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Gender Equity in Science and Engineering

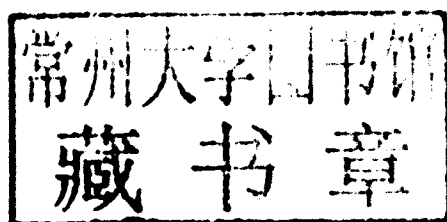
Advancing Change in Higher Education

Diana Bilimoria and Xiangfen Liang

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1 Gender Equity and Institutional Transformation in Academic Science and Engineering

Science and engineering play a significant role in everyday life and are critical engines of innovation and economic growth. Sectors such as biochemistry, telecommunications, energy, health science, health technology, environmental science, materials science, and information technology, among others, continually bring improvements to our daily lives as well as offer growth in business and employment opportunities. Cutting-edge science and engineering are systematically applied to discover new opportunities and solve problems, and shape the formation, design, and development of new products and innovative production processes. Much of the United States' economic growth in the last 50 years has been produced by scientific innovation (National Science Foundation 2004; U.S. Department of Labor 2007). An advanced science and technology enterprise offers distinctive societal advantages to compete and win in the fast-paced global business environment. The U.S. has the single largest value-added world share (35% in 2005) of any country in high-technology manufacturing industries, ranked first in three of five high-technology industries (scientific instruments, aerospace, and pharmaceuticals) and second on the other two (communications equipment and office machinery and computers), as well as leads in market-oriented, knowledge-intensive service industries, responsible for about 40% of world revenues on a value-added basis over the past decade (National Science Foundation 2008).

With the increasing importance of science and technology for U.S. economic competitiveness and growth, considerable attention is being paid to these industries as career choices for men and women. Individuals with science, technology, engineering, and mathematics (STEM) backgrounds are highly sought after by high-tech firms as these talents are conducive to an increased capacity for innovation. According to the Science and Engineering Indicators 2010 published by National Science Foundation (2010), the number of workers in STEM occupations grew from about 182,000 in 1950 to 5.5 million in 2007. This represents an average annual growth rate of 6.2%, nearly four times the 1.6% growth rate for the total U.S. workforce older than 18 years during this period (National Science Foundation 2010). From 2004 to 2007, the science and engineering workforce growth

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averaged 3.2% but was still twice as high as that of the total U.S. workforce. The sustained growth in the U.S. science and engineering workforce has largely been attributed to three factors: increased STEM degree production, immigration of scientists and engineers, and few retirements because of the relative youth of the STEM workforce compared to the total U.S. workforce (National Science Foundation 2010). Yet future national STEM growth is in danger; some have estimated that if current global trends continue, more than 90% of all scientists and engineers will live in Asia (U.S. Chamber of Commerce 2005).

The full participation of women and men in the national STEM workforce is necessary to solidify and grow the global leadership position of the United States in science and engineering in the coming years and decades, yielding long-term benefits to the U.S. economy. As noted in the influential report *Rising above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future*, without a national policy-level response to enhance the science and technology enterprise, the U.S. will lose quality jobs to other nations, jeopardizing its standard of living and other economic benefits (National Academies 2007a). The 2007 report *The STEM Workforce Challenge: the Role of the Public Workforce System in a National Solution for a Competitive Science, Technology, Engineering, and Mathematics (STEM) Workforce* similarly identifies the STEM workforce challenge and calls for “coordinated efforts among public, private, and not-for-profit entities to promote innovation and to prepare an adequate supply of qualified workers for employment in STEM fields” (U.S. Department of Labor 2007, 1).

A central part of the STEM workforce challenge facing the country is the composition of the academic workforce, particularly the faculty in the nation’s higher education institutions. Diversifying the academic STEM workforce to increase the participation of women faculty has become a national priority because “women faculty, specifically contribute to the culture and climate of the university and to the development of students’ capacities and potential in science and engineering, with potential consequences for future generations of scientists and engineers” (Fox 2008, 73). Recent research has documented the strong positive influence of female professors on female students’ performance in math and science courses, their likelihood of taking future math and science courses, and their likelihood of graduating with a math, science, or engineering degree, effects that are largest for female students whose SAT math scores are in the top 5% (Carrell, Page, & West 2010).

Other recent seminal reports identify this critical importance of women STEM faculty and call for urgency in diversifying the academic workforces in U.S. universities and colleges. These reports include the National Academies’ (National Academy of Sciences, National Academy of Engineering, and Institute of Medicine) reports *Beyond Bias and Barriers* (2007b) and *Rising above the Gathering Storm* (2007a), the Department of Labor’s

report *The STEM Workforce Challenge* (2007), and *Gender Differences at Critical Transitions in the Careers of Science, Engineering, and Mathematics Faculty* (2010) by the Committee on Women in Science, Engineering, and Medicine and the Committee on National Statistics. These studies converge on the urgent necessity for U.S. universities and colleges to invest resources in developing and diversifying their faculty workforces as well as transforming their institutional cultures to support gender equity through the full participation and advancement of women faculty in academic science and engineering.

GENDER EQUITY, DIVERSITY, AND INCLUSION IN ACADEMIC SCIENCE AND ENGINEERING

In particular, academic science and engineering (S&E), inclusive of all STEM disciplines as well as the social and behavioral sciences, has emerged as a focal site in the study of gender equity, diversity, and inclusion in higher education not just because of its central role in U.S. long-term economic competitiveness and growth. Social equity issues in access to and rewards for professional participation in S&E also are of concern (Fox 2008). Drawing on Merton (1942/1973), Fox (2008, 74) points out that since a central ethos of science prescribes that scientists should be rewarded for contributions, scientific careers in particular should be “open to talent” and not precluded or disadvantaged by personal characteristics such as gender.

Gender refers to the socially constructed roles of and relations between women and men. Gender differences include characteristics and behaviors that are not only tied to women’s and men’s biology (sex) but which also originate from culture-specific perception and treatment of what women and men “should” be. Norms regarding gender-specific speech, movement, activities, thoughts, and feelings may vary by place, time, and culture. Gender determines what is expected, socially permitted, and valued about women and men in a particular context.

Gender equity is “a social order in which women and men share the same opportunities and the same constraints on full participation in both the economic and the domestic realm” (Bailyn 2006). It refers to “parity between males and females in the quality of life, academic, and work outcomes valued by our society” (Koch & Irby 2002, 3). The United Nations’ Office of the Special Advisor on Gender Issues and Advancement of Women defines equality between women and men as referring to the “equal rights, responsibilities and opportunities of women and men and girls and boys. Equality does not mean that women and men will become the same but that women’s and men’s rights, responsibilities and opportunities will not depend on whether they are born male or female” (<http://www.un.org/womenwatch/osagi/conceptsanddefinitions.htm>).

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Gender equity is a critical component of human rights and civil rights. Title IX of the U.S. Education Amendments of 1972 prohibits exclusion from participation, denial of benefits, or discrimination on the basis of sex in education programs or activities receiving federal financial assistance. Title VII of the Civil Rights Act of 1964 prohibits discrimination in education on the basis of sex, race, and national origin. The U.S. federal government has prioritized and invested in the field of gender equity in education since the passage of Title IX. The purpose of the field of gender equity is to “develop, implement, and evaluate the success of strategies, programs, and policies designed to promote equal outcomes” (Koch & Irby 2002, 3). Specifically, the Department of Education, the Department of Labor Women’s Bureau, the National Science Foundation’s program of research on gender in science and engineering, and the National Institutes for Health’s Working Group on Women in Biomedical Careers are national agencies that support work in the field of gender equity in higher education while state and local government agencies help implement federal and state civil- and human-rights laws (Klein, Ortman, & Friedman 2002). While considerable progress has been made in the recent decades, gender inequities persist. “Many deep-seated and apparently intractable social inequities, such as gender related discrimination and stereotyping, have only begun to give way in the face of national mandates that they be changed and national mechanisms to support and enforce those changes” (Klein, Ortman, & Friedman 2002, 23).

While gender equity refers to making the playing field level for the workforce participation, performance, and success of all participants (women and men, majority and minority), two other concepts support their positive relations and contributions. *Diversity*, or the spectrum of human differences, refers to the distribution of the workforce composition, or commonly, the participation (representation) of women and underrepresented minority group members within the workforce. When the workforce participation of minority group members in influential positions within a system forms a critical mass (more than 35% minority members), token dynamics on account of skewed composition (less than 15% minority members), or tilted composition (between 15 and 35% minority members), diminish (cf. Kanter 1977; Yoder 1994). Typical token dynamics occurring in conditions of proportional underrepresentation include performance pressures for minority-group members due to extreme visibility and scrutiny, exaggeration of the differences between tokens and dominants, and magnified intergroup boundaries, and assimilation or role entrapment due to stereotyping or generalizing the characteristics of tokens (Kanter 1977).

Inclusion refers to the social processes that influence an individual’s or subgroup’s efficacy and sense of belonging and value in a work system. Inclusion represents a person’s ability to participate in and contribute fully and effectively to an organization, and be recognized and valued as contributing to the organization’s success. Organizational theorists have defined inclusion variously, including “the degree to which an employee is accepted

and treated as insiders by others in a work system” (Pelled, Ledford, & Mohrman 1999, 1014), “the extent to which employees believe their organizations engage in efforts to involve all employees in the mission and operation of the organization with respect to their individual talents” (Avery, McKay, Wilson, & Volpone 2008, 6), and “the removal of obstacles to the full participation and contribution of employees in organizations” (Roberson 2006, 217). At the most micro level, inclusion refers to an individual’s sense of being a part of the formal and informal processes of the organizational system (Mor Barak 2000). An inclusive work environment is one that facilitates “the full utilization of diverse human resources to maximize both the employees’ and organization’s potential” (Nishii, Rich, & Woods 2007, 1). Indicators of inclusion comprise the extent to which employees have job security, are involved in meaningful groups (in-groups), can access information and resources necessary for effective job performance, and can influence organizational decision-making processes (Mor Barak 2000). Zelechowski and Bilimoria (2003) measured inclusion in terms of the extent to which women were successfully integrated within their workplace groups to enable their effective performance, advancement, and professional development, such that they are not systematically excluded, isolated, marginalized, or derailed.

As described in Chapter 2, particular institution-level problems concerning the lack of gender equity, diversity, and inclusion in academic STEM include the persistent underrepresentation and lack of a critical mass of women faculty at all ranks and in leadership, a leaky pipeline (the systematic loss of women at each academic career transition point from secondary school through scientific leadership), unequal employment opportunities and job segregation (e.g., disproportionate numbers of women in the nontenure track or less valued academic career paths), inequitable treatment and valuing of women employees (e.g., stereotyping, excessive scrutiny, biased evaluations, and unequal access to resources and compensation), and differential effects of conflicts between work and life/family demands for women and men faculty.

INSTITUTIONAL TRANSFORMATION

As increasingly recognized, if academic science and engineering is to truly realize its potential for fostering innovation, competitiveness and growth in the U.S. workforce in the global economy of the 21st century, higher education institutions must pay significant attention to issues of gender equity, diversity, and inclusion, transforming themselves to become workplaces that catalyze innovative research and inspire diverse students by removing barriers to the equal employment, performance, and professional career development of women and men scientists and engineers. In this sense, *gender equity, diversity, and inclusion transformation* refers to the processes by which institutions become more reflexive about their

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gender practices and transform their social structures and relations to enable equal employment, opportunities, treatment, evaluation, and valuing of women and men so that all employees can fully participate, contribute, and develop in their careers and enable their organizations to achieve their goals of effectiveness.

The issues of gender underrepresentation and inequities in organizations have received much attention from researchers and practitioners alike, and their manifestations and causes have been well studied (Ely & Meyerson 2000a; Meyerson & Kolb 2000). Organizational solutions vary in the underlying assumptions and approach utilized to redress these problems. Supply-side or pipeline initiatives contend that if sufficient women are encouraged to enter the workforce and are well-equipped to perform, gender gaps in occupational participation, advancement, compensation, and retention may disappear (Etzkowitz, Kemelgor, & Uzzi 2000). Initiatives such as affirmative action and antidiscrimination policies focusing primarily on compliance with existing laws, mentoring, training programs, and special job assignments for women may facilitate career advancement. Demand-side initiatives, as for improved work-life balance, such as flextime and child care support, are other popular remedies. Though rarely, some organizations have attempted to build awareness about the tacit mental models driving behavior (e.g., Stuart 1999; McCracken 2000). The outcomes of these efforts are mixed—some initiatives have yielded positive results (e.g., Dreher 2003) while others have not proved sustainable. Women's representation and inclusion, particularly in leadership, remains a widespread problem for organizations.

The lackluster and unsustainable experience of many ad hoc gender equity-related organizational change efforts to date indicates that simplistic, ad hoc, or piecemeal solutions cannot eradicate systematic, historical, and widespread gender underrepresentation and inequities. For example, infusing more women at lower levels is rarely sufficient for increased representation at higher levels. Offering individual mentoring and skill-development opportunities to women can be less than effective for their advancement if other organizational factors are not simultaneously addressed. What is needed is a wider and deeper change in organizations—a transformation of the organizational structures, processes, work practices, and mental models that perpetuate inequity (McCracken 2000; Meyerson & Fletcher 2000). Enabling equity in organizations is the process of changing the character of the workplace that has traditionally been manned (literally and figuratively) by employees of a certain type to accommodate a different type (Thomas & Ely 1996), recasting the institutionalized routines and practices embedded in the social-structural fabric of the organization. Transformation is thus about changing an institution's structures and culture (Eckel & Kezar 2003). Transformation pertains to fundamentally changing how an organization conducts its day-to-day operations (who we are), as well as how the organization views itself in the future (who we want to be).