A National Science Foundation Workshop

NEW EXPECTATIONS FOR UNDERGRADUATE EDUCATION IN SCIENCE, MATHEMATICS, ENGINEERING AND TECHNOLOGY

Changing Institutional and Faculty Roles for the Future

By G. Wayne Clough
President
Georgia Institute of Technology

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It is my pleasure to speak to you about the subject of this workshop – New Expectations for Undergraduate Education in Science, Mathematics, Engineering and Technology. The subject is timely and I congratulate Clark Atlanta and the National Science Foundation for sponsoring this important event. I note that the workshop has been on going for a day and a half and I am sure you have accomplished a great deal to this point. I only wish I could have been with you for your deliberations. The session topics sound stimulating – use of new technology, need for changing cultures, P-12 teacher preparation, creating a learning environment, collaborations between higher education and K-12 (P-16), and collaborations between business, academia and government. Each of these are important topics, and I look forward to reading the results of your deliberations.

My charge this afternoon is to share with you some thoughts about how we can assist and support our faculties to provide the education our graduates need to participate effectively in the rapidly evolving world of work and as citizens in our country, and indeed of the world. To set the stage for this, we need to think together about what the task is, by understanding the expectations our graduates will face, the competition they must be prepared for upon graduation, and how this will change in the future.

Let me give you a personalized view of based some of my own experiences during the past two months that derive from my duties as president of Georgia Tech. This summary is not intended to impress you with my durability in the face of the trials and tribulations of modern travel, but to illustrate what might be referred to as an "exposure profile" of a world my job allows me to see close up and in high speed. From these experiences we can gain some insights to our challenges.

In case you are wondering, I am going to pass over all faculty meetings, budget discussions, and meetings with concerned students and instead focus on the "outside world." First the historical record. My travels have led me to the corporate headquarters of Boeing and DuPont, to MIT to participate in a National Summit on Innovation, to Metz and Paris, France to sign educational and research agreements between Georgia Tech and French educational institutions and government agencies, to Washington D.C. to discuss the role of research with congressmen and industry leaders, to New York City to visit investment firms to discuss the role of technology in their business, and finally, to Washington D.C. again to talk about future workforce needs and enhancing the role of minorities in our technological economy. I have visited venture capitalists in California, participated in meetings between start-up companies and venture capitalists here in Atlanta, met delegations of high-tech corporate representatives who are considering moving their operations to Atlanta, and hosted a high level meeting on my campus of executives to talk about the globalization of our economy and its influences on higher education.

Principal messages from all of this begin with the understanding of the pervasive role of technology in our society and the expectation that its influence will be even greater in the

future. It is clear there is a need for our graduates to be technically competent and comfortable with the means of technological communication and information access. I would emphasize comfortable, or at ease, with technology, since the pace of change is going to be fast, and those who have to struggle will be left behind. Simply said, our graduates need to know their basics thoroughly and well. But the other part of the message I have received is that our graduates also must possess skills that allow them to be adaptable, to learn on their own, to be able to communicate ideas, work in a global economy, apply their skills to business ideas, work in teams, and be welcoming of diversity. They also must not be locked in by disciplines since the world of work and government are growing more and more along interdisciplinary lines.

The corporate leaders I have spoken to emphasize that their world has undergone a profound change, and the old order will not come back. No matter how well known or presently sound a company is today, nothing is assured for tomorrow, and the competition is global. They are looking for graduates who are not complacent and who are open to change and challenge. In the world of venture capital and entrepreneurial business, these employers and managers emphasize that good ideas are a necessary start, but much more is required for success. Business acumen, communication skills and hard work are also needed. It is clear in the entrepreneurial world that ideas are coming so fast, we will see an even faster rate of change in the future than in the past. Finally, all agree that the information and computing revolution will have a profound effect on how they do business.

Let me give you three illustrations of our new world. The first relates to the planning and design of the Boeing 777. A radical departure was used to create this magnificent aircraft, one of the most complex machines in the world. It was designed entirely by teams using the best and most powerful computers with the information shared through over 400 companies here in the U.S. and in 12 other countries. No mock-up of this plane was ever made – computer simulations tested the design and the plans converted directly into an airplane that flew when it was assembled. Remarkable. My second anecdote relates to a visit I made to the headquarters of the Hewlett Packard Corporation in Palo Alto. During a briefing one of their engineers stated that 60% of HP's business sales came from products developed in the last two years. Think about what this says – in the world of high-tech, you have to depend of the success of almost every product since if your latest idea is not a winner, your sales will immediately reflect it. Finally, about a month ago you may have read about a new company in Atlanta that offered its stock for public sale (IPO). The odd thing about this company was that it really had not been in business yet. Its core competency was a technology to provide security for Internet transactions. Upon the stock offering, $600 million of stock was sold and the CEO became richer by $160 million overnight. How could this be? Clearly it reflects the incredible importance of the Internet to the future of commerce.

Are our graduates going to be ready for this world of work? Can they provide government with the talent that can set policies so that technology will serve society in the future? These are the challenges we in education face. How can we help our faculty in their daunting role? Some suggestions:

1. The "Raw Material" or Pipeline

We are all familiar with the statistics showing that high school students in the U.S. lag far behind those in many other countries in math and science skills. It disadvantages our faculty who teach at the undergraduate level if they have to spend large amounts of their time revisiting materials the student should already know. This workshop has addressed the area of college and university collaboration with K-12, a very important concept. It does us no good to point fingers since the problems are complex. We are all in this together and collaborations, while not a panacea, do provide an important device to help. At Georgia Tech we created a special organization, CESIMC, or the Center for Integrating Science, Math and Computing to coordinate our activities with K-12. This was an important step since K-12/university collaborations are typically best accomplished by experienced professionals, not by well-meaning amateurs. CESIMC provides us with a group that assembles Georgia Tech talent as needed, writes proposals to obtain funding, and comes up with creative ideas in corporation with our friends in the K-12 education sector. The results are impressive. For example CESIMC recently put Zoo Atlanta on-line so that students who visit the Zoo can stay in touch with animal keepers and researchers after they return home. A simple, but profound concept that keeps the information flowing and the student's interest in science pumping.

Georgia Tech also provides a home to SECME, the Southeastern Consortium for Minorities in Engineering. SECME has long been one of the premier organizations for encouraging our talented minority students here in the south to tackle engineering and science as a career path. It has done it through summer programs that allow teachers exposure to the latest developments and to experience time in industry.

2. Making it Real – or Providing the Motivation by Doing

Two weeks ago the Carnegie Foundation released its report, "Reinventing Undergraduate Education, A Blueprint for America's Research Universities." It advocates an ideal of learning by doing, stating, "The experience of most undergraduates at most research universities is that of receiving what is served out to them....The ideal... would turn the prevailing undergraduate culture of receivers into a culture of inquirers, a culture in which faculty, graduate students, and undergraduates share an adventure of discovery."

The pathbreaking work at the Rensselaer Polytechnic Institute is cited in adopting a studio approach to introductory science courses instead of the more typical large lecture format. This approach emphasizes team efforts in laboratory work, problem solving and co-operative learning.

Many universities, Georgia Tech included, use co-operative education as a means to bring students into the world of work and to use this to leaven the educational experience. As a student at Georgia Tech I followed this path and am a true believer in the value of the co-op experience.

Much more of this type of effort needs to be done to get our students to see the world of work and government. These efforts will also help our faculty see more clearly the changes that are occurring outside the gates of academia.

3. Embracing the Use of Information Technology

For a long while universities and colleges have taken steps to adopt educational and information technology advances into our teaching processes. We have moved slowly since all too often a heralded advance turned out to be more virtual than real. However, the pace of real advances is picking up and the students who are coming to our campuses are probably well ahead of us and our infrastructure in using them. Indeed, one can argue we are going to be run over by the train.

Some examples of experiments that are working on my campus include:

- Classrooms with video feed and electronic whiteboards that allow faculty lectures to be directly recorded, along with student notes from their own electronic note pads, and delivered directly to the student's computer in their rooms.
- Multi-location design project interaction using electronic whiteboards, and special "chat rooms" for discussion that allow teams to work together and exchange information instantly.
- On-demand learning offerings using the Internet and host servers that can be accessed at any time of the day, with e-mail or audio for direction interaction with the faculty member.

The latter item will be a powerful tool for the non-traditional student and in meeting needs for continuing education and training.

The bottom line is that universities and colleges will have to make every effort to supply the technology and training needed for our faculty to adapt to the new landscape. They, in turn, will have to take the initiative to access all of the opportunities available to prepare themselves.

4. Evolution of the Teaching/Learning Culture

Our culture needs to change from an emphasis on teaching and lecturing and disciplinary ideas to one that allows room for self-learning, development of team skills, and interdisciplinary studies. Our students are coming to us with this understanding and there is a growing mismatch in what we do and what they expect if we don't prepare ourselves. We have to provide our faculty with the training, time and equipment needed to make this transition. The pace of this effort cannot be slow, or we will be over-run by non-traditional education suppliers.

Technology will be a major part of this evolution since the new computer/information systems allow our students to explore and discover vast realms of information while staying in contact with their fellow students and faculty. We don't need to feel

threatened by this since information is a long way from knowledge and it is our faculty who are the key to making the conversion from one to the other. Self-learning will in no way de-emphasize the need for faculty and faculty guidance, but rather it will offer our faculty a more meaningful use of their time in the teaching side of the equation.

Finally, we need to provide exposure to interdisciplinary ideas, but within a rigorous context that relies on fundamental knowledge. At Georgia Tech we have undertaken an educational initiative in the highly interdisciplinary area of sustainable technology. The course sequence is grounded in technical fundamentals and leads to design principles and ultimately to case histories.
We are extending this effort to include policy and governmental aspects of sustainable technology.

To make such initiatives happen, institutions have to put up resources for their faculty and give them time to develop the needed course materials while visiting with industry to see that they new materials make sense.

Conclusion

As we look ahead, it is clear that our challenge is substantial for those of us engaged in education in mathematics, science, engineering, technology and computing. Yet the opportunities are staggering. It is estimated that there are 300,000 unfilled, high paying jobs in information technology today. One of the reasons they are unfilled is that we don't yet have the capacity to produce the needed numbers of people, but also, we have not prepared our educational processes for the type of skills that are needed.

Consider the following quote: "The security and prosperity of the United States depend today, as never before, upon the rapid extension of scientific knowledge. So important, in fact, has this extension become to our country that it may be reasonably said to be a major factor in national survival." It could have been said yesterday by President Clinton, but President Harry Truman said it in 1946. In short order such sentiments led to the formation of the National Science Foundation. President John Kennedy understood later, similar imperatives and this led to the development of our world-leading space program.

Today we have another major national challenge and it lies squarely on our plate. We will either accept this challenge and win the battle, or others will step in and do it. I would suggest our nation's traditional universities and colleges are the best avenue, but we must be willing to change and adapt our ways if we are to be successful. I am sure the results of this workshop will provide us with guidance for the work that lies ahead and I look forward to hearing about the results.