Information Sheet:
The Talent Crisis in Science and Engineering

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There is a talent crisis in science and engineering that constrains America's economic productivity, competitiveness, quality of life, and security. Our educational system is not producing the workforce – in numbers of people, skills, or diversity – we need to continue a position of international leadership in innovation and technology. Technology is key to our growth, contributing as much as 85% in per capita income (Committee on Prospering in the Global Economy of the 21st Century, 2006).

Reliance on Foreign Talent
Our reliance on imported talent is high and increasing. Of the Ph.D. engineering, mathematics, computers sciences, physics, and economics graduates from U.S. colleges and universities – the pool for our future faculty – over 50% are foreign students (National Science Board, 2008).

National Productivity Comparisons
Other countries are increasing their rate of production of undergraduates in S&E. Where the U.S. is producing S&E undergraduates at the rate of 15% of all undergraduates, South Korea is at 38%, France 47%, China 50%, and Singapore 67%. China and India have doubled their rate of production (Committee on Prospering in the Global Economy of the 21st Century, 2006). U.S. graduate programs are not able to recruit and graduate American students to meet the demand. The number of degrees in computer science decreased in 2005 and undergraduate enrollment in engineering is declining (National Science Board, 2008).

Tapping Local Talent
The need for greater diversity in higher education and in the S&E workforce is widely recognized (Commission on the Advancement of Women and Minorities in Science, Engineering, and Technology Development, 2000; Building Engineering and Science Talent, 2004). In many top departments in science and engineering, the faculty does not reflect the diversity of graduating Ph.D. students, showing a failure to encourage, recruit, hire, and support women and minorities as faculty entering critical fields, when they have been available in the hiring pool for decades (Nelson & Rogers, 2005).

Participation of Women - Status
Large segments of our population are not participating fully in science and engineering and they could be available to fill the talent gap. Women comprise 43.5% of the workforce having a degree (in 2006), yet they are earning only 19.5% of bachelor's degrees in engineering and 20.5% in computer science – the fields most in demand for U.S. economic interests (National Science Board, 2008).

Diversity Among Women
The demographic "women" tends to disguise groups that have special challenges due to race, ethnicity, disability, socio-economic status, religion, and immigration status. Only recently have studies addressed populations that included multiple sub-groups, and/or disaggregated their data and their analyses by sub-group. Demographic data (2006) shows that Blacks are 11.1% of the adult population, Hispanics 12.3%,

and Native Americans 1.7% (NSB, 2008, Figure A-1). Their rates of participation S&E fields clearly lag, showing potential for recruitment. For example, Blacks in the S&E workforce with degrees were at 3.9% in 2008. Hispanics in the S&E workforce with degrees were at 4.5%. Native Americans were at .4% (NSB, 2008, Table H-6).

Why The Continuing Gap?

Why isn't the United States tapping into under-utilized populations for the sake of competitiveness and prosperity? There are a number of reasons: tradition, discrimination, work/family pressures, narrow and inaccurate images of S&E professions, inadequate educational preparation, and weak legal or moral pressure to change educational practice.

Tradition and Stereotypes

Tradition has many people still believing that men and women are innately different in intellectual capacity. Unconscious assumptions about gender – called gender schemata – are formed from birth on and lead us to over-rate men and under-rate women (Valian, 1998). These assumptions can lead to unequal treatment in small ways. Small disadvantages accrue and can explain imbalances and gaps over time, especially at higher levels of advancement (Martell, Lane & Emrich, 1996). Negative stereotypes play a role in differential performance on tests (Steele & Aronson, 1995).

A common view is that women are not interested in careers, especially professional careers that require long preparation and demanding work pressures. Yet women are graduating from medical school at a rate approaching parity (47%) (Association of American Medical Colleges, 2006) and women are earning more than half of law degrees (American Bar Association Commission on Women in the Profession, 2005).

Another view is that girls and women are inherently less capable at mathematics which is a necessary skill in preparing for a career in many S&E fields. Recently studies found no gender differences in math performance (for example, Hyde et al., 2008).

The Compounding Effects of Other Factors

There are additional stereotypes and barriers due to race, ethnicity, disability, socio-economic status, religion, and immigration status. Women of color are said to be in a "double bind" (Malcom, 1976). Studies are finding different patterns for sub-groups based on these other characteristics, and differences between men and women of the same race or ethnicity (for example, Hanson, 2008; U.S. Department of Education, National Center for Education Statistics, 2000).

Discrimination

There is evidence of bias and discrimination in general and in the academic workplace in particular. Researchers have shown that most of us are unconsciously biased (Harvard University, 2007). One study found that female applicants had to have more credentials than men to get the same competence rating from reviewers (Wenneras & Wold, 1997). Both male and female reviewers of faculty curricula vitae favored male job applicants (Steinpreis, Anders & Ritzke, 1999). Letters of recommendation have been found to differ "systematically" in preference toward men (Trix & Psenka, 2003).

Work/Family Pressures

An academic career in science and engineering is expected to be a full, intensive commitment especially until a beginning faculty member reaches tenure. The period of intense career demands coincides with optimal child-bearing years. Very few institutions have made allowances for maternity or paternity leave,

flexible or reduced hours, or delaying the tenure clock. One of the greatest frustrations experienced by women faculty in S&E is the conflict with family life (Rosser & Daniels, 2004). A common solution for improving the retention of female faculty is to reduce pressures from the traditional tenure process (NSF, 2007). In terms of family-friendly policies in the workplace, the United States lags far behind all other wealthy countries ("U.S. workplace not family-oriented," 2007).

Legal and Moral Incentives
A number of laws forbid discrimination that impedes the participation of women in S&E. Most prominent is the Civil Rights Act of 1964 that outlawed racial segregation in schools and employment discrimination on the basis of race, color, religion, sex, or national origin. Title IX of the Educational Amendments of 1972 outlawed discrimination on the basis of sex in any educational program receiving Federal funding.

The Equal Opportunities for Women and Minorities in Science and Technology Act of 1981 mandated that the National Science Foundation report statistics on underrepresented groups, initiate a suite of programs to increase diversity in the science and engineering workforce, and to sustain these actions. For over thirty years, Title IX was applied primarily to increase girls' access to sports and to address sexual harassment, although the law does not mention either explicitly. Recently the application of the law to science and engineering education, especially higher education, became a policy cause. The Government Accountability Office was mandated to report on the issue (U.S. GAO, 2004). The policy cause has yielded awareness of the potential for legal pressure.

Solutions Are Available & Benefits Demonstrated
The S&E departments in many universities have shown that change is possible and feasible. Their success is documented in dozens of national reports and academic publications as "promising," "proven," or "best" practices (BEST, 2004a; Committee on Maximizing the Potential of Women in Academic Science and Engineering, 2007). An MIT study found persistent bias against women faculty over decades and led to specific changes (Massachusetts Institute of Technology, 1999). Harvard University produced an action plan to make working conditions better for all faculty, particularly for women (Harvard University, 2005).

Three case studies of physics departments yielded a set of characteristics that produce a high percentage of female graduates in physics (Whitten, 2003). A case study of a successful industrial engineering department found similar characteristics (Harris et al, 2004).

Among the best recent work on promising practices are the "implementation kits" for practitioners by the National Center for Women in Information Technology, for example, Computer-Science-in-a-Box: Unplug Your Curriculum (NCWIT, 2008). NSF's ADVANCE funding program created a network of universities experienced with introducing a wide range of improvements for faculty and their common knowledge is shared with the public via a rich information portal (Virginia Tech, 2008).

Measures of Change
Measures that allow us to characterize and monitor the status of women in society generally, and in S&E professions specifically, are available. The National Science Foundation publishes *Science and engineering indicators* biennially, and a more detailed volume *Women, minorities and persons with disabilities* (NSF Division of Science Resources Statistics, 2007). The most detailed statistics on education at the K-12 level are available from the National Center for Education Statistics, including *Trends in educational equity of girls & women: 2004* (U.S. Department of Education, 2004). The Commission on

Professionals in Science and Technology monitors national statistics on human resources in science, engineering and technology through the biennial *Professional women and minorities* (CPST, 2007).

There has been much progress on developing indicators specifically for science and engineering faculty. A special project compared graduation rates by sex, race/ethnicity, and faculty composition at the top fifty research departments in S&E (Nelson & Rogers, 2005; Beutel & Nelson, 2005). The American Association of University Professors looked at four indicators for "faculty gender equity" across all fields in higher education, not just science and engineering (AAUP, 2006). The National Science Foundation's ADVANCE program funded a number of institutions with the aim of institutional transformation in advancing female faculty, and they are using a common set of measures (NSF, 2007; De Cohen & Clewell, 2006).

Summary

Two frontiers are prominent: greater recruitment of students to engineering and computer science education, and employment and advancement through faculty ranks in most fields. Further research and action to solve the talent crisis must continue on a number of fronts that have been identified for a long time:

1. Improve the image of professions in science and engineering to raise awareness of their richness, appeal, and social contributions, in order to attract students.
2. Make everyone – the public, parents, counselors, teachers, faculty, and employers aware of stereotypes and biases that operate to limit opportunities to recruit talent.
3. Change educational practices – courses, social environments, pedagogy, admissions policies – to attract and retain a wider spectrum of students, and improve basic early preparation for S&E careers.
4. Review and improve faculty recruitment and advancement processes and conditions of work, to increase diversity, thereby demonstrating that S&E fields are indeed open to all.
5. Identify and address the particular needs of groups based on race, ethnicity, disability, socio-economic status, religion, and immigration status, to better recruit them to S&E.
6. Make educators aware of the foundations and support for targeted programs in the law and in national policy.
7. Make our investments in targeted programs count by assessing their effectiveness, and make effective programs widely known.

REFERENCES

American Association of University Professors (2006). *AAUP faculty gender equity indicators 2006.* By Martha S. West and John W. Curtis. Retrieved October 2, 2007, from http://www.aaup.org/AAUP/pubsres/research/geneq2006

American Bar Association, Commission on Women in the Profession (2005). *A current glance at women in the law 2005.* Retrieved January 20, 2008, from http://www.abanet.org/women/ataglance.pdf

Association of American Medical Colleges (AAMC) (2006). *Women in academic medicine statistics and medical school benchmarking 2004-2005. Table 1.* Retrieved January 20, 2008, from http://www.aamc.org/members/wim/statistics/stats05/start.htm

Beutel, A.M., & Nelson, D.J. (2005). The gender and race-ethnicity of faculty in top science and engineering research departments. *Journal of Women and Minorities in Science and Engineering, 11*(4), 389-402.

Building Engineering and Science Talent (BEST) (2004a). *A bridge for all: Higher education design principles to broaden participation in science, technology, engineering and mathematics.* Retrieved January 20, 2008, from http://www.bestworkforce.org/PDFdocs/BEST_BridgeforAll_HighEdFINAL.pdf .

Building Engineering and Science Talent (2004b). *The talent imperative: Diversifying America's science and engineering workforce.* Retrieved January 9, 2008, from http://www.bestworkforce.org/PDFdocs/BESTTalentImperative_FullReport.pdf

Commission on Professionals in Science and Technology (2007). *Workforce data.* http://www.cpst.org/

Commission on the Advancement of Women and Minorities in Science, Engineering, and Technology Development (2000). *Land of plenty: Diversity as America's competitive edge in science, engineering and technology.* Retrieved January 9, 2008, from http://www.nsf.gov/publications/pub_summ.jsp?ods_key=cawmset0409

Committee on Maximizing the Potential of Women in Academic Science and Engineering (2007). *Beyond bias and barriers: Fulfilling the potential of women in academic science and engineering.* Committee on Maximizing the Potential of Women in Academic Science and Engineering / Committee on Science, Engineering, and Public Policy. Available at http://www.nap.edu/catalog.php?record_id=11741

Committee on Prospering in the Global Economy of the 21st Century: An Agenda for American Science and Technology, National Academy of Sciences, National Academy of Engineering, Institute of Medicine (2006). *Rising above the gathering storm: Energizing and employing America for a brighter economic future.* Washington, DC: National Academies Press.

De Cohen, C.C., & Clewell, B.C. (2006). *External evaluation of the ADVANCE Program Georgia Institute of Technology: Year four report.* Retrieved October 2, 2007, from http://www.advance.gatech.edu/files/GTYearFourReport.pdf

Hanson, S.L. (2008). *Swimming against the tide: African American girls and science education.* New York: Temple University Press.

Harris, B.J. et al. (2004). Gender equity in industrial engineering: A pilot study. *NWSA Journal, 16*(1), 186-193.

Harvard University (2005). *Report of the Task Force on Women Faculty.* Retrieved January 20, 2008, from http://www.hno.harvard.edu/gazette/daily/2005/05/women-faculty.pdf Also, see a list of university plans at http://www.faculty.harvard.edu/01/0152.html.

Harvard University (2007). *Project Implicit.* https://implicit.harvard.edu

Hyde, J.S., Lindberg, S.M., Linn, M.C., Ellis, A.B., & Williams, C.C. (2008: July 25). Gender similarities characterize math performance. *Science, 321*(5888), 494-495.

Martell, R.F., Lane, D.M., & Emrich, C. (1996). Male-female differences: A computer simulation. *American Psychologist, 51*, 157-58.

Massachusetts Institute of Technology (1999). *A study of the women faculty in science at MIT*. Retrieved January 20, 2008, from http://web.mit.edu/fnl/women/Fnlwomen.htm

National Science Board (2008). *Science and engineering indicators 2008*. Arlington, VA: National Science Foundation.

National Science Foundation (2007). *ADVANCE: Increasing the participation and advancement of women in academic science and engineering careers.* http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=5383&from=fund

National Science Foundation, Division of Science Resources Statistics (2007). *Science and engineering statistics*. http://www.nsf.gov/statistics/

Nelson, D.J., & Rogers, D.C. (2005). *A national analysis of diversity in science and engineering faculties at rfesearch universities.* Retrieved October 2, 2007, from http://cheminfo.ou.edu/~djn/diversity/briefings/Diversity%20Report%20Final.pdf Updated in http://cheminfo.chem.ou.edu/faculty/djn/diversity/Faculty_Tables_FY07/07Report.pdf

Rosser, S.V., & Daniels, J.Z. (2004). Widening paths to success, improving the environment, and moving toward lessons learned from the experiences of POWRE and CBL awardees. *Journal of Women and Minorities in Science and Engineering, 10*, 131-148.

Steele, C.M., & Aronson, J. (1995). Stereotype threat and the intellectual test performance of African Americans. *Journal of Personality and Social Psychology, 69*, 797-811.

Steinpreis, R.E., Anders, K.A., & D. Ritzke (1999). The impact of gender on the review of curricula vitae of job applicants and tenure candidates: A national empirical study. *Sex Roles: A Journal of Research, 41*(7-8), 509-528.

Trix, F., & Psenka, C. (2003). Exploring the color of glass: Letters of recommendation for female and male medical faculty. *Discourse & Society, 14*(2), 191-220.

U.S. Department of Education, National Center for Education Statistics (2000). *Entry and persistence of women and minorities in college science and engineering education* (NCES 2000-601). By Gary Huang, Nebiyu Taddese, and Elizabeth Walter. Project Officer, Samuel S. Peng. Washington, DC.

U.S. Department of Education, National Center for Education Statistics (2004). *Trends in educational equity of girls & women*. Retrieved October 2, 2007, from http://nces.ed.gov/pubsearch/pubsinfo.asp?pubid=2005016

U.S. Government Accountability Office (2004). *Gender issues: Women's participation in the sciences has increased, but agencies need to do more to ensure compliance with Title IX.* Retrieved January 9, 2008, from http://www.gao.gov/new.items/d04639.pdf

U.S. workplace not family-oriented (2007, May 22). *The Associated Press*. Retrieved January 8, 2008, from http://www.msnbc.msn.com/id/16907584

Valian, V. (1998). *Why so slow? The Advancement of women*. Cambridge, MA: MIT Press.

Virginia Technological University (2008). *ADVANCE portal*. http://www.advance-portal.net

Wenneras, C., & Wold, A. (1997). Nepotism and sexism in peer-review. *Nature, 387*, 341-343.

Whitten, B. et al. (2003). What works? Increasing the participation of women in undergraduate physics. *Journal of Women and Minorities in Science and Engineering, 9*(3&4), 239-258.