American Association for the Advancement of Science Annual Meeting
Remarks of University System of Maryland Chancellor William E. Kirwan
Friday, February 18, 2011

Thank you, Jay, for the invitation to take part in today's discussion and to join my colleagues on the panel in offering some thoughts on STEM education and global stewardship. I realize I need to keep my comments brief, so let me move quickly to make my few observations.

As we all know, there is nothing new about efforts to enhance STEM education. For the past two decades at least, national groups have issued urgent calls to improve the quality of STEM education and to produce more STEM graduates. I think we have to admit, to date, these calls have produced some points of light but not systemic change and improved results on the scale we need.

I detect, however, a new sense of urgency on this persistent problem brought on by an increasing awareness of the monumental problems we face, including:

- Global warming and climate change;
- Threats to water quality and ecosystems, not just in undeveloped nations but right here in the U.S.;
- Inadequate human health and nutrition; and
- A sense that we are losing our competitive edge in the global knowledge based economy.

Theses challenges are truly unprecedented. AND they demand a workforce and an educated citizenry who understand the interrelated scientific and social dimensions of these complex problems and who have the ability, skill, and motivation to address them.

In short . . .the solutions to these challenges lie in much greater participation and productivity in STEM disciplines. The rising generation of college students and their deep interest in sustainability hearten me. This bodes well for boosting enrollments in STEM disciplines.

The current administration's education agenda also heartens me. In my view, it is focused precisely where it needs to be:

- Making math and science education a national priority at the earliest grade levels;
- Increasing the number of college students in the STEM fields;
- Recruiting math and science degree graduates to teaching;
- And opening the doors of college to more young people, especially low-income and underrepresented minority students

And beyond education, the President's environmental, energy, and even healthcare agenda ALL recognize the transformative impact of STEM education.

- Creating "green jobs" & promoting "green building" technologies;
- Making the U.S. a leader on climate change and sustainability;

- Through research, developing clean, alternative energy sources…solar energy, wind energy, and biofuels; and
- Using technology to improve healthcare while reducing costs and funding critical health-based research

These are all vital policy initiatives . . . and each one is STEM-based.

At the same time, however, we face enormous challenges in expanding the teaching and learning that takes place within the STEM disciplines on the campuses of our nation's colleges and universities. We have

- A fiscal environment that is diminishing, not increasing investment in higher education;
- A culture at our institutions that resists change in pedagogy; and
- An attrition rates by students coming to our campuses intending to study a STEM disciplines this is, quite frankly, alarming.

Freeman Hrabowski, my colleague and president of the University of Maryland, Baltimore County is one of the nation's leading advocates for improving STEM education. He recently chaired a National Academies group exploring STEM education, with an emphasis on increasing minority participation.

Let me share with you some very telling statistics from this group's report:

- For Asian American students who enter college as STEM majors, less than one-third—32.4 percent—complete a STEM degree in four years.
- For white students, the STEM completion rate is less than a quarter, 24.5 percent.
- And for African American and Latino students who initially began college as a STEM majors, the four-year STEM degree completion rates are in the teens.

Undoubtedly, part of this attrition is due to inadequate preparation in our secondary schools. But, I think we are deceiving ourselves if we do not acknowledge that we in higher education also bear responsibility for these atrocious attrition rates. While there are certainly admirable counterexamples, for the most part, we are not doing enough to deliver math, science, and engineering instruction in a way that engages and excites the current generation of students coming to our campuses. Too many students arrive interested in studying STEM disciplines and we are turning them off.

The good news is that there are teaching and learning innovations out there that can turn this situation around. The question is do we have the will to embrace them. That's the subject of the remainder of my remarks.

Let me begin with a few examples that I believe hold real promise for boosting our ability to improve participation and success rates in STEM disciplines.

A few years ago the USM launched a course redesign effort based on the NCAT's model, developed by Carol Twigg. We focused on the so-called "gatekeeper" courses, the large, multi-sectional, lower division lecture courses, primarily in the STEM areas. We initiated at least one redesigned pilot course at each USM institution. The models involved:

- Active learning, using technology and online tutorials
- Collaborative learning, using social networks
- Availability of mentoring and tutorials
- And, immediate feedback for students on what they were and were not learning

Every USM pilot project was successful, with improved learning outcomes and higher pass rates at the same or—in many cases—lower costs.

A great example of how effective theses efforts are can be found at University of Maryland, Eastern Shore, which redesigned its "Principles of Chemistry I" course. By utilizing an on-demand online tutorial, providing additional technology-assisted instruction, regularly posting progress reports, and reducing weekly classes from three to two in order to free instructors up for more one-on-one assistance, the student performance went from almost half the students getting Ds or Fs to nearly 70 percent getting a C or better, and the consolidation of course sections cut costs substantially.

This approach also has great potential in mathematics. We have seen this at Towson University, which redesigned its remedial math course. Students in the redesigned sections completed the course successfully and the next credit bearing course at much higher rates.

It is perhaps counter intuitive, but the cost of course delivery in many of these redesigned sections has been lowered. In these difficult fiscal times, better learning and lower costs are a combination that simply cannot be ignored.

We are now investing several million dollars across the USM to ramp up the development of redesigned courses. Our goal is to redesign all 50 or so of the lower division "gate keeper" courses and turn them into "gateway" course to facilitate college completion. Again, we are focusing our efforts on entry-level STEM courses.

A somewhat more sophisticated approach to course redesign has been undertaken at Carnegie Mellon University, using advances in cognitive science. The learning outcomes produced at Carnegie Mellon are similarly impressive and have been described in a number of publications, which I'm sure many of you have seen.

I recently had the privilege of learning about yet another active learning model, developed by Nobel Laureate Carl Wieman, which also uses cognitive and neuroscience. As I'm sure most of you know, Carl Wieman currently serves as Associate Director for the President's Office of Science and Technology Policy, which is launching a major STEM education initiative. Incidentally, Dr. Wieman will be delivering the annual Langenberg Lecture at the University of Maryland, College Park on March 1st at 4PM. I would like to invite any of you who are interested to attend.

Using brain scans and imaging, Dr. Wieman has actually studied the ways the brain develops “expert thinking” . . . with the goal of getting students to think like experts. Students are guided to

- Develop concepts and mental models
- Test these concepts and models and recognize when they apply
- Distinguish relevant & irrelevant information
- And establish a criteria for checking solutions

The emphasis is on knowledge, process and context. The result is conceptual mastery

Like Carol Twigg’s work and the efforts at CMU, Carl Wieman’s approach changes the model to require active mental effort as opposed to passive listening.

One dramatic experiment he conducted to demonstrate the efficacy of his approach involved engineering students enrolled in an introductory course on EM. The students were divided into two groups. The first group was taught “traditionally” with a very experienced, highly rated professor.

The second group was taught by a physics postdoctoral student inexperienced at teaching, but trained to use Carl Wieman’s teaching and learning strategies. The results were dramatic. Not just grades . . . but attendance and engagement were higher, much higher, in the second group. Moreover, their higher grades persisted in the follow-on course.

Essentially, in Carl Wieman’s approach, he envisions the teacher as a “Cognitive Coach”

- Designing tasks that promote the specific elements of “expert thinking”
- Motivating students to put in LOTS of effort
- Providing timely and specific feedback
- Recognizing and addressing learning difficulties as soon as they arise
- And always challenging the students.

What is so impressive about this work, is that the teaching strategies have been developed using activities that cognitive and neuro- scientists know stimulate the portions of the brain that expand and retain knowledge.

These three examples, Carol Twigg’s NCAT, the work at Carnegie Mellon, and Carl Weiman’s dramatic results offer both a real sense of hope and a challenge for the rest of us. As I noted at the outset, change does not come easily in the academy. In some ways this is a strength because it inoculates against short-term fads. But, it becomes a formidable obstacle when real change is needed.

My view is that the approaches I have described, and others based on the same principles, have demonstrated beyond reasonable doubt that they improve learning without substantially increasing costs, and in some instances actually lowering costs. The approach I have adopted in promoting these strategies within the USM is to note that at the core we are educators with a fundamental responsibility to help the next generation master the disciplines we teach. How can we ignore pedagogical strategies that improve learning, retention, and the pursuit of STEM careers? Because I believe so strongly we cannot ignore these new pedagogical strategies, the USM has gone “all in,” so to speak with course redesign. It has become a central part of our strategic planning. We know that change will not be immediate but we are providing incentives to get more and more faculty involved. And, quite frankly, I am very encouraged by the increasing buy-in to these strategies by our faculty.

Is this approach the elusive silver bullet that can eliminate all of our deficiencies in STEM education? No. But can this approach make a huge difference and begin to abate our declines in STEM education and increase the production of STEM graduates... absolutely! Perhaps it’s a bit gratuitous to say but I feel that faculty and administrators who do not at least explore the application of these new learning strategies are not meeting their responsibility to our students.

I was pleased to see that the President’s proposed budget includes a $100M competitive grant program administered by FIPSE to promote the kind of innovative reform in STEM teaching and learning I have described today. I hope NSF will follow suit with a major program to support these kinds of reforms because I fully admit there are some initial start-up costs. I also hope AAAS will launch a campaign to spread the word about the power of these new strategies and encourage their wide adoption. In my view, they offer real hope that - at long last - we can begin to see the kind of meaningful and systemic reform in STEM education that is so badly needed and that we’ve all been advocating for the past several decades.

Thank you.