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Subcommittee on Research and Science Education
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Mr. Chairman, Mr. Ranking Member, and Members of the Subcommittee:

Good morning. My name is Barbara Bogue. I am an associate professor of engineering science and mechanics and women in engineering at Penn State. I am also the co-founder and co-director of the Society of Women Engineers' Assessing Women and Men in Engineering (AWE) Project. I am past director of Penn State's Women in Engineering Program and received a Presidential Award for Excellence in Science, Mathematics and Engineering Mentoring (PAESMEM) recognizing my work as director in increasing the retention of women in engineering. I also serve on the Advisory Group for the American Association of University Women (AAUW) Project on Women and Girls in Science, Technology Engineering and Mathematics (STEM), on the National Girls Collaborative Extension Service Project Champions Board, and as an equity expert for the National Academy of Engineering Center for the Advancement of Scholarship in Engineering Education. I am speaking today on behalf of the Society of Women Engineers (SWE) and not on behalf of my employer or any of these groups.

First, I would like to thank the Subcommittee for providing me with this opportunity to talk about how to encourage the participation of female students in STEM fields. This is important to our nation's future as a global leader in innovation. As you know, the National Academies' report, *Rising Above the Gathering Storm*, concluded that increasing the number of students entering and succeeding in the STEM fields was critical to prepare our nation for the future.[1] A more recent National Academies report entitled *Beyond Bias and Barriers: Fulfilling the Potential of Women in Academic Science and Engineering*, also reminds us that women and girls still face barriers to their success in the STEM fields, and more attention must be paid to this issue.[2]

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[1] National Academy of Sciences, National Academy of Engineering, Institute of Medicine Committee on Prospering in the Global Economy of the 21st Century: An Agenda for American Science and Technology. (2006). *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future*. Washington, D.C. : National Academies Press.
[2] National Academy of Sciences, National Academy of Engineering, Institute of Medicine Committee on Science, Engineering, and Public Policy (COSEPUP). (2009). *Beyond Bias and Barriers: Fulfilling the Potential of Women in Academic Science and Engineering.* Washington, DC: National Academies Press.

I will focus my comments on the need for improved assessment and evaluation practices of programs serving women in STEM, and on some specific challenges we face in our effort to increase the numbers of girls and women entering and succeeding in STEM-related studies. I will be emphasizing engineering, because that is where my primary experience and knowledge lie, but the basic assumptions and recommendations can apply throughout many disciplines in STEM fields in which women are underrepresented.

While there are some similarities among the various STEM fields, there are also many differences. It is important to note that engineering and science are different fields. We must recognize that, while they have common recruitment and retention challenges, the different disciplines each face unique challenges. Discussions and statistics that treat all STEM disciplines as one mask real issues. For example, 2006 National Science Foundation (NSF) statistics show that women received almost 50 percent of science and engineering bachelor's degrees in 2005-06.

Taken on face value, these statistics make it look like there is no problem. If we break out engineering, however, the percentage of women receiving degrees is a very low 18 percent. And even within engineering, there are great variations. Environmental, bio and chemical engineering—all fields related to biological sciences—have high percentages of women at 40 percent, 37 percent and 34 percent respectively. Unfortunately, these are relatively small disciplines in terms of numbers enrolled. Mechanical and electrical engineering, on the other hand, are disciplines that traditionally have the largest populations of students, but have very low percentages of women at 11 percent and 12 percent respectively. Computer engineering, another field critical to national competitiveness, has only 11 percent.[3] I am submitting some graphs for the hearing record that illustrate these statistics.

These differences have real implications for policy makers and STEM practitioners. A recent study by Sonnert and Fox finds that it is advisable "to take field differences into account and to tailor efforts and initiatives to the situation in specific fields, rather than simply targeting 'women in science' or 'women in science and engineering' *in toto*." [4] A recent National Academies study, *Gender Differences in Critical Transition Points in the Careers of Science, Engineering, and Mathematics Faculty*, did not take such research into account, and examined only select STEM fields to conclude that there is relatively no problem at critical transition points for women in academic careers.[5] This study is an example of the way that treating all disciplines collectively *conceals* problems in individual STEM fields.

Recruiting women into engineering, a field in which they are underrepresented, should be pursued as one clear path to increasing the overall yield of engineering degrees granted in the

[3] Commission of Professionals in Science and Technology. (2009). *Professional Women and Minorities: A Total Human Resources Data Compendium.* Washington, D.C.
[4] Sonnert, Gerhard; Fox, Mary Frank; Adkins, Kristen. (2007). "Undergraduate Women in Science and Engineering: Effects of Faculty, Fields, and Institutions over Time." *Social Science Quarterly*. Vol. 88 (5), pp. 1333-57.
[5] National Research Council Committee on Women in Science, Engineering, and Medicine. (2009). Prepublication Copy of *Gender Differences in Critical Transition Points in the Careers of Science, Engineering, and Mathematics Faculty*. Washington, DC: National Academies Press.

U.S. We know that women graduating from high school are prepared to enter engineering. High school girls take 55 percent of all Advanced Placement tests, including 47 percent of all calculus tests, 47 percent of chemistry tests, 31 percent of physics tests and 17 percent of computer science tests. [6] So the real question is not whether women can do engineering. It is: How can we attract them into STEM careers?

One key to answering this question is a better understanding of what is working and what is not working in our national efforts to attract girls and women into STEM fields. And, although different efforts might be required for particular STEM fields, certain activities, such as effective assessment of those efforts, are relevant across all disciplines within STEM.

We know that there are a lot of very good programs offered by knowledgeable and talented STEM professionals and volunteers throughout the country. Anecdotally and through research on specific program activities, we know that engineering outreach programs have a tremendous impact on the goal expressed by NSF, as well as by other engineering and science industrial and academic leaders, to broaden the participation of girls and young women in engineering and technology.[7] These large-scale programs are the exception and not the rule, both in terms of funding and effort level, and in terms of their means to analyze and assess effectiveness. Such efforts are well funded, well staffed and resource intensive—and not easily replicated by the people and organizations that normally do STEM outreach. The findings of these exemplary programs are important, and can inform future program development and answer questions about longitudinal retention rates, but they are not designed for export and use by individual STEM practitioners at the program level. What we need to know is how effective are the broad offerings of STEM educational practice and programming at work in K-12 schools, colleges, and community and professional organizations across the country.

When I re-established the Women in Engineering Program at Penn State, one of the first things I did was talk to several directors of similar programs throughout the country and survey the literature to find out what other programs were doing and what the most effective strategies were. What I found was a very dedicated, energetic community rich with people who ran a variety of innovative programs, often on shoestring budgets and with lean staffs and student volunteers. I also found an environment poor in meaningful assessment. And the assessments that did exist took the form of what we call “happy face,” or an assessment that asks participants how much fun they had, and includes many engaging quotes from girls and women.

I then sought out literature relevant to my program goals: recruiting women into engineering and developing their talents. Developing hands-on skills, supporting a sense of self-efficacy in engineering, and having active mentors are all well researched as ways to motivate women to

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[6] College Board. (2009). AP Data 2008. Available at: http://professionals.collegeboard.com/data-reports-research/ap/data.
[7] National Science Foundation. (2003). *New Formulas for America’s Workforce: Girls in Science and Engineering.* NSF 03-207. Available at: http://www.nsf.gov/pubs/2003/nsf03207/start.htm; Goodman, I.F.; Cunningham, C.M.; Lachapelle, C.; Thompson, M.; Bittinger, K.; Brennan, R.T.; Delci,. M. (2002). *Final Report of Women’s Experiences in College Engineering (WECE) Project.* Cambridge, MA: Goodman Research Group Inc. Available online at www.grginc.com.

succeed. I integrated all three into a three-day orientation program, the Women in Engineering Program Orientation (WEPO), that continues to yield the highest retention rate of any group in the Penn State College of Engineering and was recognized with the PAESMEM award.

The next step was creating effective assessment tools so that I could find out things like how well participants were retained. At that point, I teamed up with Rose Marra, now associate professor of learning technologies at the University of Missouri and co-founder and co-director of the AWE Project, to develop an assessment plan. The step after that was the realization that the need for help in creating good assessment was universal.

We integrated these two key concepts—effective assessment and integration of research findings into programming—when we conceived of the Assessing Women and Men in Engineering Project, or the AWE Project, to develop universal tools that could be used by STEM educational and outreach programs to measure the success of different activities and approaches, compare them with other programs, and continuously improve programs and activities. The more than fifty surveys offered by SWE AWE have been tested and proven effective for both male and female students, and help us to confirm that our efforts on behalf of women are also benefiting men.

AWE moved into the Society of Women Engineers (SWE) to broaden the scope and audience, and to sustain the project and its many products and services. Founded in 1950, SWE is a 20,000 member not-for-profit educational and service organization that empowers women to succeed and advance in the field of engineering. These activities are supported by the NSF Research in Gender in Science and Engineering (GSE) Program.[8] NSF and the GSE Program are leaders in promoting better assessment in their sponsored programs. GSE encourages other grantees to access SWE AWE products, supporting further development and dissemination. To date, the SWE AWE Project has 1065 registered users from 418 institutions and organizations.

The SWE AWE Project addresses the barriers to improving assessment and developing better metrics by looking at assessment as an organizing tool rather than as something tacked on to the end of an activity. It advocates assessment as a method to guide the development and implementation of STEM programs as well as the measurement of outcomes.

The SWE AWE Project is designed to address the core issues that inhibit the development and implementation of effective STEM programming–issues that I faced when I started Penn State's Program–particularly limited resources and a lack of will to assess or reward for assessing.

[8] National Science Foundation. (2009). Research in Gender in Science and Engineering Program. Available at: http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=5475&org=NSF&sel_org=NSF&from=fund. Award #0120642; #0607081; #0734072.

STEM initiatives typically run with small staffs or volunteers, who often have little assessment expertise, and function on soft money budgets with limited facilities.[9] The staff more often has expertise in developing and implementing programs, advising and outreach, rather than in assessment.

Programs offered by volunteers in companies or through professional societies face similar resourcing issues, with the added problem—and, it has to be stressed, *the added benefit*—that the volunteers are typically experts in STEM fields rather than in education or outreach. These professional volunteers create good programs. They can assess the success of their program with attendance figures and the results of "happy face" surveys. But good assessment and evaluation of those programs–the kind of assessment that leads to sustainable impacts–require assessment expertise, funding and other resources.

The SWE AWE Project promotes effective assessment and evaluation in two ways: 1) by providing exportable survey instruments at the pre-college and college levels that can be adapted and used by programs throughout the country; and 2) by creating capacity for assessment and evaluation among practitioners through the distillation of relevant research findings in Applying Research to Practice (ARP) papers and capacity-building workshops throughout the country. The surveys, which are available in paper and online versions, measure typical objectives for pre-college and college level activities and, at the precollege level, are available in science, computer and math versions as well as engineering. ARP resources are developed in collaboration with the National Academy of Engineering Center for the Advancement of Scholarship in Engineering Education. I am submitting a list of the current available AWE Products for the hearing record.

The second issue that the SWE AWE project is designed to address is the will to undertake and use assessment. Offering programs to girls and young women is fun, and their positive responses are rewarding. Assessment, on the other hand, takes time and is designed to tell us what to do better. If resources are limited and everyone is happy with the status quo, why change? Where are the rewards?

But lack of effective assessment precludes continuous improvement of activities. How many activities are there out there that have been offered year after year without change—they worked once, but do they still today? Have they taken advantage of new research findings or changing demographics? When I started the women in engineering orientation at Penn State, most of the girls had no experience with email! One of our most popular skill building sessions was learning to use email. That clearly had to change. Today, we offer sessions on how to manage labs and set up computer hardware networks.

Without effective assessment and evaluation, programs can actually be counterproductive. How many activities and events out there are doing the job of committing girls and women to

[9] Goodman, I.F.; Cunningham, C.M.; Lachapelle, C.; Thompson, M.; Bittinger, K.; Brennan, R.T.; Delci,. M. (2002). *Final Report of Women's Experiences in College Engineering (WECE) Project*. Cambridge, MA: Goodman Research Group Inc. Available online at www.grginc.com.; Bogue, B., & Marra, R. (2001). "Informal Survey of WIE Directors." Penn State University.

technical careers? How many girls and women are we unintentionally discouraging by not improving our activities using assessment results and new research findings?

This is where funders have a role to play. The federal government as a funder should require effective assessment of activities aimed toward NSF's goal of "broadening participation," which is a standard feature of many grant rewards. And federal Title IX reviews, like those conducted by the National Aeronautics and Space Administration (NASA), can be an effective tool for understanding the activities, such as student recruitment and retention programs, that would benefit from an assessment of effectiveness.[10] It is not enough to do "something" – that something should be proven effective, especially where federal funds are used. Industry and professional societies as funders have a similar stake in understanding the effectiveness of funded programs. By requiring annual assessment and evaluation reports, and by basing further funding on how those assessments and evaluations are used to improve programs, effective programs are rewarded; ineffective programs are motivated to improve.

Services like the SWE AWE Project offer ready-made tools that funders and practitioners alike can use to identify and achieve common goals. Greater use of uniform tools also opens the door for comparison of data from a broad variety of programs and venues—which ultimately will allow us a much clearer picture of what works and what doesn't.

There are many ways in addition to the use of good assessment that we can break down the barriers to effective recruitment and development of women in STEM.[11] I will focus on three:

- The application of research to practice,
- Improved learning environments, and
- Sustained and targeted funding.

First, the need for the application of research to practice is essential if we are to develop effective programming for women in STEM. Basic research through programs like NSF GSE is a critical tool for increasing the numbers of women in engineering. Research into why women and girls leave or stay, how psychological constructs can impact decision-making or retention, and understanding the experience of minorities in majority-built and -maintained environments can make or break our combined national effort to increase the numbers of underrepresented populations in engineering and other STEM disciplines.

Next, climate studies that look at students' learning and working environment are an important area of research for uncovering barriers for women in engineering. A student's learning environment, or "climate," can have an impact on the successful retention and development of all students in STEM fields. Unwelcoming classrooms, outdated teaching styles, and a lack of

[10] National Aeronautics and Space Administration. (2009). NASA Title IX Compliance Program. Available at: http://www.hq.nasa.gov/office/codee/compliance_program.html.
[11] National Science Foundation. (2003). *New Formulas for America's Workforce: Girls in Science and Engineering*. NSF 03-207. Available at: http://www.nsf.gov/pubs/2003/nsf03207/start.htm; Sevo, R. (2009). "10 x 10 List." Available at http://momox.org/10x10.html.

accommodation for different social or cultural experiences can all add up to create an environment that students decide to leave rather than thrive in. This affects all students, men as well as women. However, students who are already marginalized as "non typical," or who are severely underrepresented, as are women in engineering, experience these adverse environments more keenly. Much research shares common findings that women who are equally prepared academically as men when they enter engineering leave engineering or science with higher GPAs than their male counterparts who leave, having found less of a sense of community and citing that they have encountered poor teaching. Surveys of students leaving engineering or science, including surveys developed and implemented by SWE AWE, find that students who leave are less involved in discipline-related activities and fail to develop a sense of community.[12]

AWE results and other findings belie the postulation that women do not pursue engineering because they are just not interested or don't have the talent. Rather, they indicate that women who have the talent and interest are being turned off by how the discipline is presented. Women's high school preparation and GPAs once in college are comparable to men's. In fact, in our recent research females show significantly higher intentions to persist in engineering than their male counterparts.[13] These results show that we don't need to fix the women; we need to fix environments in which they fail to thrive.

Finally, sustained and targeted funding is necessary in order to increase the numbers of women entering and succeeding in engineering: funding for basic research, funding for designing and implementing programs, and funding to support individuals. Such funding has the potential to effect change when it comes with prudent conditions designed to reinforce real change in how programs are developed and evaluated. Funding that includes requirements for effective assessment plans and reports on outcomes that describe how assessment results are used. Funding that requires that basic researchers work directly with STEM practitioners to integrate findings into practice. Funding that provides individual funding to support women students who commit to the completion of studies in STEM fields in which they are underrepresented.

There is historical evidence that directed individual funding works. We saw a tremendous change in the number of men who decided to study engineering in the wake of the groundbreaking National Defense Education Act (NDEA), which occurred in the wake of the launch of Sputnik in 1958. Today, we see more modest efforts aimed at women in engineering through, for

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[12] Seymour, E. & Hewitt, N. (1997). *Talking about Leaving: Why Undergraduates leave the Sciences.* Boulder, Colorado: Westview Press; Goodman, I.F.; Cunningham, C.M.; Lachapelle, C.; Thompson, M.; Bittinger, K.; Brennan, R.T.; Delci,. M. (2002). *Final Report of Women's Experiences in College Engineering (WECE) Project*. Cambridge, MA: Goodman Research Group Inc. Available online at www.grginc.com; Hartman, H. & Hartman, M. (2006). "Leaving Engineering: Lessons from Rowan University's College of Engineering." *Journal of Engineering Education*, Vol. 95, p. 49-61; Marra, R.; Bogue, B. (2008). "Engineering Classroom Environments: Examining Differences by Gender and Departments." Proceedings of American Society for Engineering Education, June 2008, Pittsburgh, PA; Marra, R.; Rogers, K.A.; Shen, D.; & Bogue, B. (2009). "A Multi-Year, Multi-Institution Study of Women Engineering Student Self-Efficacy," *Journal of Engineering Education*, Vol. 98, p. 1 – 12.

[13] Bogue, B. & Marra, R. (2009). "The AWE Family of Projects: Assessing STEM Educational Outreach, Retention Programs and Research on Engineering Undergraduates." Poster presented at the National Science Foundation Joint Annual Meeting, June 2009; Marra, R.; Bogue, B. (2008). "Engineering Classroom Environments: Examining Differences by Gender and Departments." Proceedings of American Society for Engineering Education, June 2008, Pittsburgh, PA.

example, the NSF ADVANCE Program, which offers institutional transformation grants aimed at the goal of increasing women faculty in STEM.[14]

Directing that all federal funding in STEM fields must address these issues as a part of any funded project would validate the importance of a creating an inclusive work and study environment and encourage more girls and women to enter engineering.

In conclusion, increasing the number of women pursuing engineering degrees and succeeding in professional careers is an essential component of our ability as a nation to solve the problems we face and to remain a world leader in science and technology. Promoting the use of assessments, like those offered by the SWE AWE Project, and supporting programs at the undergraduate level to overcome barriers to recruit and retain female undergraduates in STEM should be part of the equation. Therefore, we would like to recommend the following policy recommendations to you:

- Sustain and target funding for programs and activities that focus on attracting and retaining women and girls to non-traditional and STEM careers and removing institutional barriers to their success, for basic research related to that goal, and for efforts directed at encouraging individual women to undertake and complete engineering degrees.
- Review federal funding requirements and set guidelines to ensure that funded programs address national priorities and attract a diverse population. Include requirements for effective assessment, including reporting of how findings will be used to continuously improve processes.
- Support the continuation of federal Title IX reviews, like those conducted by NASA, as one component of understanding the issues that inhibit the full participation of women in engineering and other STEM disciplines at the college level.
- Provide support for women who wish to pursue engineering degrees. Reward the institutions that make successful efforts to increase the percentages of women studying STEM disciplines in which they are currently underrepresented.

Forty years ago yesterday, Neil Armstrong became the first human to set foot on the moon, thanks to our federal government's commitment to set forth a clear vision for achieving that goal by the end of the 1960s. Not only did we have the national will to achieve that event, we supported it financially by ensuring an innovative and productive engineering workforce through the National Defense Education Act. Earlier this year, in a speech to the National Academy of Science, President Obama set out an equally ambitious goal to increase research and development funding to levels that exceed those in the era of the space race. To achieve the goal of full participation of women and other underrepresented groups in this new bold endeavor will

[14] National Science Foundation. (2009). ADVANCE: Increasing the Participation and Advancement of Women in Academic Science and Engineering Careers (ADVANCE). Available at: http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=5383. Also, see ADVANCE portal at http://www.portal.advance.vt.edu/.

require an equivalently bold commitment. We at the Society of Women Engineers look forward to and support your efforts in this regard.

Thank you again for the opportunity to present our views.

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