Increasing the Representation of Women and People of Color in Science, Technology, Engineering, and Math (STEM): Scan and Synopsis of Approaches and Opportunities.

Level Playing Field Institute

March 2005

Table of Contents

Increasing the Representation of Women and People of Color in Science, Technology, Engineering, and Math (STEM): Scan and synopsis of approaches and opportunities.

Level Playing Field Institute
March 2005

EXECUTIVE SUMMARY

Why this Report

Despite considerable efforts to correct the underrepresentation of women and people of color in the fields of science, technology, engineering, and math (STEM), progress has been slow. As an organization that creates and runs programs to bring equality to the STEM playing field (http://www.lpfi.org/education), the Level Playing Field Institute wanted to know: What does current programming in this area look like, and how could we be doing even better? Are there missed opportunities for intervention we should be supporting, effective programmatic models that could be replicated, or new ways of thinking about this issue that might better inform our programming? To find answers, we reviewed the abundant research in this area, and surveyed programs designed to increase the number of people of color and women in STEM fields. We compared and contrasted research findings with programmatic models to highlight gaps and opportunities for intervention.

We hope the results of our survey and analysis prove helpful to others in guiding program priorities to deliver on the promise of increased representation of women and people of color in STEM fields.

Additional Resources:

This report is accompanied by two resources. The first is a table of all scholarship and support programs surveyed, available at http://www.lpfi.org/reports/STEMSelectedFundingSources05.doc The second is an annotated bibliography of relevant articles and books we reviewed, available at http://www.lpfi.org/reports/STEMAnnotatedBiblio.pdf Our review, though extensive, was certainly not comprehensive, and we look forward to hearing from anyone who would like to add to these freely available resources, or to provide comments on this report. Please contact Maninder Kahlon at mkahlon@lpfi.org

About the Authors

This report is produced by the Level Playing Field Institute, with key contributions from Angela Jenks and Maninder Kahlon. Angela Jenks is a past Mellon Minority Undergraduate Fellow from the University of Pennsylvania, and is currently in the Medical Anthropology joint program at the Universities of California at Berkeley (UC Berkeley) and San Francisco (UCSF). Maninder Kahlon holds a doctorate in neuroscience from UCSF, and directs the research and workplace programs at the Level Playing Field Institute.

Findings in brief:

Multiple barriers and cumulative disadvantage.

The major finding of our review is that though there is a common understanding of many of the barriers faced by people of color and women in STEM fields, many interventions take one piece of these needs and address them individually. However, the barriers for students and professionals are not single but multiple, complex and interlinked. Indeed, researchers have begun to emphasize cumulative disadvantage as a key issue that needs to be addressed. The challenge for interventions then is to find the right balance in an integrated and student-centric approach that alleviates the multiple barriers faced by people of color and women in STEM. In addition to the overarching themes of multiple barriers and cumulative disadvantage, this is a summary of key findings:

- **Quality of education and finances, core issues currently reflected in program emphases:** There is agreement around a core group of needs, and this is reflected in programmatic emphases. At the level of K-12 schooling, the key issue is the lack of strong teaching and curricula. Permanent change would require a resolution of the inequities in funding in the public school system, but intensive summer programs can mitigate some of the failings of this system for some students, and provide models for success. In college and graduate school, financial constraints are key for students of color, and existing scholarship programs address this to some extent; however, there is a shortfall between the level of scholarship provision and students' levels of need.
- **Environmental components that require more integrated approaches:** Some issues

considered key that are being addressed, albeit in individual and non-integrated efforts, are the absence of relevant extracurricular activities for girls, the lack of role models, the lack of mentorship, few internship opportunities in college, inappropriate style of teaching and the "weed-out" culture in science classes. These issues, though, require systemic and environmental changes either at the societal or institutional level, but such larger-scale change has few backers.

- **Missing: Changes in the workplace and work/life balance:** Two higher-level issues were emphasized that have been recognized, but still require major interventions. First, it is being recognized by both researchers and scientists themselves that even with some improvements in pushing students through the education pipeline, the STEM workplace continues to reflect inequities in numbers and seniority, and needs to be changed. Second, it has also been clearly recognized that there is a pressing need to address work/life balance issues for women (and men) in graduate school and in academic and other workplaces. Currently, this latter issue disproportionately affects women of color.
- **Reframing: Whose problem, people of color and women, or science?** In completing our review, and from the vantage point of the authors and their individual experiences, we also asked if perhaps there was a different way to frame questions of underrepresentation – away from a framing that defines this as the problem of those underrepresented, and towards a framing where we test science itself. In this frame, it is the practice of STEM disciplines, rather than people of color and women, which is failing. We find an opportunity to use the understanding of the culture of science, as developed by sociologists or by practitioners themselves, especially women and people of color who 'made it' through, in informing the practical needs of those interested in changing the culture or, more tactically, in increasing the representation of people of color and women in STEM arenas.

SECTION ONE

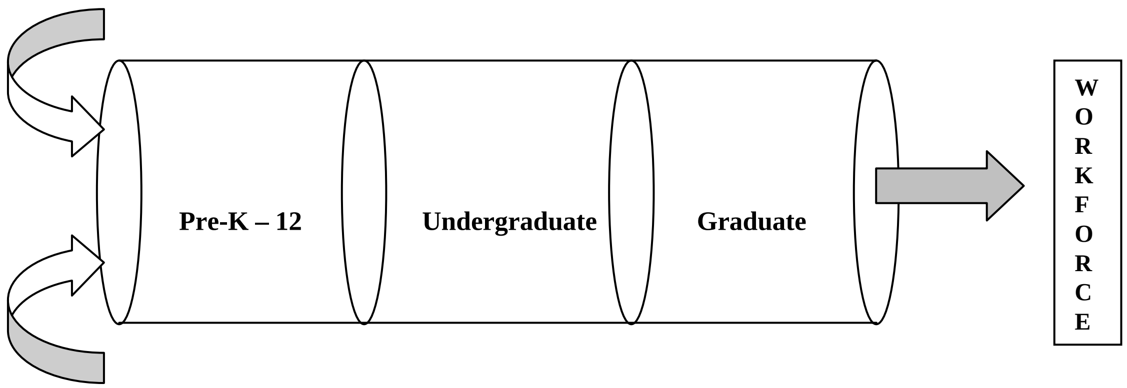
Investigating underrepresentation in STEM fields: Learning from experience

For more than a decade, significant efforts have been made to track and address underrepresentation of women and people of color in STEM fields. The National Science Foundation (NSF) monitors levels of representation at various educational levels and in the workforce, tracking how representation of women and people of color changes—or doesn't change—over time in STEM fields.[1] The NSF's recent studies found that only 24% of workers employed in a science or engineering occupation were women, around 3% were Black, another 3% were Hispanic, and less than one half of 1% were Native American.[2] Women scientists are more likely than men to be employed part-time, and "minority" scientists are more likely than Whites to be unemployed.[3] In addition, thorough reviews and insightful critiques of recent intervention strategies have been offered by the American Association of University Women Educational Foundation (AAUW)[4] and the American Association for the Advancement of Science.[5]

Making it through the pipeline

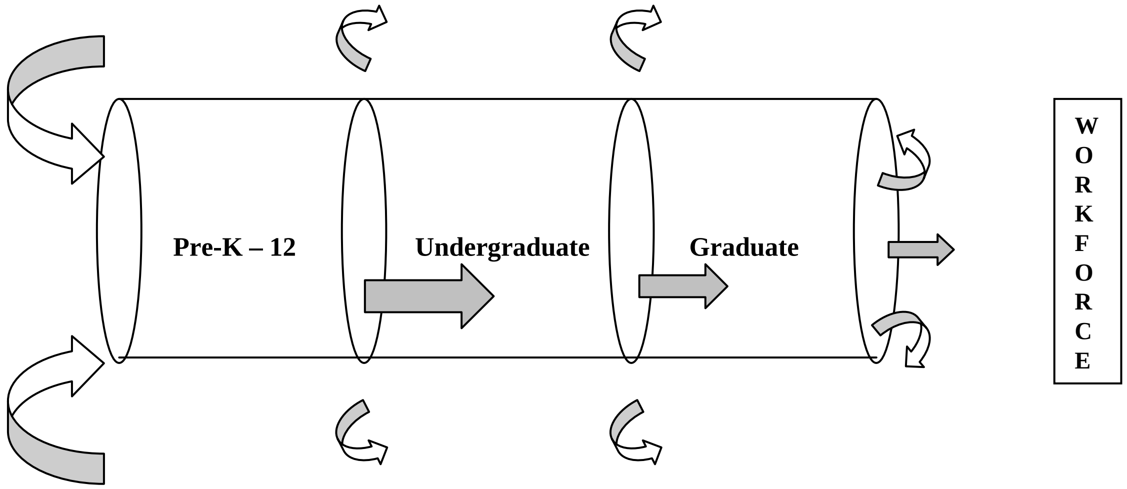
The main tool both researchers and interveners have used to understand and correct underrepresentation of women and people of color in STEM is the pipeline model (Figure 1).[6] This model argues that highly skilled jobs in science and technology require well-educated, trained workers, and that a lack of women and people of color who enter this educational process—by taking math and science in primary and secondary school, by choosing STEM majors in college, or by pursuing advanced degrees in STEM—will inevitably result in a lack of women and people of color in these professions. The solution, then, is to usher more women and people of color into the STEM educational pipeline, so that there will ultimately be more women and people of color exiting the pipeline into STEM professions.

Figure 1: The Pipeline Model



However, this pipeline is often described as "leaky" (Figure 2). Though there is still little longitudinal data following students through the pipeline and as they exit, cross-sectional data demonstrates that the proportion of women and people of color steadily decreases further along the pipeline. Recruitment and retention have thus become critical in understanding and correcting underrepresentation.

Figure 2: The Leaky Pipeline



SECTION TWO
Putting pipeline research into practice

The pipeline model has helped us understand that the underrepresentation of women and people of color in STEM fields we see today is the result of years of inequity at all stages of the educational process, and that successful interventions must operate at a variety of points along the pipeline and be sustained over time. Many researchers are now focused on examining particular stages of the pipeline to understand why women and people of color don't enter it as frequently as others, and why they leave it more often. Research into the various factors that affect students at each stage of the pipeline has been used to prompt a wide range of intervention strategies supported by private foundations, government programs, professional societies, and corporations. Below is an overview of research focusing on crucial junctures along the STEM educational pipeline, and programmatic interventions that address the issues highlighted. The programs we highlight are examples that we found through our search process. They illustrate the type of intervention that currently exists, rather than the all interventions that exist. Finally, in doing our survey we looked specifically for programs whose aim was to address issues related to students of color and/or girls.

Research findings: Pre-kindergarten – Grade 12 education

Workplace disparities begin in primary and secondary school. This is where people of color suffer a disproportionate lack of adequate educational resources, and where distinctions between boys' and girls' math/science ability, confidence, and interest first appears.[7] Since public education is mostly funded through local taxes and bonds, the amount of money a school district receives to pursue STEM and other programs is dependent on the wealth of the community.[8] Poverty differentially affects people of color, and the quality of education overall is impacted by this lack of financial resources. Black, Hispanic, and Native American students are less likely than Whites or Asians to take higher level math courses, chemistry, and physics.[9] Researchers link the lack of confidence of girls and people of color in K-12 science and math to persistent portrayals of STEM practitioners as White and male. The low estimation of abilities among girls and students of color affects K-12 achievement.[10] While boys credit natural ability as the secret to their success in science and engineering, girls are more likely to lack confidence in their science and math abilities and chalk up any successes to diligence and effort.[11]

Targeted interventions

⇒ ***Problem identified by existing research:*** *People of color have less access to high-quality pre-K-12 math and science education, one of the strongest factors affecting future STEM achievement.*[12] Furthermore, in schools with a higher percentage of students of color, teachers are less likely to be certified or have access to the Internet or computers in the classroom—factors that improve student success.[13]

Intervention supported by existing research: *Pre-K-12 programs compensate for the poor quality of education that many young students of color receive*. The $(MS)^2$ Program at the Phillips Academy in Andover, Massachusetts, the Level Playing Field Institute's Summer Math and Science Honors Academy in Berkeley, California, and the Lincoln Foundation's Math and Science Program in Jefferson County, Kentucky each offer summer academic study for public high school students, emphasizing course work in algebra, calculus, biology, and English, as well as academic and college counseling. The Mathematics, Engineering, and Science Achievement (MESA) Schools Program focuses on academic enrichment in California middle and high schools, emphasizing individual academic plans, test preparation, study skills, and career and college opportunities for students. These programs, however, all exist outside of and parallel to the public school system.

⇒ ***Problem identified by existing research:*** *Fewer opportunities for girls in STEM-related extracurricular activities at the pre-K-12 level create achievement gaps between boys and girls.* Research has pointed out that much of the difference in knowledge and experience between men and women comes not from differential preparation in school, but from extracurricular activities. Boys are more likely to have the opportunity to "tinker" with machines and technology.[14]

Intervention supported by existing research: *STEM-related extracurricular activities aimed at girls and students of color offer some opportunities for STEM involvement and achievement.* Science fairs have been sponsored by the Native American Science and Engineering Society. Community outreach programs, organized by the National Society of Black Engineers, Society of Mexican American Engineers and Scientists and the Association for Women in Mathematics introduce students to STEM career possibilities.

⇒ ***Problem identified by existing research:*** *The underrepresentation of women and people of color in STEM fields means that few role models are available*, and women and people of color are rarely portrayed as participating in STEM careers.[15] Researchers have also identified a fundamental conflict between social definitions of women and of engineering.[16]

Intervention supported by existing research: *Some effort is being made to distribute images of roles models for scientists of color or women scientists. Academic enrichment programs provide role models.* Though there are few visible STEM role models who are women or people of color, several groups have worked to change pre-K-12 students' notions of who becomes a scientist. The Alfred P. Sloan Foundation has sponsored Web-based, multimedia, and radio profiles of women mathematicians and scientists, and the Association for Women in Mathematics has encouraged students to find role models by sponsoring a contest for essays based on interviews with contemporary female mathematicians. Level Playing Field Institute's own Summer Math and Science Honors Academy (SMASH) integrates talks and interactions with STEM professionals of color and/or women into its program.

Research findings: Undergraduate education

Disparities are compounded for women and people of color in STEM fields at the undergraduate level. While women are more likely than men to graduate from high school and enroll in college, and are equally likely to graduate from college, they are significantly less likely to major in science and engineering fields.[17] Although Blacks and Hispanics are about as likely to major in science and engineering fields, they are less likely than Whites or Asians to graduate from high school or to enroll in or graduate from college.[18] These findings remind us that females and students of color may be affected by very different factors, and that women of color may be dealing with multiple forms of exclusion in STEM fields.

Furthermore, students of color are more likely than White students to enroll in two-year undergraduate programs. The curricula at two-year community colleges are often not aligned with those at bachelor's-degree granting institutions, and this poor alignment can impede the transition of underrepresented people of color from 2- to 4-year institutions.[19] Forty-four percent of undergraduate students overall were enrolled in a 2-year college in 1997, yet only 42% of White undergraduates were enrolled in a 2-year college as compared to 54% of Hispanic undergraduates, 51% of Native American undergraduates, and 46% of Asian and Black undergraduates.[20]

Targeted interventions

⇒ ***Problem identified by existing research:*** *Financial constraints are a major hurdle for people of color and women in undergraduate STEM programs.* College tuition costs are rising, but are not being met by an increase in scholarships,[21] and "minority" students are more likely than White students to cite financial difficulties as a reason for dropping out of college.[22] While Blacks, Hispanics, and Native Americans are more likely than Whites and Asians to receive financial aid, they receive a lower amount of aid.[23] In addition, studies show that the choice of a career in science is affected by the burden of educational debt a student carries,[24] and that Blacks have a higher debt at graduation than Whites, Asians, or Hispanics.[25]

Intervention supported by existing research: *Scholarships of limited amounts are available for women or people of color entering STEM fields at bachelor's degree-granting institutions.* Current scholarship programs along these lines include the United Negro College Fund (UNCF), the American Association of University Women, and the American Chemical and Physics societies. Most scholarships though do not cover all necessary costs for college tuition, room and board. Instead, they usually offer support in the thousands of dollars but less than $10,000 per year per student. For example, the Xerox Minority Technology Scholarship for undergraduates gives $1000 to a successful candidate, and HENAAC whose mission is to advance Hispanics in engineering, science, technology, and math, gives scholarships to undergraduates of up to $5000. The Mellon Mays Undergraduate Fellowship (previously the Mellon Minority Undergraduate Fellowship) includes physics and mathematics in its supported disciplines and provides similar financial support, but unlike other scholarships, provides focused mentoring and undergraduate loan repayments if students continue on to get a doctoral degree.

⇒ ***Problem identified by existing research:*** *A lack of role models and mentors in academic environments has an adverse effect on women and people of color in STEM fields.* Women science and mathematics majors who remain in the field are more likely to have a mentor than those who leave.[26] Women often lack confidence in their own abilities and the belief that they can succeed in their STEM degree programs.[27] The progress of underrepresented people of color can also be limited by their belief that race or ethnicity, and not ability, plays a major role in selection and admissions.[28]

Intervention supported by existing research: *Mentoring is included as an explicit component in a few scholarship and institutional grant programs.* Prestigious scholarships such as the Mellon Mays Undergraduate Fellowship includes a focused mentoring component. The Sloan Foundation (with its partner the National Action Council for Minorities in Engineering) provides block grants to institutions that provide a positive culture for minority students, as measured by metrics like retention, and that include mentoring.

⇒ ***Problem identified by existing research:*** *Family life and access to research opportunities can affect the progression of women and undergraduates of color.* Marriage has a much greater influence on women's obtainment of a college degree than it does on men's, and an investigation of Hispanic students found that while women are much less likely to graduate if they are married, men are more likely to graduate if they are married.[29] One study found that women science and math majors who remained in the field were more likely to have had undergraduate research experience.[30]

Intervention supported by existing research: *Some corporations and research institutions provide opportunities to get acquainted with research for students of color and women.* Several private corporations such as Lucent Technologies, AT&T, and Merck either work with other groups or sponsor their own summer research programs, and the National Society of Black Engineers offers several corporate-sponsored scholarships and summer internships. Caltech with the support of the Howard Hughes Medical Institute and the NSF offers research internships targeted to students of color and women.

⇒ ***Problem identified by existing research:*** *Undergraduate STEM programs can seem exclusive, restrictive and impersonal.* A department or school's specific recruiting practices can affect the numbers of women and people of color who apply,[31] and recent bans on affirmative action programs are limiting the progression of underrepresented people of color into both undergraduate and graduate-level study.[32] Furthermore, undergraduate STEM programs often feature a "weed out" philosophy[33] that research has shown selects for "hard-headedness" rather than scientific talent and merit.[34] Undergraduate STEM programs also feature little faculty commitment to teaching.[35] One reason Black and Hispanic students choose not to major in science is the restrictiveness of the major, and the poor quality of instruction.[36] Female students are more likely than men to be drawn to science and engineering because of its ability to benefit humanity, but these aspects of the fields are not often emphasized in courses.

Intervention supported by existing research: *Some programs and recent funding trends suggest attention to structural problems.* The vast majority of programs at the undergraduate level are directed toward supporting individual students (although most, as mentioned above, for a limited dollar commitment), rather than changing institutional frameworks. Some funders have recently begun paying attention to reform at the institutional level, most of which involves a greater monetary commitment. The Alfred P. Sloan Foundation provides institutional grants of up to $100,000 for those universities that show track records for recruiting and retaining students of color, and as part of this effort has funded the development of the *Guide for Recruiting and Advancing Academic Women in Science and Engineering*. The Howard Hughes Medical Institute recently initiated a series of grants (total commitment of $50 million) to improve undergraduate science teaching, some of which are directed towards institutions addressing the underrepresentation of students of color in the sciences. The U.S. Department of Education and the NIH offer grants to institutions that serve communities of color, and the NIH also sponsors partnerships strengthening the relationship between 2-year and 4-year institutions. In the late '90s Carnegie-Mellon increased the number of women taking first-year courses in computer science through an integrated approach that involved training high school AP teachers with the required skills and interest to improve girls' participation in high school classes, as well as a concerted effort to improve and open first-year computer science classes at the university to make them more accessible to students with varying backgrounds.[37] Attendance by women at these classes sharply increased.

Research findings: Graduate education

Underrepresentation of people of color increases in STEM fields at the graduate level. Of the science and engineering doctorates earned by US citizens in 1999, 78% were earned by Whites, 11% by Asians, 4% by Hispanics, 4% by Blacks, and 0.7% by Native Americans (NSF 2002).[38] Recent bans on affirmative action have had a negative effect on enrollment of people of color in top Research I universities.[39] Undergraduate standards also affect retention at the graduate level. At an institutional level, a student's persistence in graduate school is correlated with the selectiveness of his or her undergraduate institution, and whether the undergraduate institution had a graduate program.[40] The curricula in bachelor's degree programs and doctoral programs often do not match well, leaving many students with a difficult transition.

Targeted interventions

⇒ ***Problem identified by existing research:*** *At the level of graduate education, financial resources remain an important factor in the underrepresentation of people of color.* The NSF found that larger percentages of Black, Hispanic, and Native American recipients of science and engineering doctorates relied on loans to pay for their graduate education.[41]
Intervention supported by existing research: *Financial aid is provided for graduate students, often full support* Significant resources come from public organizations like the National Science Foundation, the National Institutes of Health, and the National Center for Environmental Research. Several professional societies such as the American Society for Microbiology, the National Consortium for Graduate Degrees for Minorities

in Engineering and Science, Inc., and the Society of Mexican American Engineers and Scientists also offer tuition payments, stipends, or both, as do a number of private corporations like AT&T and Bell Labs. The Ford Foundation Diversity Fellowship provides three years of support for predoctoral graduate candidates, as well as support for writing a dissertation.

⇒ ***Problem identified by existing research:*** *Family considerations again affect women and people of color at the graduate level.* Marital status and the presence of dependents affects the amount of financial aid a student needs, his/her decision to enroll full- or part-time, and his/her ability to complete graduate school. In 1999, only 35% of White STEM graduate students had dependents, while 55% of Native American students did, and 44-48% of Asian, Black, and Hispanic students did.[42]

Intervention supported by existing research: *Structural change is needed on a larger scale,* to shift the culture of science to accommodate family demands for all STEM practitioners. We were unable to find positive models of support that truly address this issue and look forward to hearing from those who know of any.

⇒ ***Problem identified by existing research:*** *Role models for women and people of color continue to be conspicuously absent at the graduate level.* A survey of the top 50 departments in 14 STEM disciplines found no tenured or tenure-track women in computer science departments, and only one female Black full professor in nine physical science and engineering disciplines.[43]

⇒ ***Intervention supported by existing research:*** *There is a need to support the people of color and women that are currently in positions to be role models.* The Howard Hughes Medical Institute recently initiated its “million-dollar professors” program which funds faculty who have made a mark in innovative approaches to their subject, to invest in bringing innovation to teaching. Some of these focus primarily on increasing the participation of underrepresented students. This program, though, is the only systemic intervention we found that highlights the often double duty that professionals of color and women have to accomplish in their professional lives – the first being the job, and the second serving as one of very few mentors to those students and young professionals coming through the pipeline.

SECTION THREE
Bridging the gaps

Our review of interventions reveals that two issues identified by researchers as affecting the progression of women and people of color through the STEM pipeline remain surprisingly under-addressed by intervention programs: the disproportionate effects of family responsibilities on female students, and the effects of STEM culture, both in pedagogy as well as assumptions of merit and style.

Addressing work/life balance concerns

Work/life balance is a major factor impacting representation of women in STEM fields, as demonstrated in the following findings:

- Women who have children within five years of earning a Ph.D. in science or engineering are much less likely to earn tenure than men who do the same.[44]
- While half of the women in science do not have children, only 30% of men do not.[45]
- Tenured women in science are also twice as likely as men to be single, and those who are married are more likely to be negotiating a dual-career household than men.[46]
- While not being married reduces the probability of full-time STEM employment for men, it increases the probability for women. [47]
- Women are much more likely than men (36% vs. 3%) to cite family responsibilities as a reason for not working.[48]

Targeted intervention

⇒ ***Problem identified by existing research:*** *Without institutional change to support greater work/life balance, marriage and childbearing will continue to reduce a woman's chance of advancing in STEM careers.* Women in STEM fields are required more often than men to make family decisions based on their careers, and career decisions based on their families. This disproportionately affects women of color.

⇒ ***Opportunity for intervention suggested by research:*** *Institutional support structures for STEM students and workers with outside responsibilities are needed to strengthen efforts to address underrepresentation of women in STEM fields*. The Sloan Foundation's Dual Ladder Program is one of few resources addressing the difficulties of balancing family life and academic work, and the differential responsibility for childrearing that is placed on women.

Fostering institutional change

Although research shows that teaching emphasis and curricula have an important effect on students' choice of major, very little focus in intervention programs seems to be on producing curricular change or increasing the relative importance of teaching in STEM departments. An analysis of gender equity programs funded by the American Association of University Women and the National Science Foundation suggests that the lack of integration of intervention programs into school curricula shows "that gender equity remains on the margins of teaching and learning in the STEM fields."[49] Furthermore, the "weed out" philosophy of science education is reflected in the extreme work hours and conditions that prevent many scientists—and women in particular—from having fulfilling family lives.

Targeted intervention

⇒ ***Problem identified by existing research:*** *At the university level, there are too few models for structural reform* that might improve introductory-level classes or better integrate the goals of research and education—improvements that could help alleviate underrepresentation.[50]

Opportunity for intervention suggested by research: *Programs addressing women and people of color in STEM fields must be integrated into pedagogy and curricula.* This would help correct the persistent notion (often reinforced by STEM pedagogical practices) that scientists must either devote their lives completely to their work, or relinquish it altogether.

SECTION FOUR

Patching up the pipeline

While the pipeline model has allowed for a great deal of research into the long-term causes of, and potential solutions to, the problem of underrepresentation in STEM fields, researchers have identified three major flaws in this model: a tendency to overlook cumulative disadvantage, insufficient consideration of workplace issues, and a focus on individual success rather than structural change.

Counteracting cumulative disadvantage

The sociologist of science Robert Merton used the term "cumulative advantage" to bring "…attention to the ways in which initial comparative advantages of trained capacity, structural location, and available resources make for successive increments of advantage such that the gaps between the haves and the have-nots in science…widen."[51] But while early opportunities may accumulate and lead to more and more opportunities, early disadvantages also accumulate into ever more daunting disadvantages.[52]

Targeted interventions

⇒ ***Problem identified by existing research:*** *Current models for change tend to overlook cumulative disadvantage.* The linear pipeline model suggests a steady progression from one stage of STEM education to the next, with hurdles encountered at earlier stages left behind and a clear path to success ahead. This does not reflect the experience of women and people of color in STEM fields, who are burdened by disadvantages that accrue over time. It also overlooks the cumulative impact of multiple barriers that are usually faced at any point in time by people of color and women.

Opportunity for intervention suggested by research: *Include an understanding of the total picture for women and people of color in STEM fields in recruitment and retention programs.* Some successful programs take an approach that make up for disadvantage at previous stages of education. For example, the Carnegie-Mellon approach to increasing the number of women taking computer science classes at the university included a consideration of how disadvantage was accumulating through high school. Their approach included influencing the teaching of computer science in high school, which in turn resulted in greater numbers of girls taking these classes. They then adapted introductory classes at the university itself to make them more open and accessible to students who hadn't already decided that they wanted to study computer science. Changing the format of introductory courses in this case helped account for the fact that students were not arriving at the university with similar histories – women, in this case, were arriving with a lack of role models, perhaps a negative attitude toward studying computer science because of the way it was taught, etc. Instead of continuing down this path, women were given another shot at reimagining themselves as computer scientists through the more open introductory courses. The Level Playing Field Institute's college-prep Summer Math and Science Honors Academy takes an approach of understanding what cumulative disadvantage looks like for the students in its program. This envisioning, and student-centric approach determined the features of the program which includes as its centerpiece a rigorous approach to academics and a strong curriculum for the students of color in its program. But integrated with the academics are multiple other features, including a regular introduction to potential role models, senior scientists and practitioners of color, as well as the integration of a small stipend, realizing that for these students and their families, a paying summer job is crucial.

Considering workplace issues

Simply delivering women and people of color into the labor market does not mean that they will succeed in that market.[53] Women scientists and engineers are underrepresented at research universities, more concentrated at lower-paying institutions, and tend to be employed in academic jobs that stress teaching over research.[54] A recent effort to collect data on seniority of women and people of color in the top universities in 14 science-related disciplines revealed sharp inequities in representation[55]. In 2002, for example, one would not be able to find a single (native-born) woman of color tenured or tenure-track professor in the top 50 departments of computer science.[56] NSF data show that of those employed in science and engineering occupations, women are less likely than men to be employed in the private for-profit sector (49% vs. 65%), and more likely to be employed in four-year colleges or universities (21% vs. 12%) — though at not the most prestigious colleges and universities. Even though a growing number of women and people of color are completing Ph.D.s, they are not being hired by the top academic departments.

Targeted intervention

⇒ ***Problem identified by existing research:*** *Many STEM workplaces are not appealing to women and people of color because of their "chilly climate" and undervaluing of difference.*[57] While some evidence suggests that women are more likely than their male peers to prefer teaching and value student quality, collegiality within the department, and female representation on the faculty, the authors point out that we must be careful not to equate “preference” with individual, non-systemic values. The preferences of women and people of color are limited to opportunities available to them, and influenced by adverse experiences in less adaptive STEM workplaces.

⇒ ***Opportunity for intervention suggested by research:*** *Although there is a need to change the STEM workplace, there is currently little systemeatic emphasis on this need.* A workplace that is more appealing to women and people of color, and that truly recognizes their importance, could have a profound effect on the number of people who choose to pursue STEM fields, and on the academic system itself. However, we found few examples of systematic and large-scale change in STEM workplaces, academic or commercial. The STEM academic workplace is a particularly potent locus of change, since it would address not only workplace issues, but in turn reflect back to inspire students of color and women in the academic programs.

Promoting structural change

The pipeline model for progress hinges on critical mass theory, which suggests that as a “group’s presence and level of participation grows, at a particular point the perspective of members of the minority group and the character of relations between minority and majority changes qualitatively.”[58] Many researchers also claim that increased numbers will have a feedback effect: As more women and people of color are present to serve as role models, they will encourage more female and minority students to pursue STEM careers.[59] However, since women and people of color tend to be younger, in lower status positions, and with less job security, they are not always in a position to effect change in their workplace environment.[60] Furthermore, women and people of color are not cohesive groups, and this differentiation can produce isolation even when overall numbers are high.[61] While critical mass can partly solve many problems in academic departments, it cannot be a unilateral change strategy.

Assuming that increasing the numbers of people from these groups will, alone, remove barriers also places a tremendous burden on women and people of color: Not only must they do the same (if not better) scientific work than their White and male counterparts, but they are also responsible for changing the educational system and workplace climates (in their free time). This “faculty burden” includes a disproportionate share of responsibility as contacts and role models for underrepresented students. Most often, this work is not rewarded in tenure or promotion decisions.[62] Researchers argue that targeted programs are necessary, but must be joined with structural change that will eventually make targeting unnecessary.[63]

Targeted intervention

⇒ ***Problem identified by existing research:*** *The pipeline model for addressing underrepresention focuses on individual success rather than structural change.* The emphasis on recruiting and retaining women and people of color in the pipeline encourages intervention strategies that enable students and faculty to fit into, adjust to, and negotiate the existing system, rather than challenging structures that currently exist.[64]
Opportunity for intervention suggested by research: *Some recent efforts have begun to address structural issues, but this remains a hard challenge.* The Sloan Foundation's approach to supporting underrepresented students recognizes that environments for success are created by faculty and institutions. Therefore, they provide money to those faculty and institutions with a track record of graduating students of color. In this way they reinforce efforts that improve the system. The Howard Hughes Foundation, in its recent investments in institutions to address the teaching of science in colleges, is funding some institutional-level work on increasing the diversity of students in the sciences, and it will be useful to track the progress of this work.

SECTION FIVE
Thinking outside the pipeline

Each of these critiques raises important questions about the limitations of the pipeline approach, and suggests ways in which the pipeline could be improved and expanded. But what if we step outside of the pipeline altogether? Could we find new perspectives on the problem of underrepresentation and promising new solutions to it?

Redefining the problem of underrepresention

The lack of qualified women and people of color has been described as "imperiling national prosperity", and the reaction to this concern is to produce more skilled, qualified, women and people of color. The dearth of women and people of color in STEM fields has been linked to concerns over the future of the U.S.'s position as a global technological and economic leader. As population demographics shift, women and people of color make up an increasing proportion of the U.S. workforce.[65] Many worry, however, that their absence from STEM fields could lead to a shortage of skilled American workers in those fields,[66] and an over-reliance on international talent.[67] Researchers have warned of a "quiet crisis:" As foreign nations become increasingly competitive and off-shore science and engineering options become more attractive, "our failure to act on the talent imperative could erode national innovation capabilities, increase the migration of high-wage science and engineering jobs overseas, dislocate the economy if inflows of international talent are reduced, and undercut public support for U.S. research and development."[68] From this perspective, women and people of color represent an "untapped reservoir of talent" essential to the national interest.[69]

From reactive to proactive

The pipeline model assumes that the reason women and people of color are underrepresented in STEM fields is that there are just not enough qualified women and people of color in the pipeline. But since underrepresentation persists despite a growing pool of qualified women and people of color, we need to ask: What are the causes of underrepresentation in STEM, and how could we address them directly, instead of focusing efforts on mitigating their impact? Researchers have gathered a lot of information about how children are affected by a substandard science education—but what if we asked why some schools are substandard?

Shifting the burden

In the existing framework, it is women and people of color—and their lack of skill—that become the problem, and the solution is to fix them by equipping them with the necessary STEM skills. Researchers using the pipeline model to understand and address underrepresentation have asked: "What do women and people of color need to be successful scientists?" But what if we asked: "What does science need to be successfully inclusive?" Suddenly, it is science itself that needs to change. The burden of responsibility is no longer placed on individual women and people of color, but on the field itself. While barriers to the full participation of women and people of color exist in many areas, they are especially extreme in STEM, suggesting that we must look closely at issues within these fields to understand the underrepresentation within them.

Changing science

Women and people of color bring perspectives to scientific endeavors that have the potential to radically change science. Scientific fields are more often defined than others as "universal," where the personal characteristics of the scientist are irrelevant either to the practice of science or the relationship among scientists.[70] Sociologists of science have long challenged this view, arguing that "objectivity" itself is defined as a masculine quality,[71] and pointing to the history of a scientific workplace that was developed to fit the needs of men who had wives working at home full-time. Others have pointed out that gendered and racialized notions affect not just the practice of science, but the very content of what is discovered.[72] In order to fully incorporate the perspectives of women and people of color, in STEM fields, women and people of color can not be simply "fit into" science as it is; science itself must change. For this to happen, in turn, we need to bridge the gap between our understanding of the culture of science - either as developed by those who study it, or as understood by scientists and practitioners themselves - and the practices of implementing the reform necessary to increase diversity in STEM fields. Some of the most interesting answers may be revealed through the stories and reflections of those scientists – women and people of color – that have "made it" through the system.

---

[1] National Science Foundation, *Women, Minorities, and Persons with Disabilities in Science and Engineering*. (Arlington, VA: NSF, Division of Science Resources Statistics, 2000 and 2002).

[2] National Science Foundation, *Women, Minorities, and Persons with Disabilities in Science and Engineering* (Arlington, VA: NSF, Division of Science Resources Statistics, 2002).

[3] Ibid.

[4] American Association of University Women Educational Foundation (AAUW), *Under the Microscope: A Decade*

of Gender Equity Projects in the Sciences (Washington, D.C.: AAUW Educational Foundation, 2004).

[5] George, Yolanda S., David S. Neale, Virginia Van Horne, and Shirley M. Malcom, *In Pursuit of a Diverse Science, Technology, Engineering, and Mathematics Workforce: Recommended Research Priorities to Enhance Participation by Underrepresented Minorities* (Washington, D.C.: American Association for the Advancement of Science, 2001).

[6] While this report is concerned generally with women and minorities in STEM, we recognize that there is a danger of grouping too many separate issues together. Exclusions based on race and those based on gender can be very different, and the distinction between "women" and "minorities" can often neglect the multi-layered barriers faced by women of color. An over-reliance on racial categories to evaluate representation can also mask intragroup distinctions. For example, while numbers of Black students at some schools may be increasing, some are concerned that the majority are foreign-born, not African Americans (see Sara Rimer and Karen W. Arenson, "Top Colleges Take More Blacks, But Which Ones?" *New York Times*, June 24, 2004). Also, while Asians are often described as overrepresented in STEM fields, this category does not distinguish between ethnic and national groups. Finally, there is no agreement in the literature about what counts as a STEM field; "STEM" has been applied to a wide variety of disciplines with differing levels of representation. The National Science Foundation's research (cited above) shows that women and minorities tend to be *over*represented in the social, behavioral, and biological sciences, while they are severely *under*represented in other STEM fields, such as the physical sciences and engineering. While recognizing these complexities, this report seeks to offer a response to the more general approach that underlies research and intervention priorities.

[7] Leslie, Larry L., Gregory T. McClure, and Ronald L. Oaxaca, "Women and Minorities in Science and Engineering: A Life Sequence Analysis*," Journal of Higher Education 69 (3),* 1998, 239-276.

[8] National Science Foundation, *Women, Minorities, and Persons with Disabilities in Science and Engineering* (Arlington, VA: NSF, Division of Science Resources Statistics, 2002); Babco, Eleanor, *Trends in African American and Native American Participation in STEM Higher Education* (New York: Commission on Professionals in Science and Technology, 2003).

[9] National Science Foundation, *Women, Minorities, and Persons with Disabilities in Science and Engineering* (Arlington, VA: NSF, Division of Science Resources Statistics, 2002).

[10] George, Yolanda S., David S. Neale, Virginia Van Horne, and Shirley M. Malcom, *In Pursuit of a Diverse Science, Technology, Engineering, and Mathematics Workforce: Recommended Research Priorities to Enhance Participation by Underrepresented Minorities* (Washington, D.C.: American Association for the Advancement of Science, 2001).

[11] Leslie, Larry L., Gregory T. McClure, and Ronald L. Oaxaca, "Women and Minorities in Science and Engineering: A Life Sequence Analysis*," Journal of Higher Education 69 (3),* 1998, 239-276.

[12] National Science Foundation, *Women, Minorities, and Persons with Disabilities in Science and Engineering* (Arlington, VA: NSF, Division of Science Resources Statistics, 2002); George, Yolanda S., David S. Neale, Virginia

Van Horne, and Shirley M. Malcom, *In Pursuit of a Diverse Science, Technology, Engineering, and Mathematics Workforce: Recommended Research Priorities to Enhance Participation by Underrepresented Minorities* (Washington, D.C.: American Association for the Advancement of Science, 2001); Babco, Eleanor, *Trends in African American and Native American Participation in STEM Higher Education* (New York: Commission on Professionals in Science and Technology, 2003); BEST: Building Engineering and Science Talent, *The Talent Imperative: Diversifying America's Science and Engineering Workforce* (San Diego: BEST, 2004).

[13] National Science Foundation, *Women, Minorities, and Persons with Disabilities in Science and Engineering* (Arlington, VA: NSF, Division of Science Resources Statistics, 2002)

[14] Goodman, Irene F., Christine M. Cunningham, Cathy Lachapelle, Meredith Thompson, Katherine Bittinger, Robert T. Brennan, and Mario Delci, *Final Report of the Women's Experiences in College Engineering (WECE) Project* (Cambridge, MA: Goodman Research Group, Inc., 2002);George, Yolanda S., David S. Neale, Virginia Van Horne, and Shirley M. Malcom, *In Pursuit of a Diverse Science, Technology, Engineering, and Mathematics Workforce: Recommended Research Priorities to Enhance Participation by Underrepresented Minorities* (Washington, D.C.: American Association for the Advancement of Science, 2001).

[15] Commission on the Advancement of Women and Minorities in Science, Engineering, and Technology Development (CAWMSET), *Land of Plenty: Diversity as America's Competitive Edge in Science, Engineering, and Technology*, 2000; BEST: Building Engineering and Science Talent, *The Talent Imperative: Diversifying America's Science and Engineering Workforce* (San Diego: BEST, 2004).

[16] Goodman, Irene F., Christine M. Cunningham, Cathy Lachapelle, Meredith Thompson, Katherine Bittinger, Robert T. Brennan, and Mario Delci, *Final Report of the Women's Experiences in College Engineering (WECE) Project* (Cambridge, MA: Goodman Research Group, Inc., 2002).

[17] National Science Foundation, *Women, Minorities, and Persons with Disabilities in Science and Engineering* (Arlington, VA: NSF, Division of Science Resources Statistics, 2002).

[18] Ibid.

[19] George, Yolanda S., David S. Neale, Virginia Van Horne, and Shirley M. Malcom, *In Pursuit of a Diverse Science, Technology, Engineering, and Mathematics Workforce: Recommended Research Priorities to Enhance Participation by Underrepresented Minorities* (Washington, D.C.: American Association for the Advancement of Science, 2001); Commission on the Advancement of Women and Minorities in Science, Engineering, and Technology Development (CAWMSET), *Land of Plenty: Diversity as America's Competitive Edge in Science, Engineering, and Technology*, 2000.

[20] National Science Foundation, *Women, Minorities, and Persons with Disabilities in Science and Engineering* (Arlington, VA: NSF, Division of Science Resources Statistics, 2002).

[21] Commission on the Advancement of Women and Minorities in Science, Engineering, and Technology Development (CAWMSET), *Land of Plenty: Diversity as America's Competitive Edge in Science, Engineering, and Technology*, 2000.

[22] George, Yolanda S., David S. Neale, Virginia Van Horne, and Shirley M. Malcom, *In Pursuit of a Diverse Science, Technology, Engineering, and Mathematics Workforce: Recommended Research Priorities to Enhance Participation by Underrepresented Minorities* (Washington, D.C.: American Association for the Advancement of Science, 2001).

[23] National Science Foundation, *Women, Minorities, and Persons with Disabilities in Science and Engineering* (Arlington, VA: NSF, Division of Science Resources Statistics, 2002).

[24] George, Yolanda S., David S. Neale, Virginia Van Horne, and Shirley M. Malcom, *In Pursuit of a Diverse Science, Technology, Engineering, and Mathematics Workforce: Recommended Research Priorities to Enhance Participation by Underrepresented Minorities* (Washington, D.C.: American Association for the Advancement of Science, 2001).

[25] National Science Foundation, *Women, Minorities, and Persons with Disabilities in Science and Engineering* (Arlington, VA: NSF, Division of Science Resources Statistics, 2002).

[26] Rayman, Paula and Belle Brett, "Women Science Majors: What Makes a Difference in Persistence after Graduation?" *Journal of Higher Education 66(4),* 1995, 388-414.

[27] Goodman, Irene F., Christine M. Cunningham, Cathy Lachapelle, Meredith Thompson, Katherine Bittinger, Robert T. Brennan, and Mario Delci, *Final Report of the Women's Experiences in College Engineering (WECE) Project* (Cambridge, MA: Goodman Research Group, Inc., 2002).

[28] George, Yolanda S., David S. Neale, Virginia Van Horne, and Shirley M. Malcom, *In Pursuit of a Diverse Science, Technology, Engineering, and Mathematics Workforce: Recommended Research Priorities to Enhance Participation by Underrepresented Minorities* (Washington, D.C.: American Association for the Advancement of Science, 2001).

[29] Leslie, Larry L., Gregory T. McClure, and Ronald L. Oaxaca, "Women and Minorities in Science and Engineering: A Life Sequence Analysis*,"* *Journal of Higher Education* 69 (3), 1998, 239-276.

[30] Rayman, Paula and Belle Brett, "Women Science Majors: What Makes a Difference in Persistence after Graduation?" *Journal of Higher Education 66(4),* 1995, 388-414.

[31] BEST: Building Engineering and Science Talent, *The Talent Imperative: Diversifying America's Science and Engineering Workforce* (San Diego: BEST, 2004).

[32] George, Yolanda S., David S. Neale, Virginia Van Horne, and Shirley M. Malcom, *In Pursuit of a Diverse Science, Technology, Engineering, and Mathematics Workforce: Recommended Research Priorities to Enhance Participation by Underrepresented Minorities* (Washington, D.C.: American Association for the Advancement of Science, 2001); Malcom, Shirley M., Yolanda S. George, and Virginia V. Van Horne, *The Effect of the Changing Policy Climate on Science, Mathematics, and Engineering Diversity* (Washington, D.C.: American Association for the Advancement of Science, 1996).

[33] Goodman, Irene F., Christine M. Cunningham, Cathy Lachapelle, Meredith Thompson, Katherine Bittinger, Robert T. Brennan, and Mario Delci, *Final Report of the Women's Experiences in College Engineering (WECE)*

Project (Cambridge, MA: Goodman Research Group, Inc., 2002).

[34] Seymour, Elaine and Nancy M. Hewitt, *Talking about Leaving: Why Undergraduates Leave the Sciences* (Westview Press, 2000).

[35] BEST: Building Engineering and Science Talent, *The Talent Imperative: Diversifying America's Science and Engineering Workforce* (San Diego: BEST, 2004).

[36] Clewell, Beatriz Chu, and Shirley Vining Brown, Project Talent Flow: *The Non-SEM Field Choices of Black and Latino Undergraduates with the Aptitude for Science, Engineering, and Mathematics Careers*, 1998; George, Yolanda S., David S. Neale, Virginia Van Horne, and Shirley M. Malcom, *In Pursuit of a Diverse Science, Technology, Engineering, and Mathematics Workforce: Recommended Research Priorities to Enhance Participation by Underrepresented Minorities* (Washington, D.C.: American Association for the Advancement of Science, 2001.

[37] Margolis, Jane and Allan Fisher, *Unlocking the Clubhouse: Women in Computing.* The MIT Press, 2003.

[38] National Science Foundation, *Women, Minorities, and Persons with Disabilities in Science and Engineering* (Arlington, VA: NSF, Division of Science Resources Statistics, 2002).

[39] Ibid.

[40] George, Yolanda S., David S. Neale, Virginia Van Horne, and Shirley M. Malcom, *In Pursuit of a Diverse Science, Technology, Engineering, and Mathematics Workforce: Recommended Research Priorities to Enhance Participation by Underrepresented Minorities* (Washington, D.C.: American Association for the Advancement of Science, 2001.

[41] Ibid.

[42] Ibid.

[43] Nelson, Donna J. and Diana C. Rogers, *A National Analysis of Diversity in Science and Engineering Faculties at Research Universities*, 2004.

[44] Mason, Mary Ann and Marc Goulden, "Do Babies Matter? The Effect of Family Formation on the Lifelong Careers of Academic Men and Women," *Annals of the American Academy of Political and Social Science*, 2004.

[45] Ibid.

[46] Ibid.

[47] Leslie, Larry L., Gregory T. McClure, and Ronald L. Oaxaca, "Women and Minorities in Science and Engineering: A Life Sequence Analysis," *Journal of Higher Education 69 (3),* 1998, 239-276.

[48] National Science Foundation, *Women, Minorities, and Persons with Disabilities in Science and Engineering* (Arlington, VA: NSF, Division of Science Resources Statistics, 2002).

[49] American Association of University Women Educational Foundation (AAUW), *Under the Microscope: A Decade of Gender Equity Projects in the Sciences* (Washington, D.C.: AAUW Educational Foundation, 2004), iii.

[50] Malcom, Shirley M., Yolanda S. George, and Virginia V. Van Horne, *The Effect of the Changing Policy Climate on Science, Mathematics, and Engineering Diversity* (Washington, D.C.: American Association for the

Advancement of Science, 1996).

[51] Merton, Robert K., "The Matthew Effect in Science, II: Cumulative Advantage and the Symbolism of Intellectual Property," *Isis 79*, 1998, 606.

[52] Malcom, Shirley M., "Minority Ph.D. Production in SME Fields: Distributing the Work?" *Research News on Graduate Education 2(3),* 2000.

[53] Fishman, Charlotte, *Using a Legal Toolkit to Fix the Leaky Pipeline: Overcoming Discrimination through the Interplay of Science and Strategy* (paper presented at Women in Astronomy II Conference, Pasadena, CA, June 28, 2003); Kuck, Valerie, "Refuting the Leaky Pipeline Hypothesis," *Chemistry and Engineering News 79(47),* 71-73.

[54] Bentley, Jerome T. and Rebecca Adamson, *Gender Differences in the Careers of Academic Scientists and Engineers: A Literature Review* (Arlington, VA: National Science Foundation, 2003).

[55] Nelson, Donna J. and Diana C. Rogers, *A National Analysis of Diversity in Science and Engineering Faculties at Research Universities*, 2004.

[56] Ibid.

[57] Commission on the Advancement of Women and Minorities in Science, Engineering, and Technology Development (CAWMSET), *Land of Plenty: Diversity as America's Competitive Edge in Science, Engineering, and Technology*, 2000.

[58] Etzkowitz, Henry, Carol Kemelgor, Michael Neuschatz, Brian Uzzi, and Joseph Alonzo, "The Paradox of Critical Mass for Women in Science," *Science 266(5182),* 1994, 51-54.

[59] Nelson, Donna J. and Diana C. Rogers, *A National Analysis of Diversity in Science and Engineering Faculties at Research Universities*, 2004.

[60] Ibid.

[61] Etzkowitz, Henry, Carol Kemelgor, Michael Neuschatz, Brian Uzzi, and Joseph Alonzo, "The Paradox of Critical Mass for Women in Science," *Science 266(5182),* 1994, 51-54.

[62] Malcom, Shirley M., "Minority Ph.D. Production in SME Fields: Distributing the Work?" *Research News on Graduate Education 2(3),* 2000.

[63] Malcom, Shirley M., Yolanda S. George, and Virginia V. Van Horne, *The Effect of the Changing Policy Climate on Science, Mathematics, and Engineering Diversity* (Washington, D.C.: American Association for the Advancement of Science, 1996).

[64] Matyas, M. and S.M. Malcom, eds., *Investing in Human Potential: Science and Engineering at the Crossroads* (Washington, D.C.: American Association for the Advancement of Science, 1991).

[65] BEST: Building Engineering and Science Talent, *The Talent Imperative: Diversifying America's Science and Engineering Workforce* (San Diego: BEST, 2004).

[66] Commission on the Advancement of Women and Minorities in Science, Engineering, and Technology Development (CAWMSET), *Land of Plenty: Diversity as America's Competitive Edge in Science, Engineering, and Technology*, 2000.

[67] BEST: Building Engineering and Science Talent, *The Talent Imperative: Diversifying America's Science and Engineering Workforce* (San Diego: BEST, 2004).

[68] BEST: Building Engineering and Science Talent, *The Talent Imperative: Diversifying America's Science and Engineering Workforce* (San Diego: BEST, 2004), 7.

[69] George, Yolanda S., David S. Neale, Virginia Van Horne, and Shirley M. Malcom, *In Pursuit of a Diverse Science, Technology, Engineering, and Mathematics Workforce: Recommended Research Priorities to Enhance Participation by Underrepresented Minorities* (Washington, D.C.: American Association for the Advancement of Science, 2001.

[70] MacLachlan, Anne J., Why Be a Professor? An Analysis of the Career Choices of Minority Ph.D.s in Science and Engineering Earned from the University of California Between 1980-1990 (paper presented at the Association for the Study of Higher Education Conference, November 13, 2002).

[71] Keller, Evelyn Fox, "Women in Science," *Science 236(4801)*, 1987, 507; Keller, Evelyn Fox, "Gender and Science: Origin, History, and Politics," *Osiris 10*, 1995, 26-38.

[72] Martin, Emily, "The Egg and the Sperm: How Science has Constructed a Romance Based on Stereotypical Male-Female Roles," *Signs 16*, 1991, 485-501; Keller, Evelyn Fox, "Gender and Science: Origin, History, and Politics," *Osiris 10*, 1995, 26-38. In a classic example, Martin described the way gender norms informed metaphors used to describe the roles of gametes in reproduction. The sperm was "active," "forceful," and "self-propelled," able to "penetrate" the egg and "activate the developmental program." The egg, on the other hand, was described as "swept" or "drifting" along the fallopian tube until it was "assaulted" or "penetrated" by the sperm. Details of the active process the egg plays in fertilization went unrecognized for years, due in part to the inability of scientists to conceptualize equally important roles for the "male" sperm and "female" egg.

Appendix A: Works Cited

American Association of University Women Educational Foundation (AAUW)

2004 *Under the Microscope: A Decade of Gender Equity Projects in the Sciences.* Washington, D.C.: AAUW Educational Foundation.

Babco, Eleanor

2003 *Trends in African American and Native American Participation in STEM Higher Education.* New York: Commission on Professionals in Science and Technology.

Bentley, Jerome T. and Rebecca Adamson

2003 *Gender Differences in the Careers of Academic Scientists and Engineers: A Literature Review.* Arlington, VA: National Science Foundation.

BEST: Building Engineering and Science Talent.

2004 *The Talent Imperative: Diversifying America's Science and Engineering Workforce.* San Diego: BEST.

Clewell, Beatriz Chu and Shirley Vining Brown

1998 Project Talent Flow: The non-SEM Field Choices of Black and Hispanic Undergraduates with the Aptitude for Science, Engineering, and Mathematics Careers.

Commission on the Advancement of Women and Minorities in Science, Engineering, and Technology Development (CAWMSET)

2000 Land of Plenty: Diversity as America's Competitive Edge in Science, Engineering, and Technology.

Etzkowitz, Henry, Carol Kemelgor, Michael Neuschatz, Brian Uzzi, and Joseph Alonzo

1994 "The Paradox of Critical Mass for Women in Science." *Science* 266(5182):51-54.

Fishman, Charlotte

2003 *Using a Legal Toolkit to Fix the Leaky Pipeline: Overcoming Discrimination through the Interplay of Science and Strategy.* Paper presented at the Women in Astronomy II Conference, Pasadena, CA, June 28.

George, Yolanda S., David S. Neale, Virginia Van Horne, and Shirley M. Malcom
2001 *In Pursuit of a Diverse Science, Technology, Engineering, and Mathematics Workforce: Recommended Research Priorities to Enhance Participation by Underrepresented Minorities.* Washington, D.C.: American Association for the Advancement of Science.

Goodman, Irene F., Christine M. Cunningham, Cathy Lachapelle, Meredith Thompson, Katherine Bittinger, Robert T. Brennan, and Mario Delci
2002 *Final Report of the Women's Experiences in College Engineering (WECE) Project.* Cambridge, MA: Goodman Research Group, Inc.

Keller, Evelyn Fox
1987 "Women in Science." *Science* 236(4801):507.
1995 "Gender and Science: Origin, History, and Politics." *Osiris* 10:26-38.

Kuck, Valerie
2001 "Refuting the Leaky Pipeline Hypothesis." *Chemistry and Engineering News* 79(47):71-73.

Leslie, Larry L., Gregory T. McClure, and Ronald L. Oaxaca
1998 "Women and Minorities in Science and Engineering: A Life Sequence Analysis." *Journal of Higher Education* 69(3):239-276.

MacLachlan, Anne J.
2003 *Why Be a Professor? An Analysis of the Career Choices of Minority Ph.D.s in Science and Engineering Earned from the University of California Between 1980-1990.* Paper presented at the Association for the Study of Higher Education Conference, November 13.

Malcom, Shirley M.
2000 "Minority PhD Production in SME Fields: Distributing the Work?" *Research News on Graduate Education* 2(3).

Malcom, Shirley M., Yolanda S. George, and Virginia V. Van Horne
1996 *The Effect of the Changing Policy Climate on Science, Mathematics, and Engineering Diversity.* Washington, D.C.: American Association for the Advancement of Science.

Margolis, Jane and Allan Fisher

2003 *Unlocking the Clubhouse: Women in Computing*. The MIT Press

Martin, Emily

1991 "The Egg and the Sperm: How Science has Constructed a Romance Based on Stereotypical Male-Female Roles." *Signs* 16:485-501.

Mason, Mary Ann and Marc Goulden

2004 "Do Babies Matter? The Effect of Family Formation on the Lifelong Careers of Academic Men and Women." *Annals of the American Academy of Political and Social Science.*

Matyas, M. and S.M. Malcom, eds.

1991 *Investing in Human Potential: Science and Engineering at the Crossroads.* Washington, D.C.: American Association for the Advancement of Science.

Merton, Robert K.

1988 "The Matthew Effect in Science, II: Cumulative Advantage and the Symbolism of Intellectual Property." *Isis* 79:606-623.

National Science Foundation

2000 *Women, Minorities, and Persons with Disabilities in Science and Engineering.* Arlington, VA: NSF.

2002 *Women, Minorities, and Persons with Disabilities in Science and Engineering.* Arlington, VA: NSF, Division of Science Resources Statistics.

Nelson, Donna J. and Diana C. Rogers

2004 *A National Analysis of Diversity in Science and Engineering Faculties at Research Universities.*

Rayman, Paula and Belle Brett

1995 "Women Science Majors: What Makes a Difference in Persistence after Graduation?" *Journal of Higher Education* 66(4):388-414.

Rimer, Sara, and Karen W. Arenson
2004 "Top Colleges Take More Blacks, but Which Ones?" *New York Times*, June 24.

Seymour, Elaine and Nancy M. Hewitt
2000 *Talking about Leaving: Why Undergraduates Leave the Sciences* Westview Press

Women's Research Network News
2002 *Striking a Balance: Involving Girls and Women in Science and Technology*.