Promising Practices in Engineering Education (as Viewed through Four Frames)

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I. "Change" as a Problem

Changing organizational culture is a popular mantra among STEM researchers and reformers. Increasing participation of women in engineering is only one of many challenges that organizations face. In this paper, a framework adapted from the management literature (Kolb et al., 1998) for decomposing approaches to organizational change is presented. As a lens for viewing practices that reflect healthy, welcoming, supportive, and evolving environments for women in engineering, the "four frames" help to categorize what has been tried—and worked—in changing the engineering education experience.

The emphasis here is on transforming *organizations* to be a continuing source of production both of skilled professionals and new knowledge—the hallmarks of any discipline. As economist Scott Page's *The Difference* (2008) has shown, a focus on diversity of all kinds demonstrates the power of diverse teams to perform, innovate, and succeed. The adaptation of the four frames to engineering (Holloway, 2014) likewise serves to clarify the difference between individual and organizational behavior, particularly the creation of inclusive learning environments.

The value of the four frames is their clear delineation of practice—how, in the present application, the problem of underrepresentation of a category of participant in engineering, women, has been conceptualized and studied in different ways. Each frame has a distinctive focus that constrains measurement and illuminates the problem, but only one frame combines foci and harbors the potential for transformation of organizational behavior. As has been observed, "In engineering, a field in which the educational and professional environments are closely linked, professional role confidence starts to develop as women and men begin their engineering education" (AAUW, 2015: 86).

This paper therefore is presented with the intent of *starting* a discussion. It is not comprehensive and does not present data on gender underrepresentation. It uses the four frames as a classification tool. The literature selected and described conforms to the focus of a frame *and* illustrates a promising practice for engineering. The inclusion of citations below therefore is heuristic and provocative—each is context-specific and may not satisfy some readers' standards of proof. Determining what is "promising," though anchored empirically, is still inescapably an art.

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II. Four Frames for Understanding Organizational Change

As AAUW (2015) reminds us, "we all hold gender biases shaped by cultural stereotypes in the wider culture, that affect how we evaluate and treat one another. Explicit gender bias may be declining, but "implicit or unconscious bias remains widespread." The challenge, then, takes many forms: to identify, measure, deter, rehabilitate, etc. Changing culture demands a collective response to a pervasive problem.

Each of the four frames identifies problems to be studied and acted upon. All advance our knowledge of barriers to the participation of women in engineering. But each attacks the problem differently. The accretion of what is learned represents a partial or whole strategy of what can be done to mitigate the problem. By assembling these empirical nuggets, we gain a fuller sense of what is possible, transferable, and adaptable to new settings.

The four frames are outlined below, distilling Kolb et al. (1998) in the *italicized* paragraphs below, followed by the context for the problems each frame addresses and what later will be explored through examples derived from the literature (primarily, but not solely, on engineering education). No single example produces a "promising practice." By accumulating new insights through these examples, we recognize how combining them in creative ways helps to promote gender equity and reduce the underrepresentation of women all along educational pathways to a career in engineering.

A. Equip the Women/Prepare Women for Success

The most traditional and popular approach to achieving gender equity is equipping participants with the resources to compete as equals. In practice, this means remediating women through training programs and skills development. It recognizes that organizations are flawed, but offers opportunities for individual women to acquire the skills to compete without changing the policies and structures in place.

A majority of empirical studies have historically adopted this frame—some variation on "fix-the-student-and-women's-representation-will-increase." Brainard and Carlin (1998) found no such impact a generation ago. Yet the ability to control a small set of variables through data-collection via survey or observation using pre-post designs or control-group comparisons yields changes in individual behavior, e.g., retention or persistence, that can be associated with a purposeful manipulation of treatment. Sometimes, these observed differences can be explained, especially with longitudinal data. For example, Fox, Sonnert, and Nikiforova (2011) have catalogued “individual obstacles” addressed by 49 undergraduate WEPAN programs. While various department-based activities can be influential, they tend not to disturb the learning environment in an enduring way. Retention and graduation rates may be affected by such factors as admission policies, school missions, and geographic area that are beyond a program’s control (Staying Power 2015). Frame 1 studies show that women can compete, excel, adapt, and succeed like any other student in engineering, but that broader organizational strategies are needed to translate important findings into structural change.

B. Heed Policy and Law

The second frame focuses on structural barriers, with the “deficiencies” of individual women no longer viewed as the source of the problem. Rather, structures of opportunity create an uneven playing field, with interventions introduced from outside the institution that are both legalistic and policy-based. Implementation of organizational accommodations reduce structural disadvantages to promote recruitment, retention, and graduation of women. But such actions are directed to the formal organization, not the informal rules and practices that govern behavior. Therefore, they are insufficient for achieving lasting gains because they do not change campus culture.

Gender- and race-conscious policies, contrary to much commentary, are legal remedies under federal statutes, to past discrimination. The key to their use, however, requires carefully crafted justification tied to institutional mission statements (Burgoyne et al. 2010: 23-24). Virtually all such statements in higher education explicitly cite access, diversity, and/or inclusion as essential to the achievement of educational objectives. The burden is on implementation and documentation by public and private institutions that receive federal funding.

Title IX of the Education Amendments of 1972 is a law prohibiting discrimination based on sex in educational programs that receive federal funds (Sevo ND). Historically, its application outside of athletics, i.e., equal opportunity for women to participate in collegiate competitions, has been limited. Its extension to participation in STEM dates to the new millennium (Sturm 2006), but few compliance reviews have been conducted. This all changed in 2011 when, after 40+ years of Title IX, the U.S. Department of Education announced that any college or university receiving federal aid will be held accountable for failing to deter and punish campus sexual assaults. Like all policies, however, enforcement tends to lag the offending behavior. Not surprisingly, institutions of higher education have struggled with enforcement, and today more than 100 are under investigation for alleged mishandling of cases (Wallace 2015).

The problem is even more complex. University policies vary on how to report and evaluate cases of student assault. And many institutions lack Title IX coordinators

(Fabris 2015; Moody-Adams 2015). How to ensure a fair hearing of those accused of assault, as well as establishing a causal link more generally between drinking and violence, is a challenge (New 2015). However, campuses have been put on notice by the U.S. Department of Education's Office of Civil Rights that climate surveys will soon be required (Share and Coffina 2015). Despite ambiguity over the magnitude of the problem, the larger issue is clear: a climate of discomfort, if not fear, among undergraduate women interferes with learning, adding yet another barrier to those confronting women in STEM disciplines such as engineering.

C. Value Differences

The third frame places gender equity within the context of broader diversity. It is thus more systemic about valuing differences of all kinds and focuses on practices anchored in evaluation criteria. But it fails to break down gender stereotypes and challenge the hierarchical valuing of what is "masculine"—assertiveness, decisiveness, competitive—over what is "feminine"—people skills—in producing desired organizational results. In short, valuing differences, even celebrating them, does not penetrate the culture or change the behavior of those who dominate it.

Valuing difference continues to shift the focus of analysis to the environment. Researchers must search for evidence of change in climate beyond single classrooms or category of student. Measures of faculty behavior, from notions of skill differences between male and female students to novel pedagogies that support all learners, are valued in this frame.

AAUW (2015) reports that "women are more likely than men to prioritize helping and working with other people over other career goals. . . . By emphasizing the wide variety of expertise necessary to be a successful engineer or computing professional including less stereotypically masculine skills such as writing, communicating, and organizing—college engineering . . . can help young women see engineering . . . as [where] they belong." Others refer to a redesigned engineering curriculum as integrating the liberal arts and encouraging team-teaching, supplying the "missing basics" of engineering education, in the words of the president of Olin College of Engineering, "which include design and creativity, teamwork and interdisciplinary thinking, and understanding the social, political, historical, and economic context of a project" (Bordoloi and Winebrake 2015: A25). The challenge, of course, is buy-in from faculty, which a handful of departments of Engineering Education nationally have achieved. The result is a greater array of classroom pedagogies, more faculty engagement with students, and a more explicit social relevance. At the very least, it is one promising model (Benson, Becker, Cooper, Griffin, and Smith 2010). The student composition shows the result: more diversity of all kinds.

D. Re-envision Work Culture

The fourth frame integrates the first three frames and sees the organization as inherently gendered. In other words, the organization is unconsciously biased by *privileging traits socially and culturally ascribed to men while devaluing or ignoring those ascribed to women. This frame is difficult for many to acknowledge because what has always appeared neutral and inconsequential is now re-conceived as an unearned advantage that differentially impacts men and women inhabiting the organization. To operate on the organization at its most fundamental level of practices requires an ongoing and iterative process of examining, experimenting, and learning. This takes time, demands commitment, and may sacrifice short-time organizational strife for enduring gender equity. It ties policies to their use in practice, entertains alternative strategies for success, and lays bare conceptions of ideal workers, exemplary managers, and strong leaders. Most organizations are not ready for such a cultural transformation, but the fourth frame imagines the possibilities that will benefit women, men, and the organization as a whole.*

The transforming culture is both a recognition of accumulated lessons from the three prior frames plus a self-conscious inventory of practices that expose the gender biases inherent in the organization and its people. Only then can the reconstruction proceed—or not. Knowledge is not implementation. Campus communities feature a churn in membership—administrators, faculty, and students come and go. It is unclear whether shedding organizational history is easier for newcomers or those who lived through previous phases. Again, measuring the evolution of such big changes requires a commitment to learn and replace habits and customs, rewards and punishments, with new ones. This cannot be legislated, yet must be scaled to affect more than one person or campus unit at a time (Fox, Sonnert, and Nikiforova 2009).

Seen through any of the four frames, programs develop, justify, and implement practices. These can be considered component behaviors hypothesized to positively impact categories of students that experience them. Today's categories have proliferated—at-risk, first-generation, low-income, LGBT—have joined the historically underrepresented—minorities, women, etc. With the passage of time, our criterion of positive change should become even more rigorous, with indications that the intervention dissolves any measurable difference in performance between the majority and named category of student. Such an intervention, upon replication in other settings, is a candidate for adaptation as a *promising practice*.

III. Applying the Four Frames to Undergraduate Engineering Education

The four frames outline a typology of action that can be applied to any broad discipline like engineering. They also form a continuum of actions that extend from episodic, ad hoc interventions affecting individuals at a particular time and place such as a classroom, to a breadth of behaviors that reflect the force of influences outside both the discipline and the institution. With the passage of time, the culture of the institution may be measured as "changing" or in the throes of a transformation process. Any "transformation" requires a "maintenance plan." It is not simply "reached" as a state of grace for all time.

In the spirit of the four frames, the following shorthand is offered as guides to the literature:

- equip the student
- enforce policy and law
- embrace difference
- evolve the organizational culture.

Each of these frames not only implicates different actors working independently or in concert, but also demarcates research that illustrates the most promising of practices to effect change as defined within the frame. The question to be asked is “how?” The answer to how is a “promising practice.” This notion is drawn from the term “promising programs” popularized more than a decade ago by a public-private initiative known as BEST—Building Engineering and Science Talent. In the report, *A Bridge for All* (BEST 2004), 124 university-based, undergraduate-centered STEM programs operating in the United States were reviewed, using the National Science Foundation (NSF) model of employing a face-to-face panel of experts drawn from a range of relevant disciplines.

BEST did not focus solely on women, but rather on the conditions for broadening participation for all in undergraduate STEM. Among the eight “design principles” BEST (2004: 5) identified, six are essential—leadership, engaged faculty, peer support, enriched research experience, and bridging to the next level. Each subsequently gained empirical support (summarized in Chubin and Ward 2009), demonstrating the benefits of organizational changes, especially in orientation to those underserved by disciplinary and campus-wide practices. The application of the design principles is tantamount to evolving the culture of engineering to serve all. This *is* Frame 4 (see below). But such change takes time, at least a decade, as BEST found.

Under the four frames, learning outcomes may reach parity by gender, but what about the conditions under which the learning occurs? AAUW (2015) calls this “a gendered sense of fit: [a] narrow math and science emphasis disproportionately disadvantages women because it emphasizes male-stereotyped skills while devaluing skills that are gender neutral or female-stereotyped, such as writing, communication, and managerial skills.” This relates more to environmental factors captured subjectively by climate surveys, illuminating the difference between individual characteristics such as “grit” (persistence or resilience, Hoerr 2013), and more contextual factors such as the aforementioned critical mass that can change the classroom dynamic.

In the following, each frame is illustrated by literature that captures successful interventions that go only so far. The more comprehensive they get with the addition of other frames, the closer a different organizational culture becomes visible. While the purpose is not to cite an array of sources that offer strategies and solutions for underrepresentation of women in engineering, tracing earlier signal works informing current thinking is needed.

The method for selecting these sources varied from suggestions by WIE Planning Committee members, retrieval of recent literature via keyword searches (gender, intervention, engineering, STEM) from compiler sites such as Web of Science, and my search of the empirical literature contained in online sites such as Assessing Women and Men in Engineering (AWE) and the most recent SWE (Society of Women Engineers) Annual Literature Reviews. Of particular utility was an examination of columns appearing in the 2014 and 2015 issues of *ASEE Prism*. Highlights that explicitly included a gender dimension are noted here as a leading edge of practices. They hold promise as interventions empirically assessed and generalizable to a variety of higher education settings. By appearing in *Prism* they also reflect the latest forward thinking of practicing engineering educators. They are presented as a series of vignettes—a capsule of findings and commentary suggesting they be considered for further action.

A. Equip the Student

Riley (2015) has argued that "We must make the engineering bachelor's flexible, family-friendly, and resource-rich. We must shift the balance of power between two- and four-year schools: those who know low- income, first-generation students best must be the ones to lead four-year institutions in designing learning experiences, curricula, degree plans, and support structures to see them through to a career in engineering.

The two- to four-year college transition has been a staple of the problems besetting engineering (which admittedly is more successful effecting transfer than other STEM disciplines). With a growing cadre of diverse, first-generation students today beginning their higher education in more affordable, closer-to-home two-year colleges, four-year institutions must redouble their efforts to accept, support, and help transfer students succeed. This is done not merely with articulation agreements, but through student-centered collegial exchanges negotiated by faculty and their departments (Coleman, Lipper, Keith, Chubin, and Taylor 2012).

AAUW (2015) finds that "trying to recruit girls and women into existing engineering and computing educational programs and workplaces has had limited success. Changing the environment . . . appears to be a prerequisite for fully integrating women into these fields." Practices operate in micro climates that vary among faculty and student classroom composition. The culture of the classroom is within the purview of the professor. Drawing on resources from the outside, or adjusting pedagogy based on one's own experience, makes the potential for change real albeit piecemeal. For the student, gaining benefit is luck of the draw, i.e., innovative teaching and learning may be practiced in only a few classrooms (typical of Frame 1).

1. *Classroom Pedagogies*. Peer-led team learning, the flipped classroom, just-in-time teaching, and interactive learning strategies are examples of NSF-funded instructional innovations to improve STEM student outcomes (Chubin 2013). Of

particular note for the retention of women in engineering is the classroom-based ENGAGE project (www.engageengineering.org) begun in 2012 and now operating in 72 engineering schools. Of the three primary ENGAGE strategies—everyday examples, faculty-student interaction, and spatial visualization skills—the latter has a decided gender dimension. As Metz, Donohue, and Moore (2012) explain, "significant gender disparities exist on spatial-skills test performance and . . . can directly affect perceptions of self-efficacy, especially in women and individuals from lower socioeconomic groups." Recent research shows that "spatial skills, like other cognitive skills, can be learned, and respond well to training."

A recent study of 120 undergraduate engineering students led the author to conclude that: "Overriding gender stereotypes sometimes requires creating 'microenvironments' that have more than gender parity. This may involve the occasional experience of working in small teams with a high concentration of female peers that encourage women to jump in, speak up and help their team solve technical problems" (Dasgupta in *EurekaAlert* 2015).

Yet others (Chachra 2015) suggest that demographic differences, such as gender, among engineering students don't necessarily mean that we need to design different experiences for each group. "Observed differences between genders reveal an axis along which the student experience varies; what we need to do, then, is design educational experiences that work for students along the entire axis," an example of the "universal design" principle—providing accommodations for people with mobility or other differences (as mandated by the 1990 Americans with Disabilities Act in the U.S.) makes things better for everyone. Dropped curbs are probably the best-known example.

The lesson here is the implementation of practices that help underserved students of all kinds surmount barriers that deter some from pursuing engineering as a career. It reminds us too that policy and law are can inform classroom practices, but are fruitless unless enforced. It is preferable to employ the practices we control in our educational context than tempt the punitive impositions of organizations on the outside. Better to be proactive, both professionally and pedagogically.

2. *Research Experiences*. A corollary of these cooperative learning tools is the exposure of undergraduate students to research (as detected by the BEST review of intervention programs). Nothing seems to "induct" undergrads into the prospect of a research career better than the hands-on experience of *doing* research as part of a team with graduate students, postdocs, and faculty. It promotes a key ingredient, self-efficacy, or the belief that one is capable and competent in one's skills to succeed in a STEM discipline. It is a significant predictor of both motivation and task performance,

especially among minority and women students (Bandura 1986; Rittmaier and Beier 2009).

Undergraduate research experiences "can be life changing for a young person," Duke University NSF REU Director Martha Absher says, because they provide opportunities to work with professionals and solve real-world problems. Such challenges often spark "the confidence and drive to go on into higher engineering education and research" More than a decade of research has found that those with research experience—especially in the first or second year of college and across STEM disciplines, gender, ethnicity, and various institutional settings—are more likely to pursue graduate degrees. They also were more apt to report that a faculty member played an important role in their career choice (Daniel 2014). Thus, research is simultaneously an instructional tool, a recruitment device, and a gateway to the laboratory as a possible future workplace.

B. Enforce Policy and Law

To bring legal and policy considerations to bear on institutional behavior—not just faculty and not just women—changes the narrative from one of practice alone (Frame 1) to one of sanctions (Frame 2). It also puts empirical studies to the test of application, and in so doing, raises the stakes from "discovery" (as in new knowledge) to "advocacy" (acting to mitigate discrimination).

A prominent example was documented in Patricia Gurin's (2004) defense of affirmative action. Diversity was sustained as a compelling interest in the *Grutter* and *Gratz* Supreme Court admissions rulings. A key element of that interest is "critical mass," a concept derived from social science research suggesting that individuals from minority groups are easily marginalized when they are "only a small presence in a larger population, and as a result, may not contribute as fully to their learning environment. The same phenomenon is observed when women are a small presence" (Burgoyne et al. 2010: 27).

Critical mass demonstrates the power of numbers—a measurable, yet relative situation where there is more than one student with a visible difference, e.g., gender or color. In any context, being a minority can inhibit, even stigmatize, by creating a unwelcome climate for those who are perceived as different. Like diversity itself, critical mass is a context-specific construct. It is socially relevant because it points to a condition—the presence or absence of difference. Thus, increasing the number who are different—in a classroom, discipline, or workplace—recalibrates expectations of capability and a sense of belonging by faculty and students alike.

Classroom, and especially campus climate, of course, does not impact just engineering majors, but all women. It can infect the classroom and interactions outside. One response is to resist assimilating into an unwelcoming culture. That is to say, women may leave engineering for reasons unrelated to their ability, interest, or performance. That disengagement is the hallmark of stereotype threat (Steele 1997), a far cry from what law and policy are implemented to protect, but at the very core of affirmative action.

Affirmative action policies—not just Title IX, but Titles VI and VII of the Civil Rights Act of 1964 and the Equal Protection Clause of the 14th Amendment (Malcom et al. 2004)—are a tool to be used to counteract gender biases, unwitting or not, that keep women and persons of color out of engineering. In short, federal funding defines the public interest. Viewed through Frame 2, the burden in an academic context shifts from the enrolled student to the host educating institution.

C. Embrace Difference

There are pockets of diversity on every campus. But demographic scorekeeping by the institution only describes the composition of its student body, and perhaps where there are critical masses of minorities and women. It says nothing about the inclusiveness of the the campus and the organization's respect and comfort for difference. Some institutions cultivate inclusiveness through constituent units (colleges, centers, institutes, living-learning facilities), which can vary student experiences by diversifying or (in contrast to the norm) homogenizing the composition of participants. Three opportunities to embrace difference institutionally are curriculum redesign, modifying admissions criteria, and rethinking faculty hiring.

1. *Curriculum Re-design.* Besides reconfiguring the engineering classroom to account for student diversity and learning styles, the engineering curriculum can widen the circle of professionals to whom the student is exposed and offer different work contexts. Out-of-class experiences preview the kinds of work cultures one may encounter. Therefore, the teamwork, problem-solving, and on-the-job training that engineering is known for becomes a real-time test that may be a wild departure from classroom projects featuring skewed sex ratios and unsupportive peers. Cooperative education, either mandatory or optional, extends the internship experience to more than a single semester-long experience. Female co-op students in particular were found to have higher retention from year 2 to 4, enhanced academic achievement and self-efficacy, and and overall sense of contextual support (Raelin et al. 2014). Co-op represents a curriculum that provides options—organizationally endorsed and faculty practiced—that value off-campus work. Co-op also succeeds in illustrating that what occurs in the work environment is possible in the educational environment. In the process, it inoculates against stereotype threat.

2. *Modifying Admissions Criteria.* Undergraduate admissions is typically centralized in a single office on campus. Faculty are detached from this process (unlike their involvement in graduate admissions decisions). Holloway et al. (2014) hypothesized that “If admissions policies have a significant role in the opportunity to become an engineer, changing such policies may play a role in increasing the representation of groups such as women and minorities in engineering.” Using Institutional data from a public university for the years 2006-10, when the cutoff score for standardized math tests was removed as an admissions factor, the number of “women admitted to the College of Engineering increased and mitigation of gender bias was statistically confirmed.” The research impact was a change in the admissions policy at this university.

A single data point, of course, does not suggest that this could be done at other engineering degree-granting institutions. It does signal, however, that control over undergraduate admissions might be better administered by the School of Engineering instead of a central university office. Put another way, even in this era of “holistic review” (Burgoyne et al. 2010: 28-35, 51-52), if the university resists amending its admissions policy in the face of evidence of gender bias, then should Engineering (or any other School on campus) argue for more decentralized admissions decision making authority?

3. *Rethinking Faculty Hiring.* ASEE (2014) has explored the relationship between gender diversity in the university faculty pool and the rate of female students graduating from bachelor’s degree programs. Extracting faculty and graduation data between 2005 and 2013, ASEE found a correlation between the proportions of women faculty members and women’s graduation rates in disciplines that traditionally have low proportions of female faculty. However, they did not find a similar correlation in disciplines that traditionally attract a high number of female faculty members, such as engineering management and environmental, chemical, and biomedical engineering.

Perhaps a key, both symbolic *and* substantive, is the presence of a female *dean* of engineering—a growing phenomenon. About two dozen engineering colleges are now led by a female dean. The perception of a woman as the locus of authority may be more powerful as a role model and guarantor of fairness than the dean’s actual impact on the student’s classroom experience. Extending this hypothesis further, one looks to woman presidents and chancellors who infuse this can-do attitude into their entire institutions, notably Maria Klawe at Harvey Mudd and Linda Katehi at UC-Davis, with an eye on inspiring women in STEM.

Another variation on faculty hiring is the “cluster hire” approach, which can increase interdisciplinary collaboration and improve diversity, campus climate, and faculty success (Urban Universities for Health 2015). While legally defensible, such hiring is akin to “target of opportunity” models that cannot be gender- or race-conscious, i.e., they must grow out of a publicly-advertised recruitment (Keith and Chubin 2011: 17-18).

D. Evolve the Organizational Culture

We know that Implicit bias and stereotype threat are environmental conditions that affect individual behavior. They infect the culture and typically cannot be traced to any one cause. That is why they are so difficult to root out even when identified. The scholarship of Valian (1998), Rosser (1990), and others can be seen as resources, if not precursors, of efforts to transform organizational culture. The epitome of a successful STEM-based effort is NSF-ADVANCE, the first women-centered professional development program aimed at transforming campus culture. The shift in emphasis is significant, from what women need to do to succeed to how the institution needs to change to encourage and support all. Especially in international comparisons, the first cohort of ADVANCE institutions (e.g., Michigan and Wisconsin, which date to the mid-1990s) are on a trajectory of thorough-going cross-campus structural change, far from complete but undeniably more than promising (Chubin, Didion, and Boku-Betts 2015).

Specifically, the collection of "best practices," either under the aegis of a campus program or its evolution as the behavioral norm, requires an embrace from top administrators to in-the-trenches personnel. Indeed, the BEST (2004: 6) analysis concluded that: (1) the components of effective programs should not be viewed as an a la carte menu but as a package; (2) outstanding programs have the capacity to acknowledge and learn from their mistakes; (3) what often sets best-in-class apart is not a difference in kind but in degree—the quality of teaching, mentoring, research opportunity, etc., that separates top producers of technical talent from other institutions; and (4) the next generation of scientists and engineers is being developed in an educational setting far different from the baby boomers that they will replace. New learning technologies; eroding boundaries between campus, home and work; and demographic shifts demand a keen understanding of the role that context plays in changing culture. According to the BEST criteria, the only institution to experience whole campus culture change was the University of Maryland-Baltimore County with the Meyerhoff Fellows Program as the catalyst.

Taken together, a regime of experimental interventions must demonstrate the support and success of all students, the reward of participating faculty, and a transformation in how the institution capitalizes on difference to achieve educational goals. Such integration, with diversity at the core, is transformative of the culture (Frame 4).

Catalyst has found that a vital ingredient for organizational culture change is breaking barriers to men's engagement. The three barriers are apathy, fear, and ignorance. But organizations limit men's awareness of gender bias by touting "the idea that the are wholly meritocratic and that their human resource policies and practices are invulnerable to bias. By perpetuating the myth of meritocracy and failing to institute checks and balances to limit bias, organizations can inadvertently decrease men's sensitivity to gender inequalities" (Prime and Moss-Racusin 2009).

A hallmark of ADVANCE and much corporate scorekeeping on cultural change within organizations is the use of diversity and inclusion benchmarks. Such metrics utilize institutional data augmented by periodic climate surveys to characterize movements beyond measures by human resource offices, individual academic units, or categories of personnel (Worthington, Stanley, and Lewis 2014). Monitoring change keeps organizational culture uppermost in everyone's mind and provides feedback on the effectiveness of promising practices.

IV. Options for Action

Gleaning from recent (AAUW's *Solving the Equation*) and seasoned (BEST's *A Bridge for All*) reports, as well as the literature discussed above, here are a set of actions that different actors, all represented in this workshop, can take to move *organizations* toward Frame 4. This is an unvarnished act of advocacy focused on the "what" if not the "how." The options are presented in no particular order by category of organizational change agent.

Universities

- Identify "champions of diversity" on campus. These are visible scholars, especially men, with impeccable research records who are also known to mentor and coach women students toward careers in engineering, if not STEM more generally.

- Raise awareness about the costs of gender inequality, discourage zero-sum thinking, help men recognize their gender biases, and provide opportunities for dialogue both within and across gender groups.

- Institute gender-inclusive policies that defines sexual harassment, reduces work-family conflicts, and uses gender-neutral language in public documents—mission statement, job postings, internal communications—and as part of classroom decorum.

- Require the Implicit Association Test (www.implicit.harvard.edu) as a university-wide tool of self-awareness that helps to establish a "bias" baseline. Link administration of this tool to stereotype threat training.

Schools of Engineering/Departments of Engineering

- Conduct curriculum reviews that may result in reconnecting engineering with the rest of the campus through team-taught courses and dual-degree programs.

- Explore decentralized admissions by granting more discretion in applying supplementary criteria to those used in university admissions decisions (much like the practice in graduate program admissions).

- Consult with ABET on accreditation criteria to include diversity metrics for department faculty as well as student enrollment and degree completion.

- Revisit gender bias through climate surveys disaggregated by engineering department to allow for comparisons with School of Engineering norms.

- Commit to hiring and promoting women through the ranks of engineering faculty, chair, dean, and upper administration.

- Adjust recruitment and hiring procedures to ensure diverse searches, i.e., a pool with a diversity of candidates, and accountability for selections through the department chair and dean.

- Pair faculty mentors with new hires to provide a roadmap and guidance to career development.

- Ensure undergraduate contact early and often with non-faculty engineering professionals, especially female role models

- Encourage consultation of sources presenting ENGAGE-like everyday examples that brings engineering to life in the classroom. Similarly, Schools of Engineering could regularly bring novel research on classroom practices to the faculty. Linking adaptation of pedagogical innovations should become a consideration in promotion and tenure evaluation.

Federal Agencies

- Link Title IX compliance reviews on pending investigations to pre-award review after competitive proposal review has recommended new funding.

- Use evidence of sluggish hiring, retention, and advancement of hiring to trigger on-campus training by federal officials, even in the absence of Title IX or other discrimination suits.

- Recognize the top annual producers of women baccalaureates awarded in engineering (as a proportion of total degrees awarded and by institutional type). A Presidential Award modeled on Presidential Awards for Excellence in Science, Mathematics, and Engineering Mentoring (PAESMEM—for higher education faculty) or Presidential Awards for Excellence in Mathematics and Science Teaching

(PAEMST—for precollege educators) could be created and administered by one of the R&D agencies.

V. Conclusions

Engineering writ large is a successful discipline as measured by enrollments, degrees granted, and market demand (entry-level positions and starting salaries). Other metrics, however, tell a different, more nuanced story highlighted above—gender disparities in admissions, retention unrelated to academic performance (lack of critical mass in particular fields, harassment, impediments to access and social relevance), and workplace biases. The reality is that success breeds inertia, not action. Why change—especially if such exhortations flow primarily from those wronged? AAUW (2015) reports that diversity-championing efforts are valued and approved when performed by white men, but disapproved when women and other underrepresented groups dominate. That is why it is vital that white males advocate (Ashcraft et al. 2013) for the action agenda proposed here. Any so-called special pleading must more accurately be seen on behalf of a socially-conscious engineering as a discipline and profession.

Organizationally, the overarching purpose of culture change is not merely to increase the success of certain members, but to reconstitute what they know and can do. To change an organization is to alter the character of the discipline it inhabits and the profession it renews. The Four Frames is thus a blueprint for action enabling progress toward leveling the playing-field in engineering education. But to do so, engineering education must continue to equip, enforce, embrace, and evolve.

VI. References

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