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Senator Wyden, members of the Subcommittee on Science, Technology and Space, and congressional staff, I am honored to have been invited to share my thoughts with you today on the barriers to the involvement and advancement of women in science and technology, and to make suggestions on how we can lower these barriers, to the benefit of society.

My name is Kristina Johnson. I am a professor of electrical engineering and dean of the Pratt School of Engineering at Duke University. I am a third-generation engineer. My father, Robert G. Johnson, was an electrical engineer with Westinghouse for 37 years, and my grandfather, Charles W. Johnson, was the engineering assistant to George Westinghouse himself. I had, therefore, extraordinary role models and mentors. I never knew I couldn't be a scientist or engineer because those closest to me wouldn't let me. Just the opposite, I was led to believe I could be one. While every girl doesn't have the benefit as I did of parents who convinced me I could be an excellent engineer, the principles behind my success should provide a road map for other young women and for programs to ensure they have the same vision I did.

Background

What do engineers do? We generate wealth and provide high-paying careers for our citizens. In the last century, engineers built the transportation, communication and industrial infrastructure that created the greatest nation on earth. It is stunning that at the beginning of the 20th century, the main mode of transportation was horse and buggy, limiting travel on a daily basis to a short radius of the home. It took at least a week to go across the country by train, and the telephone was in its infancy. At the end of the century, we had the technology to travel anywhere in the world within hours, and to communicate to a billion people anywhere, anytime, including outer space, and within a fraction of a second. The resulting globalization opened up new markets and opportunities for historic economic and social growth.

To be competitive in the 21st century global marketplace, and maintain our quality of life, we have an obligation to maintain our competency and leadership in engineering, science and technology. And this will be a major challenge for our society, as the number of undergraduates graduating from institutions of higher education with engineering and technology-based degrees has steadily declined over the past generation, from 77,000 in 1985 to 60,000 in 1998. Furthermore, our country's majority demographics are changing from male and Caucasian to female and African American, Asian and Hispanic. We need to ensure that groups currently underrepresented in science, engineering and technology are attracted to careers in

these fields. In today's competitive global environment, we cannot afford to lose the human capital these groups represent.

Women constitute less than 20 percent of the graduates from schools and colleges of engineering in this country, and our current minority population accounts for fewer than 14.7 percent of graduates in technical fields. What was once a moral obligation to promote diversity by providing equal opportunity for interesting, high-paying careers for all citizens is now a national imperative. Simply put, unless we bring more women and minorities into science and engineering fields, we will not have the intellectual capital to address the major economic, environmental, health and security issues facing our nation. Developing our underutilized human resources can be our competitive advantage.

Barriers to entry

What are the barriers to women getting involved, succeeding and advancing in technological fields? There are many, but none is insurmountable.

My parents and my teachers assumed I could do the work and insisted that I take four years of math and science. The first barrier to women's access to engineering and science is a fundamental problem in the level of competency we require of young people – both men and women -- in math and science. Many high schools allow students to "opt out" of four years of math or science classes, but a true college-preparatory education must include four years of these subjects, as it includes four years of English. We disadvantage our students by permitting them to opt out. Maybe math is the broccoli of high school education. But we don't let our children get by without broccoli just because they don't like it. Nor should we let them avoid math just because they don't like it.

The Third International Mathematics and Science Study published in 1996 showed that America's 12th-grade students ranked among the lowest in the world in mathematical proficiency. Yet in the same study, our fourth graders scored above average as compared to their counterparts in the 26 other countries in the study. There is a steady decline between the fourth and 12th grades in the competency and competitiveness of U.S. students as compared to their international peers in science and mathematical understanding. The drop is even more dramatic among young girls. This is because we don't apply the same standards to math and science instruction and expectation of student competence as we do to the social sciences.

Another barrier is developing confidence and competency in the basics required to pursue a career in engineering, science and technology. Studies indicate that girls and minority students start to lose interest in science and mathematics in the fourth or fifth grade. I never faced this dropoff because my parents and teachers expected me to succeed and do well in math, and I believed correctly that there was no reason I or any other young woman couldn't succeed in these areas of study.

According to a report by Women in Electrical and Computer Engineering (WECE), women who succeed in graduating with engineering degrees, and pursuing technological careers do so because they have had the opportunity to develop confidence in these subjects through

"self-efficacy" -- competence in outside, extra-curricular technology activities where they gained confidence in their skills, and got "hooked on science and engineering." This is certainly true from my own experience. I successfully competed in high school science fair projects (actually winning first at state, and a first and second in the international fair). This success helped overcome times when I would question whether I was "meant to be an engineer."

Engineering and technology careers are unfortunately saddled with the misperception of being dry, without interaction with people, and unattractive to women. In a study conducted by WECE, 90 percent of women polled cited altruistic reasons for choosing a career in science, engineering or technology. In fact, in engineering departments where opportunities to make social contributions are obvious, such as biomedical engineering, women make up a substantial percentage of the graduates. At the Pratt School at Duke, slightly more than half of the women we graduate earn degrees in biomedical engineering, where we are recognized as having one of the best and most demanding programs in the nation. We expect our women engineering students to succeed and convey this to them both in direct and subtle ways.

A third barrier to inspiring women and minority students to pursue science and technology careers is the critical lack of role models and support. The ability to look at a professor and say, "Hey, I look like her or him, therefore I belong here," is powerful. Currently the percentage of women engineering faculty is 8 percent of the total professoriat in the academy. As an undergraduate, I had only one woman professor, in a psychology course, and as a graduate student, I had only one woman professor, in a "writing about science" course. Had it not been for my parents and some of my teachers, I wouldn't have been able to see that I could make it. We need to identify and support young women engineers and to encourage them to be mentors and teachers of succeeding generations.

We must attract a more diverse population to the professoriat. We need more women and minority students going to graduate school to provide the role models and mentors for our changing population. When they get to graduate school, we need to provide adequate support. Women graduate students more often support themselves in graduate school on their own funds, and/or by working as teaching and research assistants, while men are funded usually on research assistantships, allowing them to focus on the research necessary to obtain a Ph.D., the necessary degree for obtaining a faculty position in the academy.

Things that work and could work: the intellectual victory gardens

To overcome the first barrier, we need to require all our college-bound students to take math through trigonometry and advanced algebra – if not calculus -- and one course each in biology, chemistry and physics as a requirement for graduation from high school. It is too easy now for students to opt out of math and science, because they can meet graduation requirements with less proficiency than peers in other countries. This easy road is a real threat to our economic growth and our national security. We need the help of legislators at the state and national levels to create incentives and programs to support students and teachers to make science and math proficiency a national priority.

To capture the minds of young girls, in the early 1990s, my sister, Dr. Sara Cohen, and I developed a program for the National Science Foundation called "Making the Connection." Together with Denver Public Schools and in partnership with Metropolitan State College, we designed for inner-city girls a three-week summer camp that provided hands-on experience with science and math concepts, but placing them in a social context. For example, when we studied Galileo, we covered not only his findings and discoveries, but the times he lived in, including its language, dress and poetry.

At Duke, we have a similar program, headed by Pratt Professor Gary Ybarra. The Math Understanding through the Science of Life (MUSCLE) Program teams Pratt engineering students with area middle and elementary students to tend gardens, study worms, predict the weather and other projects aimed at boosting math skills.

These are the kinds of intellectual "victory gardens" that are cropping up across the country. They are cultivating and sustaining math and science capabilities and interests in all our children, particularly in girls and minority students whose interests tend to wilt midway through elementary school. As these promising young people become adults, let's reap the rewards by continuing to support their aspirations and instilling such aspirations in youngsters who don't yet have them.

Overcoming the inspirational barrier involves aligning engineering careers with social issues. It has been done through unique partnerships forged between and among universities, foundations, government and industry. I believe schools and colleges of engineering should emphasize technology in service to society. We must focus on "engineering" better quality of life -- life without pain (biomedical engineering), life without fear (technology for counter-terrorism), and life in harmony with the environment (appropriate use of our natural resources, and harnessing new sources of renewable energy).

Wouldn't it be great if we could see the same advances in the academic world of science and engineering participation by women, as we have produced due to Title IX legislation— a tenfold increase in participation of girls in competitive athletics at the high school level and women at the intercollegiate level, just by insuring proportionate participation in scholarships that created tremendous opportunity. Furthermore, child care support would allow women the flexibility to pursue both an advanced degree and to start a family at the same time.

Summary

In summary, I see three significant barriers that prevent more women and minorities from promising careers in science and technology:

- Lack of fundamental math and science standards in high school curricula
- Lack of role models and opportunities that inspire and cultivate interest
- Lack of equal access to financial aid and child care for women in graduate school

To overcome these barriers, I recommend three solutions:

- High school curricula requiring four years of math (at least through trigonometry, if not calculus) and one year each of biology, chemistry and physics
- Creation of national centers of excellence in engineering quality of life, including domestic security, international security and sustainable resources
- Equal opportunity for financial aid and child care for women in graduate school, so we can create the next generation of role models

Conclusions

We all share the human desire to be part of a higher purpose. In the 1960s, a goal that energized the nation was to put a man on the moon before the end of the decade. Since September 11th, I have tried to think about what we can do in the university, and specifically in schools and colleges of engineering to do our part to help prevent terrorism, both domestic and international. It is clear we are engaged in a different kind of war that must be won with advanced logistics, networking, sensors and communications systems. And we will need the most highly skilled technical workforce to succeed in this fight.

This is not rocket science. Let us make our "man on the moon" goal for this decade a call to intellectual arms, to commit ourselves to providing a superior technical education to our children, so that by the time our current fourth grade students graduate from high school in 2010, they will still be among the best in the world in math and science proficiency.