Institutional Transformation and the Advancement of Women Faculty: The Case of Academic Science and Engineering

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Introduction

The participation, status, and advancement of women in academic science and engineering have been pressing social concerns in the United States, particularly over the past 25 years. The concern is rooted in two basic sets of issues: the provision of human resources for the science and engineering workforce, and social equity in access to and rewards for professional participation in these fields.

As human resources, women are important to the size, creativity, and diversity of the scientific and engineering workforce, broadly (Hanson, 1996; Pearson & Fechter, 1994). Women faculty, specifically, contribute to the culture and climate of the university and the development of students' capacities and potential in science and engineering—with potential consequences for future generations of scientists and engineers. The percentages of women faculty are positively associated with percentages of women students who are undergraduate majors in mathematical sciences (Sharpe & Sonnert, 1999), majors in science and engineering (Canes & Rosen, 1995), and majors and recipients of bachelor's degrees in life sciences, physical sciences, and engineering (Sonnert et al., 2007). This provides empirical support for the long-standing discussion about women faculty as "role models" for undergraduate women in scientific (and other) fields (Astin & Sax, 1996; Hackett et al., 1989; Stake & Noonan, 1983; Xie & Shauman, 1997).

In graduate education in science and engineering, women faculty are consequential because of whom they train and the ways in which they do so. In a survey of 1,215 faculty in doctoral granting departments in five science and engineering fields, women faculty reported acting as primary research advisors for a larger number of women graduate students than did men, and also had larger number of women students on their research teams. Further, women faculty put significantly more emphasis upon giving help to advisees across areas, not only in designing, executing, and publishing research but also in gaining social capacities, including participating in laboratory meetings, making presentations, and interacting with faculty (Fox, 2003a).

The status and advancement of women faculty in science and engineering is a pressing, national issue also because of related concerns of social equity (or inequity)

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in access to participation, and rewards gained, in science. This connects to an idealized "ethos of science," articulated over 60 years ago by Robert Merton (1942/ 1973), prescribing that scientists should be rewarded for contributions, with their "careers open to talent" and characteristics as race and gender, irrelevant for making claims and gaining rewards.[1] This system of belief continues to underlie the appeal for public support of science and helps justify the federal investment in science—although status and rewards in scientific employment do not accrue independently of gender, as discussed in this chapter and documented in a considerable stream of research (see reviews in Long & Fox, 1995; Sonnert & Holton, 1995; Zuckerman et al., 1991).

Women in academic science and engineering are a highly accomplished group who have already survived series of selection—both their own self-selection into scientific fields and selection by educational institutions. They have moved through the proverbial educational pipeline. They have completed doctoral degrees and have credentials for professional work. Yet the highest career attainments tend to elude this socially selective group. Across US four-year colleges and universities in 2003, women were still less than 10% of the full professors in mathematics, statistics, and physical sciences, and less than 5% of those at full rank in engineering. Life sciences have a higher proportion of women faculty, but even in these fields, women remain under 20% of the full professors (CPST, 2006: Table 4-50).

These relatively low proportions at full professorial rank—the rank associated with highest level of influence and decision-making in academia—exist despite the increase in women's share of doctoral degrees in scientific fields, and the passage of time for women to mature in professional years and experience. In life sciences, the proportion of doctoral degrees awarded to women rose from 18% in the decade of the 1970s, to 29% in the 1980s, and 38% in the 1990s (CPST, 2006: Table 3-27). In the mathematical, physical, and environmental sciences, women's proportions of doctoral degrees are lower than in life sciences; but across these fields, women's share of doctoral degrees was 8% in the 1970s, 15% in the 1980s, and 21% in the 1990s (CPST, 2006: calculated from Table 3-27).

These patterns raise issues about the nature of the problem of women's relatively slow and low attainment of full rank, and the solutions that may be applied to improve the advancement of women faculty in academic science and engineering. This chapter addresses these issues by:

1. Presenting a rationale for scientific fields, particularly, as a critical research site for understanding both gender and status, and higher education in the United States

[1] This ethos maintains that science is governed by "universalistic" norms—that is, norms and standards that operate apart from characteristics of persons (race, gender, national origin). The universalism is contrasted with "particularism," relations governed by "particular properties" of persons (Merton, 1942/ 1973). Science has been characterized both as an institution in which universalism operates and one in which universalistic standards fall short (see Cole, 1992, pp. 157–176; Mitroff, 1974; and Mulkay, 1976 for reviews of the debate). Whether inequality in science is *equitable* or *inequitable* depends upon the extent to which it may be explained by normatively justifiable criteria, generally merit- or achievement-based standards (see Long & Fox, 1995).

2. Summarizing perspectives on women's stalled advancement in academic science, and implications for solutions taken
3. Addressing "institutional transformation," as a concept in the study of higher education, broadly, and as an organized initiative of the National Science Foundation ADVANCE program
4. In conclusion, considering both the prospects for, and limits upon, institutional transformation as a strategy for the advancement of women in academic science and engineering.

Science as a Focal Research Site in the Study of Gender and Higher Education

In the study of gender and status, scientific fields are a focal research site.[2] This is because of the hierarchical nature of gendered relations, generally, and because of the hierarchy of science, particularly. Relations of gender are hierarchical because women and men are not social groups that are categorized—and distinguished from each other—neutrally. Rather, women and men are differentially ranked and evaluated, usually according to masculine norms or valued standards. Science, in turn, is fundamentally hierarchical. Gender relations are reflected in and also reinforced by participation and status in science. Because science is a powerful institution, it mirrors and expands gender stratification. Science is a critical and powerful social institution in the following key ways.

First, science is an agent of power, with consequences for the present and future human condition (see also Cockburn, 1985; Wajcman, 1991). Grounded in abstract and systematic theory and rationality, science is a prototype of professional claim to "authoritative knowledge" (Fox & Braxton, 1994, p. 374). Science defines what is "taken for granted" in daily lives and activities by literally billions of people (Cozzens & Woodhouse, 1995, p. 551). To be in control of science is to be involved in directing the future, and this is highly valued (Wajcman, 1991, p. 144).

Second, science connects with mighty institutions, especially education and the state. Mathematics, integral to science, operates as a key filter subject in progression to continuing educational levels, as Latin once operated as a filter

[2] Science comprises the eight classifications of the National Science Foundation/National Research Council: physical, mathematical, computer, environmental, life, and engineering, as well as the psychological and social sciences. In this chapter, sciences refer primarily to the first six of these fields, excluding psychology and social sciences—which are, in turn, the focus of the NSF ADVANCE initiative, analyzed subsequently. In this chapter, the short-hand term, "science" or "scientific fields" is sometimes used; and at other times, the term, "science and engineering" is used. The framework presented here on gender, science, and higher education draws from, and is discussed in more detail in Fox, 1999.

subject, when the church controlled education. By the eighteenth century, the church had lost its dominance over education, and Latin began to give way, initially to philosophy and logic, and then to science and mathematics as prominent subjects. Science and mathematics began to function as "proofs of competence" and a means of upward social and occupational mobility, based upon meritocratic performance (see Artz, 1966, pp. 66–67; Hacker, 1989, pp. 60–66; Noble, 1977, pp. 20–32; Schneider, 1981). In the process, mathematics and quantitative tests (standardized admissions tests [SAT] and graduate record exams [GRE], for examples) came to serve as important filters in continuing educational progression (Hacker, 1990, p. 141).

As with education, a strong connection exists between science and the political order, pointing to science as an agent of power. The root is this: science costs, and the government finances. The state, in turn, has a strong stake in science. Science is supported largely through public funds, distributed through federal agencies. Under the "social contract for science"—an arrangement originally outlined by Vannevar Bush in 1945—the federal government provides funds for basic research and scientific training, and agrees not to interfere with scientific decision-making, in exchange for unspecified benefits to the public good expected to result ultimately from science. In practice, however, scientific research is shaped by the interests of both scientists and the federal sponsors and funders of science. The shaping of scientific research by sponsors and by public and congressional constituencies is manifest in areas such as oceanography, funded by the Office of Naval Research, and "the war on cancer" and research attention to AIDS and to Alzheimer's disease, funded by National Institutes of Health. Particularly telling of the relationship between science and the state is that scientific products and research achievements have been taken as gauges of national resourcefulness, power, and prestige. Scientific progress is considered to be in "the national interest."

Third, and in keeping with its hierarchical features, science is marked by immense inequality in status and rewards (Zuckerman, 1988, pp. 526–527), and values ascribed to science, such as rationality and control, have been more ascribed to men than to women (Keller, 1985, 1995). As stated earlier, science is a focal and strategic site for the study of gender because it both reflects and reinforces the hierarchical relations of gender. In academic science, this gender stratification is manifest in women's compared to men's greater concentration in four year and two year colleges (compared to universities and medical schools), location in lower academic ranks, lower publication productivity, and lower salaries (see Cole, 1979; Fox, 1999, 2001; Long, 2001; Long et al., 1993; Long & Fox, 1995; Reskin, 1978a; Sonnert & Holton, 1995; Ward & Grant, 1996; Xie & Shauman, 2003). In this chapter, the focus is upon rank and advancement in rank, as key dimensions of the status of academic women in science and engineering.

Finally and importantly, science is critical to the study of higher education because science has shaped the development of the modern, complex university. In order to understand higher education, and in turn, faculty within higher education, one needs to understand science, as depicted in the following section.

Science and Higher Education: Reciprocal Developments in the United States

In the United States, science and higher education have evolved as "reciprocal developments." Science played a major role in transforming the college of the early nineteenth century into the modern university, and science may be regarded still as a force shaping the characteristics of the university. The reciprocal effects of science and academia have been in at least three areas.[3]

First, from the mid-nineteenth century onward, science was a force breaking up the generalist, classical curriculum of the old college tradition, which, based largely upon religion, prepared young men for the ministry, law, or leadership positions in government service. In the mid-nineteenth century, two events consequential to science and higher education occurred in the US: the passage of the Morrill Land-Grant Act and the establishment of experimental stations for agricultural research.

The Morrill Act, first introduced to Congress in 1857 and re-introduced, passed by Congress and signed into law by President Lincoln in 1862, provided to states grants of federal land to use for the founding of colleges devoted to agriculture and mechanical arts. This "infusion of land and capital" (Montgomery, 1994, p. 113) established state colleges, which later became universities, throughout the nation. In ushering this bill into law, Representative Justin Morrill of Maine raised a political specter of "national competitiveness" that would be heard time and again throughout the following, twentieth century—the threat of Russian dominance in education: "[in Russia] we find a despotism … placing it within the power of her agriculturalists and artisans to become educated and skillful, while our people with government in their own hands, parley to the brink, and do nothing for their own benefit" (quoted in Wolfle, 1972, p. 52).

In the same year (1862) that the Morrill Act was passed, the federal Department of Agriculture was founded, and agricultural experimental stations, under the direction of the newly established state colleges, boosted scientific research through the study of agricultural problems—soils, crops, fermentation, and entomology. The stations increased public support for the state colleges and universities by working on issues of political and economic concern to the states, but the stations also undertook basic research in genetics, physiology, and other life sciences (Wolfle, 1972, p. 56).

These developments helped shepherd into US higher education specialized curriculum, lectures, seminars, and independent work. Eventually, this new education largely replaced the traditional, classical education of canonical literature and philosophy, and pedagogy emphasizing drill and recitation (Fallon, 1980; Montgomery, 1994; Wolfle, 1972).

Second, sciences paved the way for graduate education across fields. The first doctorate awarded in America was in science from the Sheffield School of Scientific Study of

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[3] This analysis of the "reciprocal developments" of science and higher education draws in part from Fox, 1996.

Yale in 1861. In the next 20 years, 14 of 20 (that is, 70%) doctorates awarded in the United States were in scientific fields (Wolfle, 1972, p. 89). In the process, the generalist "natural scientist" gave way to botanists, zoologists, and geologists, and "natural philosophy" to chemistry and physics. This had consequences for specialization and graduate education, and for hiring based upon specialized qualifications (Wolfle, 1972, p. 87). As graduate work spread to other fields, the proportion of doctoral degrees awarded in science fields declined, although the sheer number of science degrees increased. Between 1911 and 1945, the physical and natural sciences accounted for 45% of doctorates awarded (Wolfle, 1972, p. 89). Additionally, the first post-doctoral appointments in the US, established by the Rockefeller Foundation and the National Research Council in 1919, were limited to mathematics, physics, and chemistry. In the first dozen years of these post-doctoral programs, 80% of those who completed these fellowships took academic appointments at US universities (Geiger, 1993, pp. 248–249).

In like manner, sciences led the way in securing federal support for research and training. This partnership of higher education and the federal government began in agricultural colleges, spread to other scientific fields, and filtered down throughout the university. The "filtering" was not passive flow. Scientists did not merely set a pattern adopted by other (nonscientific) fields; rather, they played leading roles in establishing the pace, including holding important positions in the development of federal agencies for the arts and humanities. The pattern was to create a line of development in science and extend it to psychology, the social sciences, humanities, and then the arts (Wolfle, 1972, p. 91).

Third, with specialization, federal support for research, and winning of autonomy in research,[4] forces largely related to developments of science, the university became decentralized, even fragmented. Power in appointments and control of research funds moved away from central administration toward departments. Such decentralization came to define the complex university which continues to dominate higher education in the United States.

None of this happened without conflict and opposition (Montgomery, 1994), and current tensions in faculty roles and the ambivalence of institutional functions in higher education reflect a history of strain between teaching and research, particularly (Fox, 1992a, pp. 301–302). However from mid-nineteenth century onward, higher education did transform from the generalist curriculum of the college tradition as described, and scientists were largely responsible for the characteristic features of the modern university. Accordingly, within higher education and for the public support underlying it, science became a model (albeit sometimes faltering) of research expertise, a standard for research training and apprenticeship, and often a continuing gauge of national economic competitiveness, military defense, and power and prestige (Montgomery, 1994).

The US model of university-based scientific research—which has continued to evolve more recently with extended ties between universities and industry

[4] Of the original (1915) council of the American Association of University Professors on Academic Freedom and Academic Tenure, seventeen of the twenty eight members were scientists or social scientists (Wolfle, 1972, p. 91).

(Dietz & Bozeman, 2005; Slaughter & Leslie, 1997; Slaughter & Rhoades, 2004)—contrasts with the greater importance that European nations have placed upon independent research institutes as central homes of science. In Germany, for example, basic and applied research is conducted in independent institutes, as well as in universities. The Max Planck Society for the advancement of science, founded in 1948, undertakes basic research, especially within "new and innovative research areas," in natural, life, and social sciences. The Society supports 80 research institutes with a total of over 12,000 staff members, and 9,000 doctoral students, post-doctoral students, guest scientists and researchers, and student assistants as of 2007. The institutes emphasize "autonomous and independent" research carried out within the scope set by Society.[5] Notable also are the Helmholtz Association, formed in Germany in 1958, and now constituting 15 research centers in core areas of energy, earth/atmosphere, health, transport and space; and the Fraunhofter-Gesselschaft which undertakes applied scientific research in 56 institutes in Germany, making it the largest organization for applied research in Europe.[6]

The Status and Advancement of Women Faculty in Science and Engineering: Perspectives and Connection to Institutional Transformation

In accounting for the depressed rank and advancement of women in academic science and engineering, the explanations have centered on the role of individual characteristics of the women and on the role of organizational features of the settings in which women are educated and work, constituting perspectives that may be termed "individualistic" compared to "organizational/institutional" (Cronin & Roger, 1999; Fox, 1996, 1998, 2001, 2006a; Robinson & Mcllwee, 1989; Sonnert & Holton, 1995).

Individual characteristics of women play a part in explaining the status of women in academic science. But the individual characteristics do not exist in a social vacuum, and by themselves, do not explain the status of women in academic science. For example, no direct relationship has been found between measured creative ability or intelligence and research productivity among scientists (with implications, in turn, for advancement) (Andrews, 1976; Cole & Cole, 1973). Rather, organizational conditions in the workplace, such as autonomy and availability of human and material resources, are important (Damanpour, 1991; Glynn, 1996). The

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[5] "Research for the Future—the Mission Statement of the Max Planck Society" is on-line at: http://www.mpg.de/english/portal/index.html.

[6] The History and Mission of the German Helmholtz Association is on-line at http://www.helmholtz.de/ "Driving Force in Innovation," the statement of the Fraunhofer-Gesselschaft, is on-line at http://www.fraunhofer.de/fhg/EN/company/index.jsp.

presence, compared to absence, of these conditions may enhance (or alternatively, block) the translation of individuals' creative characteristics into productive or innovative outcomes or products. In addition, although women scientists' career attainments (including rank) are lower than that of men scientists, their measured intelligence (IQ) is higher, suggesting that, intellectually, women in scientific fields are an even more selective group than men (Cole, 1979). In prestige of doctoral origins as well, women do not obtain degrees from lower-ranking institutions than do men. Both men and women scientists are as apt to have received doctoral degrees from top-ranking universities (Fox, 1995, p. 217).

Family and household statuses are individual characteristics of scientists that have received scholarly, as well as popular, attention. The conventional wisdom is that good scientists are either men with wives, or women without husbands or children (Bruer, 1984). However, the data contradicts the mythology. Although marriage has been found to affect negatively the rank and salary of academic women, the effects are significant only in the case of salary for those in research universities (Ahern & Scott, 1981). Among biochemists, marriage has been reported to have positive effect on being promoted from assistant to associate professor rank for both women and men; and for promotion to the rank of full professor, marriage had no effect (Long et al., 1993).

Further, in studies across physical, biological, and social sciences, married women have been found to publish more than women who are not married (Astin & Davis, 1985; Cole & Zuckerman, 1987; Fox, 2005; Helmreich et al., 1980; Kyvik, 1990). Moreover, among samples of academic scientists, the presence of children had either no effect on women's publication productivity (Cole & Zuckerman, 1987), a slightly, negative, nonsignificant effect (Reskin, 1978a; Long, 1990), or a positive effect (Astin & Davis, 1985; Fox, 2005; Fox & Faver, 1985).

It is important to emphasize, however, that these data do not indicate that marriage and parenthood have no effect upon academic women in science and engineering. Family circumstances can have a multitude of effects in personal sacrifices as well as rewards and extraordinary accommodations made among women scientists (Grant et al., 2000). What the data indicate is that marriage and parenthood do not negatively affect advancement in rank and publication productivity among those who hold academic positions (at the time data are collected in the studies). Family demands may take their toll along the way, through graduate school and early career, so that a proportion of women are eliminated from scientific careers and do not fall into cross-sectional data of professional, employed scientists (Long, 1987).[7]

In understanding the status and advancement of women faculty in science and engineering, it is important to look to features of the organizations in which academics

[7] Thus, as discussed subsequently, work-family practices and policies can support the participation of women in science.

are educated and work. Women's status in academic science and engineering is not a simple function of their individual characteristics, including background, aptitude, attitudes, and ability. Rather it is a consequence also of complex factors of their organizational environments—characteristics and practices of the settings in which they study and work, including evaluative practices, access to human and material resources, and patterns of inclusion and exclusion (see Fox, 1991, 1992b, 1998, 2000, 2001, 2003a, 2005, 2006a; Fox & Mohapatra, 2007; Long & McGinnis, 1981; Reskin, 1978b).

Organizational settings are important in understanding the status and advancement of men and women—across occupations. But they are especially important in fields of science. This is because scientific work is fundamentally social and organizational. It is carried out "on site" with costly space, instrumentation, and equipment; is conducted in cooperation with students and others; requires significant funding; and in short, is an interdependent enterprise. Compared to sciences, the humanities, for example, are more likely to be performed solo rather than as teamwork; to be carried out in the absence of equipment and instrumentation; to require modest funding; and to be more individually-based activities (Fox, 1991, 1992b).

More so than men, women in academic science are outside of the networks in which human and material resources circulate. In graduate education, for example, men and women are as likely to obtain degrees from prestigious universities, as indicated above. However, women and men graduate students report different experiences in their departments, in research groups, and with their advisors, encompassing matters of inclusion and exclusion, and nuances of training. Responses from a national survey of 3,300 doctoral students in five science and engineering departments indicate that women are (1) less likely to believe that they are taken seriously by faculty and respected by faculty; (2) less comfortable speaking in research team meetings; (3) less likely to report receiving help from faculty in learning to write grants proposals and publish papers; and (4) more likely to view their relationship with their advisor as one of "student-and-faculty" compared to "mentor-mentee" or "colleagues" (Fox, 2001). Such factors, in turn, suggest differential opportunities to gain significant, sustained roles in the scientific enterprise.

In keeping with this, a recent survey of all women faculty and a stratified random sample of men faculty in four colleges at Georgia Institute of Technology (Georgia Tech), a leading scientific and technological institution, points to gender differentiation in departmental work environments, as experienced by women and men faculty. Notably, women report less frequent interaction around research with faculty in their home units; 30% of men, compared to 13% of women, report speaking daily about research with faculty in their home unit (Fox, 2003b). This may be a function of access and opportunity, and socially-conditioned "preferences," of one gender group compared to the other.

Speaking about research is an important dimension of scientific work, as it operates in departmental units. This is because face-to-face interaction with colleagues helps to generate and support research activity. Ongoing, informal discussion about research problems encountered and progress made activates interests, test ideas, and reinforces the work (Blau, 1973; Reskin, 1978b; Pelz & Andrews, 1976). In a study of 200 research initiatives, Garvey (1979) found that less than 15% of initial ideas for papers originated from journal articles or presentations at professional meetings; rather the projects got their start from informal networks of information and discussion. Compared to formal communication, informal exchange also provides more room for speculation, retraction, and sharing of failures as well as successes. Those located outside of circles of communication, interaction, and exchange are then limited in means of testing and developing ideas (Fox, 1991).

Collaboration is central to the work of science. Most scientific research is, in fact, collaborative and the publications are coauthored. Women and men in science are as likely to coauthor their publications (Cole & Zuckerman, 1987). But the issue may be more subtle than simply the rates of collaboration and coauthorship. Even when women publish coauthored work, they may have more difficulty finding and establishing collaborators, and may have fewer collaborators available to them (and in turn, may then work with a more narrow range of persons) (Long, 1992). Accordingly, the survey of faculty at Georgia Tech indicates that women and men faculty are as likely to report that they have colleagues in their home unit who work in a research-area related to their own; but women are less likely than men to report that that the faculty are "willing" to collaborate to them (Fox, 2003b).

This leads to consideration of publication productivity. In analysis of gender, status, and advancement in science, publication productivity is important for two reasons. First publication is the central social process of science, the way in which research is communicated, verified, and archived, and the way in which scientific priority is established (Fox, 1983, 1985; Merton, 1973; Mullins, 1973). Second, until we understand productivity differences, we cannot adequately address gender differences in rank and advancement, which are related to—but not wholly explained by—publication productivity. Although the gender gap in publications has been narrowing recently in biological and social sciences, women publish less than men, especially in physical sciences (see Creamer, 1998; Long & Fox, 1995; Long, 2001; Sonnert & Holton, 1995; Ward & Grant, 1996). Women's depressed publication productivity is both cause *and* effect of their career attainments. That is, it both reflects women's location in lower ranks, and it partially accounts for it. "Partially" is a key term: holding constant levels of publication productivity, women's advancement in rank remains lower than men's. Although understanding is incomplete of the underlying processes, women are promoted at lower and slower rates, after controlling for numbers of articles published and citations to articles (Cole, 1979; Long et al., 1993; Long & Fox, 1995; Sonnert & Holton, 1995). This holds among different types of institutions, varying in levels of prestige.

For these sets of reasons, the status and advancement of women in academic science and engineering are organizational issues—and as such, they are subject to organizational transformation (Fox & Colatrella, 2006). Consequential, in turn, are the concept and meaning of "institutional transformation" and the factors that facilitate transformation of higher education institutions, addressed in the following section.

Institutional Transformation: Meaning and Facilitating Factors

Institutional "transformation" is not merely institutional "change." Transformation involves *planned* alterations in core elements of the institution: authority, goals, decision-making, practices, and policies (Levy & Merry, 1986; Nutt & Backoff, 1997). Thus, transformation has been referred to variously as "quantum change," "second-order change," "large-scale change," and "strategic reorientation" (Wischnevsky & Damanpour, 2006, p. 104).

Based upon definitions and descriptions in eighteen studies of change compared to planned transformation, Levy and Merry (1986) characterize institutional transformation as: (1) deliberate, purposeful, and explicit; (2) a "process" of alteration; (3) engaging external or internal expertise; and (4) involving a strategy of collaboration and power sharing between the experts and others (Tables 1.1–1.2, pp. 1–9). Transformation then has consequences for an institution's purpose, goals, and directions and its functional processes in organizational structure, management and leadership, reward structures, and communication patterns (Levy & Merry, 1986).

Organizational research also emphasizes that transformation involves radical alteration not just in traditional practices or "ways of doing business," but also "ways of thinking" that alter taken-for-granted customs, norms, and rules. Summarizing 13 studies of transformation, primarily within business-settings, Nutt and Backoff (1997) point to transformative ways of thinking that involve "visions of a desired future," "visionary possibilities," and coherent changes that help to specify what it means to think about clients or customers, products, services, or strategic alliances in ways that "break away from traditional thinking."

The concept and study of institutional transformation, applied to higher education, specifically, have resulted a national project sponsored by the Kellogg Foundation and three reports, two published by the Higher Education Research Institute of the University of California-Lost Angeles (Astin & Associates, 2001; Astin & Astin, 2001), and a third report of the Kellogg Forum on Higher Education Transformation (Burkhardt, 2002). The definition and core strategies of transformation in higher education, especially as related to dimensions of organizational culture, are analyzed and published in a volume by Eckel and Kezar (2003a), and are addressed in a range of other representative articles (Eckel & Kezar, 2003b; Gioia & Thomas, 1996; Kezar & Eckel, 2002; Hearn, 1996; Neave, 2004).

Applied to higher education, transformation is characterized as change that is: (1) systemic, (2) deep, (3) intentional, and (4) cultural (Astin & Associates, 2001; Burkhardt, 2002; Eckel & Kezar, 2003a).

1. Systemic change involves alteration in the range of functioning parts of the institution. These functioning parts are connected, and change in one area/part has implications for change in other parts of the organization. The systemic parts or elements, subject to inter-connected transformation, may include, for example, fiscal policies, personnel policies and practices, faculty development, recruitment and admissions, advising, and publications (Burkhardt, 2002, p. 120). Creating systemic change is more complex than effecting an isolated change. Changes

attempted in any significant part of the institution result in stresses and tensions in connections to other parts of the institution; and unless these tensions are resolved in the connected elements, they are likely to result in resistance to change (Astin & Associates, 2001). Owing to its systemic feature, transformation is slow, challenging, and often unpredictable (Burkhardt, 2002).

2. Transformation is deep to the extent that it affects values and assumptions, as well as structures and processes in higher education. Transformation that is deep involves values and beliefs of individuals and groups, with implications for the ways that teaching, advising, research, and service are conducted by individuals and by departments and programs, more collectively. This feature of transformation is sometimes specified as both "interior" and "exterior." "Interior" beliefs, values, and intents affect any effort of transformation in higher education. Thus, if reformers make significant changes in "exterior" programs or policies, changes in the programs and policies need to be accompanied also by changes in individuals' and groups' shared ("interior") values and beliefs (Astin & Associates, 2001).
3. Transformation is intentional because it involves deliberate and purposeful decision making about institutional actions and directions. The details of such a plan will evolve over time, however, and are subject to external pressures that may come from federal, state, and/or private funding, and accrediting bodies.
4. Finally, transformation of higher education is cultural because it involves changing institutional cultures, that is, the dominant and prevailing patterns of assumptions, ideologies, and beliefs that people have about their organization and that shape their attitudes, priorities, and actions regarding teaching, research, and service (Eckel & Kezar, 2003a, pp. 27–28). Thus, an institution cannot transform without altering parts of its culture; and reciprocally, characteristics of a current institutional culture will place constraints upon the nature and extent of institutional transformation that is feasible. Further, because aspects of the culture of higher education institutions are shaped by external factors (such as the federal economy) over which "reformers" may have little control, it is unlikely that transformation will lead to a entirely "new culture" within the institution (Eckel & Kezer, 2003a, p. 27).

What, in turn, then are some of the key factors that help to facilitate transformation in higher education? First, leadership is critical because leaders shape organizational visions, send institutional signals and messages, and have power to implement change (Fox, 2006b). In academic institutions, the support of central administration is frequently indispensable for transformation because high-level administrators can make decisions, set policy, convene groups, and allocate resources in favor of transformation (for examples, see Asmar, 2004; Lindman & Tahamont, 2006).

Leaders in central administration are also well-positioned to use the institution's stated mission and values to generate awareness and support of, and involvement in, transformation (Burkhardt, 2002, p. 132). This approach may be subtle as it is in citing the discrepancies between "stated" or "espoused" values and actual institutional policies and practices, and the way in which the transformation aims to reconcile the two—for example, by citing discrepancies between values of broad participation and design of the curriculum, and then bringing democratic participation into the design of the work (Astin & Associates, 2001, pp. 32–33). "Motivating visions," in turn, are potentially important because institutional transformation incurs risk and uncertainties, and a vision can provide a blue-print and compass toward something that is new, but uncertain (Eckel & Kezar, 2003a, p. 77).

The administrative role of the president and/or provost is probably indispensable at the start-up or initiation of transformation, but it may be unwise to depend indefinitely upon administrators as change-agents (Astin & Associates, 2001). Research universities (and other settings) tend to be strongly influenced by the professional and expert authority of the faculty, and this makes partnership with faculty important for the impetus and impact of upper-level, administrative decision-making (Birnbaum, 1992).

In fact, a second key facilitator of transformation is identifying stakeholders throughout an institution who may be involved in designing and implementing activities for the process of transformation. This, in turn, heightens commitment, empowerment, and engagement in the process of transformation (Eckel & Kezar, 2003a, pp. 76–77). Such involvement may be accomplished in a range of modes including retreats, seminars, symposia, and focused discussions, and through the use of newsletters, talks, taskforce reports, and email notes and announcements (Burkhardt, 2002; Eckel & Kezar, 2003a). The aim is not simply disseminating information about the initiative of change, but also obtaining feedback from members of the institutional community (Astin & Associates, 2001, p. 32).

Effective networks for institutional innovation are supported through specific means including: (1) coalitions developed among persons at various ranks within the organization who can help steer the process of change and develop commitment to change; (2) early and continuing information conveyed about the need for change and the steps to ensure change, without adverse consequences for faculty, students, and administrators; and (3) training made available for participation in institutional innovation (Daft, 2004, pp. 426–428).

Third, institutional transformation is facilitated by positive incentives that support innovative behavior and practices. An institutional reward structure can enhance transformation by reducing individuals' risk and resistance, aligning individuals' efforts toward transformation through positive recognition and rewards (salary, advancement) (Fox, 2006b). Institutional transformation is enhanced when the desired innovations undertaken "count" for individuals as well as for the institution at large; and when the institution's criteria for evaluation are clear (Fox et al., 2007; Whitman & Weiss, 1982).

Fourth, transformation is enhanced by generating support outside of the institution. Toward this, a key strategy has been obtaining grants from respected agencies and foundations, which provide both material and symbolic support (Astin & Associates, 2001). External consultants and advisory boards can also provide outside credibility for the planned change, and advisory boards can offer fresh perspectives and advice, and act as a sounding board for the changes planned (Burkhardt, 2002, pp. 133–134). In addition, peer institutions engaged in similar efforts of transformation can enhance each others' efforts by sharing resources, agreeing to implement common assessment procedures, and by having collective training and discussion sessions (Astin & Associates, 2001, p. 33).

Finally, long-term investment is key to transformation. Transformation requires focus and attention over a continuing period of time in order to implement and maintain change that is intentional, systemic, deep, and cultural. Efforts of institutional transformation often fail because leadership and incentives, and other key components for transformation, are present for a short-phase, rather than for the sustained years required (Eckel & Kezar, 2003, p. 77).

NSF ADVANCE: Initiative for Institutional Transformation for the Advancement of Women Faculty in Science and Engineering

In 2001, the National Science Foundation (NSF) released a call for proposals for a new program, called ADVANCE, with the goal to "increase the representation and advancement of women in academic science and engineering careers, thereby contributing to the development of a more diverse science and engineering workforce" (NSF program solicitation 01-69). The rationale stated for this program was that:

> Pursuit of new scientific and engineering knowledge and its use in service to society requires the talent, perspectives, and insight that can only be assured by increasing diversity in the science, engineering and technological workforce. Despite advances made in the proportion of women choosing to pursue science and engineering careers, women continue to be significantly underrepresented in all science and engineering fields (NSF program solicitation 01-69, p. 3).

In this solicitation, three types of awards were announced: Fellows Awards to establish independent research careers, Leadership Awards to recognize outstanding contributions made by organizations or individuals for the increased participation and advancement of women in academic science and engineering careers, and Institutional Transformation Awards to support the increased participation and advancement of women scientists and engineers in academe. Of these, the largest investment ($3–4 million per institution awarded) was made for the Institutional Transformation Awards—constituting a new approach within NSF funding to support advancement of women in science and engineering.[8]

How and why did NSF come to pursue institutional transformation as an award program? Created in 1950 as a federal agency awarding competitive grants for research and education in science and engineering fields, NSF has had a long-standing commitment to assure that "there will always be plenty of skilled people available to work in new and emerging scientific, engineering and technological fields, and plenty of capable teachers to educate the next generation" (NSF, 2007). In 1980, the Science and Technology Equal Opportunity Act, enacted by Congress, mandated that NSF

[8] Three solicitations for Institutional Transformation Awards followed, one in 2002 (NSF 02-121), another in 2005 (NSF 05-584), and a third in 2007 (NSF 07-582).

collect and report data on women and minorities in science and engineering. Biennial NSF reports on “women and minorities in science and engineering” (later including also “persons with disabilities”) appeared, beginning in 1982.

In the 1980s, NSF also undertook initiatives to address the underrepresentation of women through Career Advancement Awards for individual women to develop and pursue their research programs, and Visiting Professorships for Women to expose women faculty in science and engineering to research experiences and approaches outside of their home universities. The Visiting Professorships also had a component for about a third of the awardees’ time and effort to be devoted to attracting and retaining women scientists and engineers at the institutions visited. In 1996, NSF replaced the Visiting Professorships with the Professional Opportunities for Women in Research and Education to provide awards for women’s career advancement and to provide greater visibility for women scientists and engineers in academic settings. Each of these programs of the 1980s and 1990s focused upon awards made to individual women, principally for support of their research programs in science and engineering (Rosser & Lane, 2002, pp. 328–332).

In 1999, Joseph Bordogna, then Deputy Director of the NSF, convened a group called the ADVANCE Coordinating Committee, organized in response to an assessment of the impact of NSF’s programs focusing upon women in science and engineering and a concern about the continuing, significant underrepresentation of women in science and engineering, especially in high-ranked positions in academia. This working group, chaired by Alice Hogan, concluded that it would be difficult to enable the advancement of women without changing the settings in which they work. The conclusion was supported by “academic research accumulated to produce a shared understanding of gender bias’s structural and cultural underpinnings” (Sturm, 2006, p. 276). Thus, the NSF ADVANCE program was established, with Alice Hogan as the founding program director. The first solicitation, posted in 2001, pointed to “institutional information” in this way:

> There is increasing recognition that the lack of women’s full participation at the senior level of academe is often a systemic consequence of academic culture. To catalyze change will transform academic environments in ways that enhance the participation and advancement of women in science and engineering, NSF seeks proposals for institutional transformation (NSF program solicitation 01-69, p. 8).

NSF Initiatives of Institutional Transformation Among the First Two Rounds of Awardees: Emphases and Range

In the first two rounds of awards (2001–06, 2002–07), institutional transformation grants were made to 19 institutions.[9] Based upon the websites of these institutions and their annual reports to NSF (posted on the respective websites), I coded the

[9] The initiatives of the 2005 awards are not addressed in this chapter, because the awards are recent and the initiatives not yet developed and fully depicted on-line.

central initiatives undertaken in the past five to six years by each of these (19) institutions. The aim of this method is to depict the emphases and range in the initiatives involving: (1) fundamental structures (leadership, work-family arrangements, tenure and promotion); (2) faculty composition (recruitment, retention); (3) internal networks of education, communication, networking, and material resources (for faculty; for departments); (4) other internal networks; and (5) networks of external supporters (Table 1).

This is not an “evaluation” of the NSF ADVANCE initiatives; the ways and means for such an undertaking are neither available nor within the scope of this chapter. Rather, the focus here is upon the description of the patterns of the ADVANCE initiatives, and ways that they correspond to what is known about key dimensions and facilitating factors of transformation in higher education, as described in the previous section of this chapter.

The vast (84%) majority of these sites have leadership initiatives as a type of structural initiative; in fact, of all types of initiatives for transformation, those addressing leaderships are the most common (Fig. 1). In four of the institutions, leadership initiatives include ADVANCE professors or chairs. These professors participate in leadership teams for institutional transformation, bring awareness of gender equity to the campus, communicate goals of advancement within their colleges and throughout the institution, provide feedback to administrators, and also undertake their own research programs. In addition, leadership initiatives among award sites include policy, institutional action, and collaborative leadership teams, and at six institutions, explicit leadership development for senior women faculty so that they may better understand the institution and be able to foster advancement for other women.

Initiatives addressing work-family arrangements are a second set of structural initiatives (Table 1). Forty-two percent of the awardees have initiatives that seek to integrate work and family, aiming to overcome the extent to which work and family are competing spheres (Fig. 1). Specific work-family initiatives include “modified academic duties” at the time birth or adoption of a child or illness of a family member, dual-partner hiring programs, funds for release time from teaching for periods of critical transitions in life, and at in one institution, the opening of a day-care center and establishment of lactation rooms for nursing mothers (Table 1).

Although structures of promotion and tenure codes and practices are core to outcomes of advancement, initiatives that directly address promotion and tenure are exceptional, present in only four (21% of) institutions (Fig. 1). One institution has undertaken a comprehensive canvass of evaluation processes across units and a survey on tenure/promotion issues, and has introduced and implemented a set of “best practices” and developed a web-based instrument to assist users in identifying forms of bias and in promoting more fair and equitable processes of evaluation. A second institution has proposed changes in tenure and promotion of the “Faculty Code” that would include a mentoring meeting three years after tenure and promotion to rank of associate professor, and would provide an institutional ombudsperson for promotion and tenure. A third institution works with the Office of the Provost to sponsor tenure and promotion workshops each semester. The fall workshop addresses issues across-colleges. The spring workshop involves unstructured

Table 1 Initiatives of ADVANCE Institutional Transformation awardees, 2001–06 and 2002–07

Category of initiative	Initiative	Examples of initiatives
A. Fundamental structures	1. Leadership	- ADVANCE professors or chairs - Policy committee - Institutional action committee - Leadership workshops for faculty and administrators - Leadership retreats for administrators - Leadership development program - Leadership awards
	2. Work-Family Arrangements	- Day care center - "Modified" duties for child or family care - Dual partner programs and/or reports - Funds for release time for family (and other) needs
	3. Tenure and Promotion (P&T): evaluation for advancement	- P&T committee, including review of all P&T documents/practices, and development of web-based instrument - P&T workshops - Proposed changes in P&T code/ documents
B. Faculty composition	1. Recruitment	- Resources provided for "start-up" packages - Faculty "lines" provided - Advisors and/or assistants who participate in recruitment - Identifying female candidates - Tool-kit for recruitment - "Offer-letter" templates for equity - Workshops and/or training for search chairs/committees - Affirmative action principles outlined
	2. Retention	- Tool-kit for retention - Retention guidelines
C. Internal networks of education, communication, mentoring and resources	1. For faculty (a) Faculty development	- Sponsorship for research development - Formal and informal mentoring - Career advising and coaching - Workshops on faculty development
	(b) Distribution of material resources	- Research funding—inc. equipment, research expenses, release time, and grad/undergrad research assistants - Funding for workshops, symposia, seminars on-campus - Funding for attendance at conferences
	2. For departments (a) Dept chair development	- Workshops, training, and coaching in issues and best practices of equity and diversity for department chairs

(continued)

Table 1 (continued)

Category of initiative	Initiative	Examples of initiatives
		- Programs for department and chairs in "climate" and "transformations"
	(b) Distribution of material resources	- Funds provided for "departmental transformation" and "climate change"
	3. Other Internal Networks	- On-campus conferences and retreats - Symposia - Networking lunches and meetings - Internal advisory boards
D. Networks of—mechanisms for— External Supporters		- Visiting scientists as speakers and/or mentors and research advisors - External advisory boards

roundtable discussions, by college, permitting interaction with college deans and promotion and tenure committee representatives, so that faculty may bring forward their questions about promotion and tenure requirements, and strategies and practices for promotion within their college. A fourth institution has also initiated workshops on tenure and promotion, cosponsored with the Provost's office.

The second broad category of initiatives focuses upon faculty composition—means of increasing the recruitment and retention of women faculty (Table 1). Initiatives of recruitment are common among the institutions, and are present in nearly four-fifths (79%) of the sites (Fig. 1). At two institutions, recruitment initiatives are direct, involving the provision of ADVANCE funds for hiring two to three women faculty, or commitment of a college for two new faculty lines for diversity. Initiatives at four institutions directly supplement hires with provision of ADVANCE funds to support "start-up packages" for recruitment of women faculty. Another initiative is also relatively direct, funding "equity advisors" who participate in faculty recruitment, and another initiative provides training sessions in equity for recruitment committees. Recruitment initiatives at other institutions are less direct—that is, less directly involved in the actual recruitment—and provide reports, tool-kits, templates, and guidelines with concrete suggestions for recruiting a diverse pool of applicants, workshops, or ADVANCE staff support geared to the hiring of women faculty. In contrast to recruitment, *explicit* retention initiatives are exceptional, present in two (11% of) institutions, and consist of guidelines and/or tool kits on ways to enhance faculty's experiences and retain excellent faculty (Fig. 1).

Education, communication, and mentoring, a third broad category of initiative, are pervasive among ADVANCE institutional awardees (Table 1). One set of these initiatives, present in three quarters (74%) of the institutions, focuses upon faculty development for academic women in science and engineering (Fig. 1). Specific activities at these institutions include sponsors to enhance research programs, formal and informal

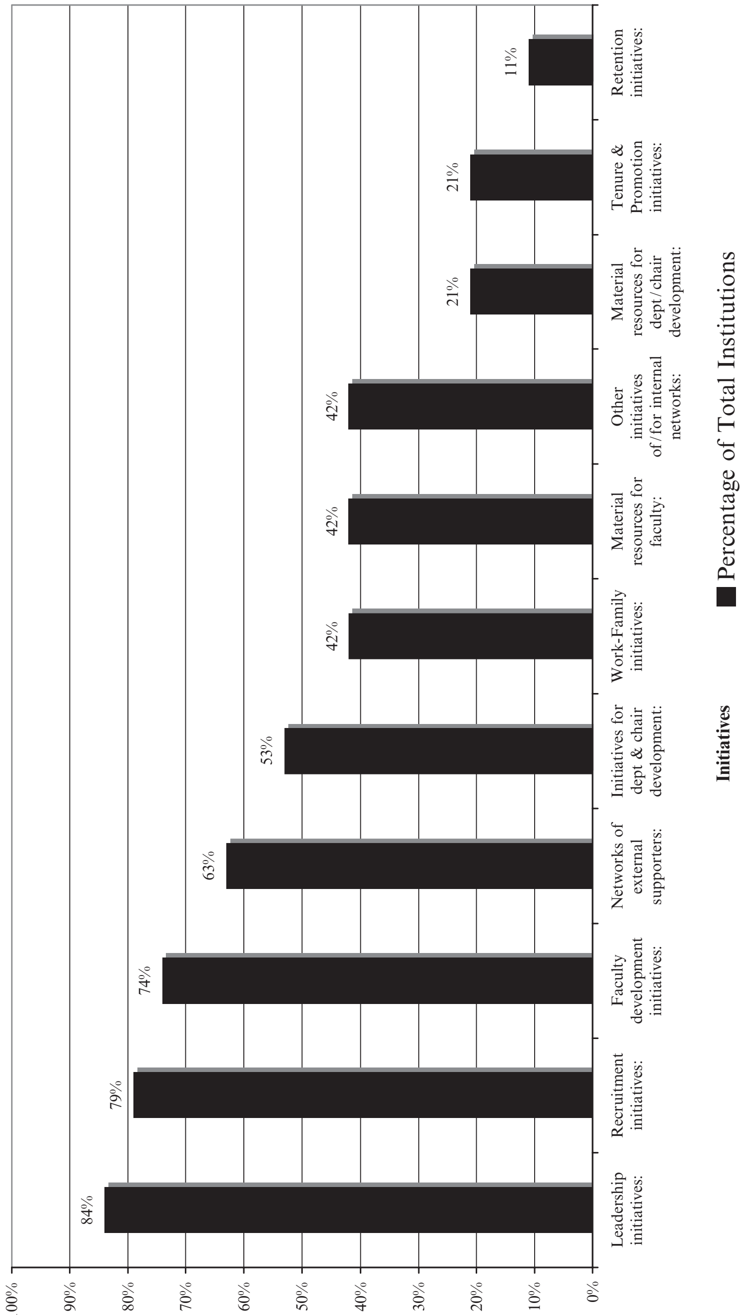

Fig. 1 Percentage of institutions undertaking types of initiatives

mentoring, coaching and advising for advancement, and a range of workshops on topics such as obtaining external funding (Table 1). Less frequent, but still present in 42% of the institutions, is material support provided through ADVANCE for women faculty's development (Fig. 1), with grants for travel and conference attendance, and for current or proposed research through funding for release time, equipment, graduate research assistants, and other research expenses (Table 1).

Another set of initiatives of education and communication focus upon chairs and departments, rather than women faculty, and are present in over half (53%) of the institutional sites (Fig. 1). The initiatives with chairs address issues of equity and inclusion (Table 1), and are represented, for example, by one institution's use of focus groups among chairs to highlight (and solve) issues of departmental climate, collaboration, and environment among colleagues. Other initiatives go beyond chairs to include faculty within the departments as well. This is represented by one institution's program with chairs, faculty members, and ADVANCE team members, to enrich communication, enhance collaboration, and seek support of faculty diversity. An initiative at a second institution works internally with departments to help ensure equity among faculty in access to resources and opportunities for success. This program uses an outside consultant to interview departmental members; and in assessment of the program, compares the "experimental group" exposed to the program to a "control group" not exposed. An initiative at a third institution, focusing upon the departmental-level, organizes workshops with small groups of chairs to increase awareness of departmental climates, identify issues of concern, and address them. In four institutions (21% of total sites), material resources in the form of "grants" or "awards," funded through ADVANCE, are provided to departments with fundable proposals to transform climates and cultures toward improved equity, inclusion, and advancement of faculty within the context of their own department.

Initiatives of education, communication, and exchange also encompass a significant range of other initiatives (Table 1), present among 42% of the sites (Fig. 1), including on-campus conferences and retreats, symposia on diversity, networking lunches and meetings, and in the case of five institutions, formal internal advisory boards.

The final broad category involves networks of—and mechanisms for—external supporters (Table 1). These are present in 63% of the ADVANCE award sites (Fig. 1). Five institutions have external advisory boards to help inform, and provide feedback on, their initiatives. Five institutions (including one that also has an external advisory board) have programs that bring visiting scientists to campus to serve as speakers and research role models. These visitors are also variously expected to provide visibility for the scientific achievements of women, establish networking opportunities, and enable potential research connections and collaborations, and mentoring relationships.

What may be the central ways in which the ADVANCE initiatives embody key dimensions and facilitating factors of transformation in higher education? Transformation of higher education has been characterized as change that is systemic, deep, intentional, and cultural, described in the previous section. The ADVANCE initiatives result from proposals for Institutional Transformation grants made by NSF, and cooperative agreements between NSF and the institutions awarded; thus, the sets of initiatives can be characterized as "deliberate" and "intentional." The extent to which the initiatives are systemic, involving alteration in the range of functioning institutional parts, vary. Focusing upon "recruitment" without addressing the ways, means, and functioning parts that translate "intake" into "advancement" (through, for example, patterns of research collaboration and evaluative practices) may be less systemic approaches. Development of women faculty through ways and means to research performance is systemic, or at least "institutional" compared to "individual" in its approach—to the extent that this approach focuses upon continuing access and opportunity to participation and performance of under-represented groups (compared to simply support of individuals' research). The inclusion of work-family initiatives and structural changes in work-family practices and policies, points, on the other hand, to systemic approach in this area. Initiatives that address evaluative processes, faculty codes in tenure and promotion, and equity in departmental decision making—which, in turn, connect directly and indirectly to advancement—are yet more systemic approaches.

Nearly all of the institutions' initiatives may be characterized as deep and as cultural. The approaches are deep to the extent that the institutions address ("internal") values and beliefs about equity as well as aspects of ("exterior") programs and policies, in for example, the iteration of affirmative action principles, development of best practices of equity at the departmental-level, and guidelines for retention. In their documents and websites, the initiatives display understanding that changes in programs and policies need to be accompanied by changes in values and beliefs. These values are specified variously among sites as "diversity and excellence," "greater understanding of gender issues and how to address those issues," "a family-friendly edge," and "frameworks of shared vision," for examples. Relatedly, the initiatives involve changes in institutional cultures or assumptions and beliefs that shape attitudes, priorities, and actions regarding teaching, research, and/or service. The institutions' approaches to changes in institutional culture are manifest in a range of initiatives, such as ADVANCE advisors who participate in recruitment and raise awareness of best practices for equity; information and advise provided for search committees to promote strategies and tactics for excellent and diverse applicants, and for fair and thorough review of candidates; and a leadership program to create and sustain organizational climates and organizational structures that facilitate the recruitment, retention, and promotion of women.

Of the factors described earlier in this chapter as facilitating transformation, those employed most extensively among ADVANCE awardees are leadership, development of stakeholders and networks of communication, reward structures for transformation, and support generated outside of the institution.

First, leadership initiatives are the most pervasive ADVANCE initiatives, present in the vast (84%) majority of sites (Fig. 1), as explained above. Further, administrative leadership is present in the institutions' structure of principal investigators and co-investigators for the ADVANCE awards. Forty-seven percent of the institutions have a principal investigator who is a president, vice chancellor, provost, or associate provost. Forty-two percent of the institutions have at least one co-principal investigator who is a provost or vice provost; 21% have one co-principal investigator who is a dean, and 26% have more two or more co-principal investigators who are deans. Administrative leaders in these positions can send signals and messages about the importance of the transformation envisioned, convene groups, make decisions in favor of transformation, and allocate continuing resources toward transformation (beyond the ADVANCE award period, which lasts for five years). Further, for core initiatives involving tenure and promotion, the involvement of central administration is indispensable in implementing such fundamental change across academic colleges and departments.

Second, the ADVANCE initiatives are facilitated in extensive networks of stakeholders and communication with them. In each institution, administrators, chairs, and faculty, across numbers of colleges and departments, are enlisted in the ADVANCE initiatives for institutional transformation. This occurs through a range of means including: (1) on-campus, annual retreats and conferences in which goals of transformation are conveyed, and refined and updated by the academic community; (2) symposia that communicate visions of change; (3) networking lunches and meetings that heighten awareness of ADVANCE and build communities of people committed to collective goals; and (4) internal advisory boards constituted to discuss and promote practices, formulate policies, create a sense of "ownership" in the initiatives, and expand support (Table 1).

Third, reward structures are apparent explicitly in research funding for faculty through release time, travel, and undergraduate and graduate assistants, provided in some form in 42% of the institutions (Fig. 1). Reward structures for collective transformation are evident in material resources for programs of climate change and transformation for departments and chairs, provided in 21% of the institutions (Fig. 1). In addition, reward structures for recruitment of women faculty are explicit in two institutions in which ADVANCE funds support new lines for hire of women faculty, and in four institutions in which ADVANCE funds provide or supplement "start-up packages" for recruitment of women faculty in science and engineering. The connection between faculty composition and transformation depends upon how composition ultimately relates to—or affects—patterns of interaction, collaboration, and exchange that are central to the social processes, and markers of significant participation and performance, in academic science and engineering (Fox, 1991, 1996, 2001).

Finally, outside supporters, as a facilitating factor, are apparent in the external networks characteristics of over half (63%) of the ADVANCE awardees (Fig. 1), and of course, in all of the awardees, when the grant, itself, is considered as significant outside support. The external networks expand and inform support of the transformation through the infusion of "visiting professors" who are a component in five (26%) of the institutions' initiatives, and external advisory boards, also present in 26% of the institutions. External networks also have potential for providing outside credibility, fresh perspectives, and feedback on the initiatives undertaken.

Summary and Conclusions

In summary, the participation, status, and advancement of women in science and engineering have been pressing social concerns for reasons of human resources for, and social equity in access to and rewards within, these fields. Women in academic science and engineering are a highly accomplished group—but the highest career attainments tend to elude this socially selective group. This is particularly notable in women's lower and slower advancement to the rank of full professor in academic science and engineering. The pattern of depressed rank raises questions about the nature of the problem of advancement and of solutions that may be applied.

In the study of gender and status, scientific fields are a focal case, because of the hierarchical feature of gendered relations, broadly, and because of the immense inequality in—and power of—science, particularly. Science is a medium of social power in its consequences for present and future conditions, and science connects to weighty social institutions, especially education and the state. In order to understand higher education, one needs to understand science (and vice versa). This is because in the United States, science and higher education evolved as reciprocal developments. Science played a strong role in changing the colleges of the nineteenth century into modern universities, and science still shapes the American university.

Explanations for the depressed rank and advancement of women in academic science have centered on the role of individual characteristics of women, and of organizational features of academic work and the workplace. Personal/individual characteristics play a part in explaining career outcomes in scientific fields. But individual characteristics of people do not exist in a social vacuum. Women's status in academic science is not a simple function of aptitude, attitudes, and ability. It is a consequence, more so, of complex factors of organizational context—the characteristics and practices of the settings in which they work (and in which they have been educated). The participation, status, and advancement of women in academic science are then organizational issues, and are subject to institutional transformation.

Consequential, in turn, are the meaning of institutional transformation and the factors that facilitate transformation of higher education institutions. Institutional transformation involves planned alterations in core elements of an institution, and radical change not only in traditional practices, but in ways of thinking as well. In higher education, institutional transformation has been characterized as systemic, deep, intentional, and cultural. Transformation of higher education is facilitated by leadership, networks of shared stakeholders, positive incentives for innovation, and support generated outside the institution.

In 2001, the National Science Foundation released a call for proposals for a new program "to increase the representation and advancement of women in academic science and engineering careers, thereby contributing to the development of a more diverse science and engineering workforce." A new type of award and approach, going beyond grants to individuals, was announced: ADVANCE Institutional Transformation awards.

Analyses in this chapter of the initiatives of the first two rounds of ADVANCE Institutional Transformation awardees (2001–06 and 2002–07) point to both central tendencies and range in initiatives involving fundamental structures, composition of faculty, internal networks of education and communication, and networks of external supporters. These initiatives relate to what is known about transformation in higher education, broadly, because the initiatives are clearly deliberate, address external structure and internal values, and institutional culture or assumptions and beliefs about the institution, and are more to less systemic. These (19) ADVANCE institutional sites employ facilitating factors for transformation especially through leadership, development of stakeholders, reward structures, and support generated outside the institution.

In conclusion, what appear to be the prospects for—and limitations upon—institutional transformation as a strategy and solution for the advancement of women faculty in science and engineering? Improvement in women's status in academic science and engineering relies not merely upon the detection, cultivation, and enhancement of individuals' backgrounds, talents, and skills. Rather, improvement depends on attention to organizational and environmental factors such as allocation of resources, access to interaction and collaboration in research, and operation of equitable evaluation schemes in the work and workplace (Fox, 1991, 1992b, 1998, 2000, 2003a, 2006b). To the extent that institutional transformation addresses such factors, it is a promising strategy for improving the status of women in academic science and engineering.

The NSF ADVANCE initiative, in particular, is an important, national initiative because it goes beyond focus upon individuals and deals with certain features of institutions as they shape outcomes for women. Transformation is a long-term investment and it will be a continuing process for recipients of the first two (and subsequent) rounds of NSF Institutional Transformation awards. Although it would be premature to declare "success" (or lack of it), gains appear to be made in structural areas, especially in work-family policies and practices, undertaken by 42% of the first 19 award sites; and in internal networks of education, communication, and mentoring undertaken for faculty in 74% of the institutions, and undertaken for departments, in 53% of the institutions (see Fig. 1). For systemic transformation—that is, transformation that extends to core, inter-related elements of the institution—attention to evaluation and tenure and promotion practices is critical and present in 21% of the institutional sites (Fig. 1).

Attention to systemic institutional components—including practices and policies of evaluation—is both crucial to and challenging for the establishment of equitable advancement. Equity in tenure and promotion is supported by organizational practices that involve relatively complete information on candidates' records and qualifications, clear and written standards for evaluation, and systematic and specified processes for candidates as well as evaluators (Long & Fox, 1995, pp. 64–65). Processes of evaluation that are subjective, loosely defined, and a matter of "judgment" are associated with bias and inequity (Blalock, 1991; Fox, 1991; Reskin, 2003). Further, it is important to consider that changes in composition of faculty—through recruitment of women—may not, by themselves, transform key, systemic, institutional practices, such as evaluation. This is because increasing the "numbers of women" in science, while requisite, does not necessarily change patterns of status and hierarchy within an institution or change patterns of valued norms and values that may favor currently dominant groups (Fox, 1999, pp. 453–454).

Transforming key practices and policies, especially those involving evaluation in higher education, is difficult and complex. Academic institutions tend to be decentralized, with decision-making about promotion and advancement occurring in a range of departmental units that exercise—and claim—degress of "autonomy." Decentralization of authority and decision-making certainly has organizational advantages: it enables flexible and rapid response to issues by individual groups and it may enhance responsibility across ranks. However, decentralization also has its costs: it can reduce the capacity to forge a broad, unifying organizational strategy, such as institutional transformation (see Harrison, 1994, p. 102).

The decentralization of decision-making in higher education reflects, in part, the strength of faculty. This strength—which makes faculty potentially critical allies and supporters as well as potential resisters to transformation— derives from the "legitimacy" of faculty's role in higher education, their average length of time in institutions which far exceeds that of most presidents and administrators, and academic tenure which means that tenured faculty members cannot be dismissed readily and replaced (Burkhardt, 2002, p. 124; Keup et al., 2001, p. 26). In science and engineering fields, faculty strength is fortified further because the research programs, external funding, and graduate training of the scientific fields are especially critical to the universities' levels of status, national ranking, and material resources (Benezet, 1977; Long & Fox, 1995; Salancik & Pfeffer, 1974). These factors can reduce administrators' motivation to take steps to alter the decentralized decision making in departments' of science and engineering (Fox, 2000).

Resistance of faculty or others may be considered an "inevitable part" of institutional transformation; and in fact, the existence of resistance may also be an indicator that transformation is at least beginning to take effect (Keup et al., 2001, p. 26). Current institutional arrangements tend to be embedded in the organization and supported by a given academic culture, so that attempts to change practices result in resistance (Burkhardt, 2002). For example, faculty members' patterns of research collaboration and interaction that are constituted informally, with informal social boundaries for inclusion (or exclusion), may be resistant to transformative initiatives that seek to place junior faculty members in existing research projects and programs. Likewise, department chairs' informal practices offering variable start-up packages or release time from teaching to newly recruited faculty may be resistant to transformative initiatives that subject practices of "administrative prerogative" to gender-equitable standards for incoming faculty. Further, "flexible," unspecified, and subjective processes of evaluation, operating among faculty and among chairs, may be highly resistant to transformative initiatives that emphasize written guidelines and specified benchmarks for the performance and in turn, evaluation, of candidates for tenure and promotion.

When faculty members (and others) defend current practices and arrangements, they frequently invoke arguments that "excellence" is at stake (Astin & Associates, 2001, pp. 27–28; Burkhardt, 2002, p. 27). For example, faculty members and others may deflect transformative initiatives to help ensure equity in access to resources and opportunities for success if they regard these as practices that will reduce "excellence" by diminishing competition, rigor, productivity, and in turn, national ranking of the institution and individuals within it. Consequently, those undertaking transformative initiatives for the advancement of women faculty need to be aware of implicit (and often unexamined) beliefs about quality, perceived to be challenged by new, proposed practices and policies. Efforts for change will be enhanced if they connect with the institutions' values and missions. The capacity for institutional transformation rests, in part, upon "finding ideas that fit needs" (Daft, 2004, p. 427; Daft & Becker, 1978). Thus, in universities in which research values predominate, the acceptance of strategies for institutional transformation is enhanced when innovations proposed have a research-basis or strong research component (see for example, Allan & Estler, 2005, p. 230), or when the transformation is carried out in ways perceived to be "rigorous" and "theoretically sound" (Asmar, 2004).

Relatedly, the prospects for transformation are enhanced by positive "incentives" that support innovative practices and behavior (Fox, 2006b). Resistance to transformation tends to come from those who are invested in the status quo. An institutional structure can enhance transformation by reducing individuals' sense of risk, and aligning efforts toward transformation with positive recognition and rewards—as in the example of ADVANCE institutional sites' provision of material resources to departments for programs of climate change (Table 1).

Institutional transformation is a positive prospect for improving the status and advancement of women faculty in science and engineering. The success of sustained transformation rests with sustained organizational will. Those with authority to influence others and accomplish transformation can do so by continuing to direct the flow of signals, priorities, interactions, and critically, material and social rewards in favor of transformative practices and policies. This involves ongoing examination and attention to the ways in which the organization of departments and groups, evaluation of faculty, and distribution of human and material resources support gender equity in career outcomes. This, in turn, is a long-term organizational process.

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