boulder: Westview Press.
Sonnert, G., & Holton, G. (1995a). *Gender differences in science careers*. New Brunswick, New Jersey: Rutgers University Press.
Sonnert, G., & Holton, G. (1995b). *Who succeeds in science? The gender dimension*. New Brunswick, New Jersey: Rutgers University Press.
Stage, E. (1992). Interventions defined, implemented, and evaluated. In M. L. Matyas & L. S. Dix (Eds.), *Science and engineering programs: On target for women?* (pp. 15–26). Washington, D. C: National Academy Press.
Sturm, S. (2006). The architecture of inclusion: Advancing workplace equity in higher education. *Harvard Journal of Law and Gender, 29*(Summer), 247–334.
Weber, M. (1947). *The theory of social and economic organizations*. New York: Free Press.
Xie, Y., & Shauman, K. (2003). *Women in science: Career processes and outcomes*. Cambridge: Mass.: Harvard University Press.