

# ENHANCING THE ROLE OF WOMEN IN ENGINEERING: A CRITICAL MISSION FOR THE FUTURE OF THE UNITED STATES

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If we look back over the past century, two of the most powerful social trends to emerge were the women's movement and the technological revolution. More than two-thirds of women now work outside the home, compared to just one-third only 30 years ago, and their advances have affected our social institutions to such a degree that we cannot imagine how a woman's role in society could have been so narrowly defined 100 or even just 50 years ago.

Coincidentally, this last year we celebrated 50 years of women at Georgia Tech – the anniversary of the graduation of the first women from this university. In the course of our celebration we highlighted 50 firsts by Georgia Tech women, including our hiring our first women's chief of campus police last year. Reviewing the accomplishments of Georgia Tech women caused me to wonder how much further the world could have come if we had had women as partners in pursuit of the use of technology for human goals for 100 years and not just 50.

Paralleling the penetration of women in the workforce, we have seen the influence of technology expand and permeate every facet of our lives from the office to the kitchen to the recreation room. Virtually every device that plugs into the wall or uses batteries has a microchip in it somewhere. That is how it is...an ever expanding role for technology in our lives, and a steadily enhanced role for women in the world of work – two trends in parallel, but not convergent. As we enter the 21<sup>st</sup> century it is essential that we find ways to forge a stronger connection between them. Increasing the number of women in science and engineering is not a new objective, but I believe it has taken on a new urgency as we face the challenges of a global economy. As reasonable as this sounds to many of us in this room, it is crucial that we all understand not everyone sees it this way. I will refer to this again later in my remarks.

Today, we live in a global economy where careers can shift with short notice, and where rapid-fire Internet linkages and growing international talent pools are loosening white-collar jobs from their local moorings and moving them to nations like Russia, China, and India. Even after American businesses have pared costs to the bone, nations like these can still offer a cheaper alternative.

In contrast to the United States, where public institutions of higher education are seeing steadily reduced support at the state level, China and India among others are making the steadfast investments required to build world-class education systems that produce skilled technology workers like engineers. *BusinessWeek* recently reported that India's schools are pumping out 260,000 engineers a year who will work for salaries much lower than in this country. China is graduating more engineers than any other country in the world – more than twice as many as the United States – and Russia has a large number of high quality engineers who are welcoming U.S. companies to open shop there.

It is clear that we cannot compete in this economic climate by offering the same old solutions. For the foreseeable future we are likely to be both “out-manned” and disadvantaged by a higher cost structure. The advantages our global competitors have are particularly effective at the end of the spectrum where processes and products have been standardized and become routine. Our opportunity is at the other end of the spectrum, where our success will be based on our ability to compete with high-end products and services, and where quality and ability to innovate is of greatest importance.

To lead the way at the high end of the economic spectrum, we need to build an economy based on innovation. The process begins with targeted investments in fundamental research that is balanced across the science and engineering disciplines that are increasingly interacting to produce new knowledge. Then innovation emerges at the intersection of technology with business and the marketplace.

This year I have the privilege of co-chairing with IBM CEO Sam Palmisano the National Innovation Initiative of the U.S. Council on Competitiveness. Our goal is to develop an action agenda of things the United States needs to do in order to create a fertile environment for the innovation that will drive our future prosperity. We believe this nation’s economic future will be dependent on having access to the best and most creative minds our nation can produce.

Simultaneously with the National Innovation Initiative, I am also chairing a second initiative by the National Academy of Engineering called the Engineer of 2020. And although these two initiatives are being conducted independently of each other, the ideas they address are joined at the hip. Building an economy based on innovation raises questions about the skills and the size of the science and technology workforce that we need for the job. And the Engineer of 2020 initiative is looking at how to educate engineers to prepare them for the future that lies ahead.

Our world economy is presently in a state of transformation, and we do not know yet where all the chips will fall. But it is clear that the education we provide to scientists and engineers must prepare them to move beyond merely fulfilling a technical function to becoming leaders in making wise decisions about technology and in setting policies that will foster innovation. It is clear that we must seek to engage the best and brightest minds to help in the task ahead.

As we work to develop the science and technology leaders of the future, we at Georgia Tech among many others believe that women and minorities represent a critically needed but mostly untapped resource. Our present science and engineering workforce is aging, and there will be a dramatic increase in retirements in the coming years. The old fallbacks, looking to a population of white males or willing and talented immigrants to the U.S., are not likely to work, although some in industry continue to push for ever more lenient visa rules to help address the workforce issues. Yes, we should hope that talent from other countries will continue to seek our country as a home where they can help create a workforce that can sustain our future. But, no, this avenue should not be seen as an easy way out rather than doing the heavy lifting we need to open opportunity to all the members of our nation’s potential workforce.

Taken together, women, under-represented minorities, and disabled persons now comprise more than two-thirds of America’s workers. In 2000, women made up 49 percent of the U.S.

workforce with college degrees, but less than 25 percent of the science and engineering workforce with college degrees. This shift in gender demographics has been even more pronounced at our colleges and universities over the past few decades. Women now outnumber men in undergraduate enrollment at the nation's colleges, and by 2010 women will outnumber men among graduates in the majority of degree levels from associate to Ph.D. But just as in the workforce, women are shying away from studying science and engineering.

It is not a question of ability. Girls are graduating from high school with skill and achievement levels in mathematics that are comparable to boys. Data on 17-year-olds tell us that in high school boys and girls take advanced math classes in about the same numbers and score about the same on the National Assessment of Education Progress math achievement tests. But less than a quarter of the high school students who expect to major in computer science in college are girls, and less than one tenth of the high school students who expect to major in engineering are girls.

It should not be surprising that the nation's engineering graduates are only roughly 20 percent women, compared to 60 percent women in the social sciences and psychology. And the number of women earning baccalaureate degrees in computing peaked back in 1985 and has been in decline ever since.

So, as women comprise an ever-larger proportion of college students, the number of science and engineering majors has conversely gotten smaller. From 1986 to 1998, for example, engineering degrees decreased from 8 percent to 5 percent of the total undergraduate degrees awarded.

For many years, we have been able to compensate for the decline in students seeking science and engineering degrees by filling the seats in our classrooms and the vacancies in our workforce with talented international students, scientists and engineers. By 2001, 56 percent of the Ph.D. degrees in engineering and 36 percent of the Ph.D. degrees in the natural sciences were being awarded to foreign-born students, many of whom stayed to take jobs here.

But visa requirements have tightened following September 11, 2001, making it more difficult for them to come. At the same time, nations like India and China are increasingly offering quality educational opportunities at home. And according to NSF, the international students who still come are much more likely to return home, because good jobs are now waiting for them in their own countries.

My colleague Shirley Jackson, who is president of Rensselaer Polytechnic Institute, describes these circumstances as the makings of a demographic, educational, and economic "perfect storm." It is clear that we need a much more robust approach to attracting women to science and technology. ADVANCE is not simply about expanding career opportunities for women in higher education. It is about expanding the opportunities for the United States to compete and prosper.

The bright side of this challenge is that I believe we have an opportunity to provide an exciting new face for science and engineering that enables us to attract more women to these fields. Historically educators assumed that women's lack of interest in science and engineering was due to the heavy dose of math they required and the dominance of males in these fields. But, as I have already noted, young women have proven that they can do math as well as men, and the

traditional dominance of males in fields like medicine and law has not stopped women from moving aggressively into these areas.

I suspect that what enabled women to see past the math and the men in fields like medicine was their understanding of the relevance of the material. They did not go into medicine because they were good at biology in high school. They went into medicine because it offered an opportunity to help people and make a difference in their lives. They could see the social value and the relevance.

By comparison, science and engineering have a PR problem. It begins with computer and video games that appeal more to boys than to girls because they tend to involve violence and men's sports. As a result, boys grow up with an abstract view of technology, while girls do not see the point and feel that it lacks any redeeming social value.

We can see this disconnect expressed in broader public perceptions of technology. Those of us here in this room understand that the development of environmentally sustainable technology is critical to our ability to pursue economic development without devastating the natural environment. But public perception surveys indicate that only 5 percent of the general public believes that engineers have a role to play in solving our environmental problems.

We can also see it more specifically in the gender patterns of graduate school enrollments. Women now earn more than two-thirds of the doctorates in psychology, while they are sorely underrepresented in the physical sciences – 23 percent, computer sciences – 18 percent, and engineering – 15 percent.

Scientists and engineers have always been good at invention. But the circumstances of our changing world call for them to move beyond invention to innovation, which means taking those new discoveries and technological break-throughs and putting them to work in novel ways to serve society's needs. The scientists and engineers of tomorrow need to be much more aware of the larger context of their work, and more customer focused. Our future professional value will be measured by how indispensable we are in solving the pressing problems society faces.

When you place science and technology in this larger context of social relevance and improving life, it becomes more appealing to women (and men if truth be told). The question is how to do this in higher education. Graduate programs in the sciences have always been geared toward the Ph.D. degree followed by an academic career, and the size and scope of the programs tend to be determined by research funding rather than the needs of the job market, so that social relevance has not always been very obvious. And over the past decade or so, Georgia Tech has been one of a number of universities that have watched with concern as bright students, many of them women, opted out of graduate school and hence potential careers as faculty members and future university leaders.

Our strategic plan calls for us not just to worry about issues, but to be among the nation's leaders in addressing the problems. We believe the solution is going to be found in long-term commitment and use of multiple, innovative approaches. One such effort relates to creating non-traditional majors in areas like science that have a broader appeal than the conventional majors.

With the help of the Sloan Foundation over the course of the past five years, we developed four professional master's degrees at Georgia Tech. These programs are focused on real-world needs, and they are also interdisciplinary – connecting the physical sciences and engineering with other disciplines, which bring together theory with application. For example, our program in bioinformatics connects math and computer science with the life sciences to help provide technology that will open new pathways leading to cures for our most perplexing diseases. And our program in human-computer interaction combines computing with psychology and social sciences to put computing technology to use in solving elder care issues and other social problems our society will face in growing abundance in the future. Our newest program in prosthetics and orthotics combines medicine with the engineering skills needed to provide new productive lives to those who have lost limbs to landmines or accidents.

Our experience is that these master's degree programs attract a much high proportion of women, minorities, and American-born students than traditional graduate programs in the sciences and engineering. Our human-computer interaction program, for example, has a large percentage of female students, in sharp contrast to traditional computer science programs where women have been declining for more than a decade. As a result, organizations like the President's Council of Science and Technology Advisors, the Sloan Foundation, and the Council on Competitiveness are promoting the development of professional master's degrees in science and technology as one way to increase the number of women and minorities in the science and engineering workforce.

However, the specific goal for ADVANCE is to increase women in academic careers in science and engineering, and that means finding ways to inject a greater sense of relevance into the more traditional Ph.D. programs. Part of the answer lies in federal funding patterns. The members of PCAST – the President's Council of Science and Technology Advisors – have been studying the trends in graduate enrollment in the sciences and engineering, and we have been struck by the extent to which enrollment levels mirror federal research funding.

During the latter half of the 90s, Congress was focused on doubling the budget for life sciences research through the National Institutes of Health, and that increase came at the expense of research in the physical sciences and engineering. As a result, we saw a decline in graduate enrollment in the physical sciences and engineering. This trend is not simply the result of a reduction in federally funded fellowships, although that did happen. It is evident in the broader graduate student body. In fact, the sharpest decline was among students who did not receive any federal assistance at all.

Graduate students tend to view the level of federal funding for research as a broad bell-weather for the importance and relevance of a particular field. If the research money does not go there, neither do they. Increased federal funding, both for research and for fellowships is essential to attracting more students into graduate studies in the physical sciences and engineering. And if we can combine that with a better job of communicating the growing dependence of society on science and engineering for its well being, I believe more women and minorities will respond to that opportunity. It is gratifying that based on a collective will that developed in the course of our PCAST hearings, a number of federal agencies are gearing up to create robust fellowship

programs that will support advanced study by U.S. citizens in the physical sciences and engineering. Special programs will be created to encourage participation by women.

Of course, we also need to do a better job of making employment in science and engineering friendlier to women. If you look at the science and engineering workforce in general, the profile of the female professional differs from the male professional. Women professionals in science and engineering tend to be younger – almost half of them under age 40 – and they are less likely to be married. Those who are married are almost twice as likely as their male counterparts to have spouses who also work full-time, making them much more susceptible to the problems of accommodating dual careers.

Women clearly bear the lion's share of the burden in raising a family, especially when their children are young, and this responsibility competes with their careers. In the broader workforce, this balancing act between career and family is reflected in the fact that more than one in five women works part-time. Even in professions like medicine, accounting, and law where a high-powered career requires long hours, part-time work is nevertheless made available for those who choose it. In contrast, a 2001 study funded by the Sloan Foundation found that only two percent of the roughly one million tenured and tenure-track faculty in the United States work less than full-time, particularly in science and engineering.

The few women in academe who manage to wrangle a part-time working arrangement often find they have killed their chances of tenure in the process. While their university has made part-time work available, the schedule for attaining tenure has too often not been adjusted accordingly.

Increasingly we also find academic couples that face the challenge of finding two tenure-track jobs that allow them to live together under the same roof. Here in Atlanta we have a dozen colleges and universities within reasonable commuting distance, which makes life easier for academic couples. But in many smaller cities and rural areas, there is only one higher-education game in town.

As a result, too few of the women who earn Ph.D.s in science and engineering end up pursuing careers in higher education. A study just released in January found that in most science and engineering fields, the proportion of doctoral degrees earned by women is higher than the proportion of beginning faculty members teaching in the discipline. In biological sciences, for example, women earned 45 percent of the Ph.D. degrees awarded between 1993 and 2002, but only 30 percent of the young assistant professors at the nation's top 50 research universities were women. In computer science, women earned nearly 21 percent of the Ph.D.s awarded during the same time, but less than 11 percent of the assistant professors at leading research universities were women.

Of those who do go into academe, problems such as those I just mentioned cause many to drop out along the way. If you look at full professors, the number of women in science and engineering at the nation's top 50 universities gets even smaller, ranging from 3 to 15 percent, depending on the discipline. When few senior women are well established and visible in a field, it discourages other women from entering it. And the limited presence of women in full

professorships leads Ph.D. students and young assistant professors to wonder whether they will be treated fairly if they continue a career in academe.

I know that your parallel sessions today and tomorrow are dealing with many of these issues, and we all look forward to your advice. There is clearly a need for personnel policies that are more family friendly, and I also believe we need to go beyond adjusting the rules to adjusting our attitudes and the workplace environment.

At Georgia Tech we have made this one of our institutional goals and we have taken significant steps toward it. After working to create a system family-friendly policies, this past year we opened our first full time childcare facility for our faculty and staff. This coming fall we will open a childcare facility in our new family housing area specifically designed for graduate students. Still, there is much work to do.

As institutions we all need to take the steps we can take on our own. But beyond this we need to join together to insure that we continue to work to overcome years in which progress has been agonizingly slow. I applaud you for your commitment and look forward to working with you to make a difference. Thank you all for coming and bringing your ideas, stories, and advice. Together, we will open doors of opportunity and provide incentives and encouragement for more women and minorities to participate in generating the intellectual discourse and the new ideas that will provide the bedrock for our future economic well-being.