

CHALLENGES TO AMERICAN COMPETITIVENESS IN MATH AND SCIENCE

HEARING

BEFORE THE

SUBCOMMITTEE ON 21ST CENTURY
COMPETITIVENESS

OF THE

COMMITTEE ON EDUCATION
AND THE WORKFORCE

U.S. HOUSE OF REPRESENTATIVES

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CHALLENGES TO AMERICAN COMPETITIVENESS IN MATH AND SCIENCE

Thursday, May 19, 2005
U.S. House of Representatives
Subcommittee on 21st Century Competitiveness
Committee on Education and the Workforce
Washington, DC

The Subcommittee met, pursuant to notice, at 10:02 a.m., in room 2175, Rayburn House Office Building, Hon. Howard P. “Buck” McKeon [Chairman of the Subcommittee] presiding.

Present: Representatives McKeon, Ehlers, Osborne, Inglis, Price, Boustany, Kildee, Kind, Holt, McCollum, Van Hollen, and Davis of California.

Staff present: Kevin Frank, Professional Staff Member; Allison Griffin, Professional Staff Member; Krisann Pearce, Deputy Director of Education and Human Resources Policy; Amy Raaf, Professional Staff Member; Deborah L. Samantar, Committee Clerk/Intern Coordinator; Kevin Smith, Senior Communications Advisor; and Brad Thomas, Legislative Assistant; Ricardo Martinez, Minority Legislative Associate/Education; Alex Nock, Minority Legislative Associate/Education; and Joe Novotny, Minority Legislative Assistant/Education.

Chairman McKEON. A quorum being present, the Subcommittee on 21st Century Competitiveness of the Committee on Education and the Workforce will come to order. We’re holding this hearing today to hear testimony on challenges to American competitiveness in math and science. Under Committee Rule 12(b), the opening statements are limited to the Chairman and the Ranking Minority Member of the Committee. Therefore, if other Members have statements, their statements will be included in the record.

With that, I ask unanimous consent for the hearing record to remain open 14 days to allow Members’ statements and other extraneous material referenced during the hearing to be submitted in the official hearing record. Without objection, so ordered.

STATEMENT OF HON. HOWARD P. “BUCK” McKEON, CHAIRMAN, SUBCOMMITTEE ON 21st CENTURY COMPETITIVENESS, COMMITTEE ON EDUCATION AND THE WORKFORCE

Good morning. Thank you all for joining us on this beautiful day for this important hearing to hear testimony about challenges to American competitiveness in math and science. I want to welcome

our witnesses and thank them for taking the time to appear before the Subcommittee.

Today's hearing is to examine what is happening within America's educational system in the fields of math and science that is hampering U.S. advancement and what American schools and the business community can and should be doing to reverse that trend and to bolster American competitiveness.

Some have suggested that we could improve our competitiveness in math and science fields by providing increased incentives to math and science graduates. With the average starting salary for engineering majors approximately \$50,000, this is 66 percent more than the average for liberal arts majors and 43 percent more than the average for business administration majors. In addition, many high tech businesses have high skilled jobs available, but they can't find enough workers here to fill their needs. Clearly, there are already ample incentives to attain degrees in math and science and engineering.

I believe the problem is more a pipeline issue. There are simply not enough students going through the K-12 system and the higher education system that are really interested in science. And for those students that are interested in science careers, they must overcome a number of obstacles along their educational path. For example, according to the National Science Foundation, 46 percent of math teachers did not major or minor in math in college. How can we get students to be enthusiastic about math when math was not the main interest of the teacher?

We have English teachers teaching math. We have teachers from other fields, other majors, that are trying to excite and motivate our students in the areas of math and science. When I was in Hong Kong recently, all of the teachers in junior high and high school there in math were math majors, science majors.

In addition, according to some studies, only half of the students who begin college to pursue math and science actually graduate with a degree in math or science within 6 years. Institutions of higher education can and should do more to recruit and retain these students.

Lately I've been reading the book, "The World is Flat", by Thomas Friedman, where he argues that technical innovations and investment in the 1990's made the world flat so that countries like China and India that were once marginalized can now compete with the United States on the global stage. We put out all this money, we built the net, we built this worldwide web, and all they need is a computer, and they can compete.

He even comments in the book that 20 years ago if you had had the choice to be born a B student in Boston or a genius in China, you would have taken the B student in Boston. But now if you're a genius anywhere in the world, you can compete and compete well.

I've met a number of business executives and leaders from high tech companies from my district and around the State of California and across the country, and they've encouraged me to visit China and India. They said you've got to go around and see what's happening. So we did. We took a congressional delegation a few weeks

ago. Three of my colleagues on this Committee joined us on that trip, and it was a great trip.

We saw tall skyscrapers in Shanghai on land that 15, 20 years ago was agriculture. Our hotel room was on the 87th floor, and I don't do well with heights, so. But it was amazing. I look at that, and I know where I come from, we would not have been able to go through an EIR in the time that they build those skyscrapers. So we've got to—we really need to wake up and see what we can do to compete.

While the U.S. still leads the world in scientific and technological innovation, we must continue to be adaptive and flexible to meet the challenges of today and tomorrow.

Our witnesses that are with us today will testify on what can be done at the K–12 level, what institutions of higher education can do to increase math and science graduation rates, and the problems that high tech companies are facing to fill the needs of their workforce.

I want to thank all of you for being here today, and I look forward to hearing your testimony.

I now yield to my good friend from Michigan, Mr. Kildee. We've been at this now for a few years. It's good to be here with him, and I yield what time he desires for his opening statement.

[The prepared statement of Chairman McKeon follows:]

Statement of Howard P. “Buck” McKeon, Chairman, Subcommittee on 21st Century Competitiveness, Committee on Education and the Workforce

Good morning. Thank you all for joining us for this important hearing to hear testimony about challenges to American competitiveness in math and science. I want to welcome our witnesses and thank them for taking the time to appear before the subcommittee.

Today's hearing is to examine what is happening within America's educational system in the fields of math and science that is hampering U.S. advancement, and what American schools and the business community can and should be doing to reverse this trend and bolster American competitiveness.

Some have suggested that we could improve our competitiveness in math and science fields by providing increased incentives to math and science graduates. With the average starting salary for engineering majors approximately \$50,000, this is 66% more than the average for liberal arts majors and 43% more than the average for business administration majors. In addition, many high tech businesses have high skill jobs available but they cannot find enough workers here to fill their needs. Clearly, there are already ample incentives to attain degrees in math, science, and engineering.

I believe the problem is more a “pipeline” issue. There are simply not enough students going through the K–12 system and the higher education system that are interested in science. And for those students that are interested in science careers, they must overcome a number of obstacles along their educational path.

For example, according to the National Science Foundation, 46% of math teachers did not major or minor in math in college. How can we get students to be enthusiastic about math when math was not the main interest of the teacher?

In addition, according to some studies, only half of the students who begin college to pursue math and science actually graduate with a degree in math or science within six years. Institutions of higher education can and should do more to recruit and retain these students.

Lately, I have been reading *The World is Flat*, by Thomas Friedman, where he argues that technical innovations and investment in the 1990's made the world “flat” so that countries like China and India that were once marginalized can now compete with the United States on the global stage. Today, anyone with a computer and access to the internet can compete for business with anyone else around the world.

I have also met with a number of business executives and leaders from high tech companies from my district and around the State of California who encouraged me

to visit China or India to see the progress these countries were making to catch up with the United States. About a month and a half ago, three of my colleagues on this committee and I took a trip to China to do just that.

We saw tall skyscrapers on land that was rice paddies just 15 years ago. We learned of the massive investment the Chinese were making in higher education, particularly in the math, science, and engineering fields.

While the U.S. stills lead the world in scientific and technological innovation, we must continue to be adaptive and flexible to meet the challenges of today and of tomorrow.

Our witnesses that are with us today will testify on what can be done at the K-12 level, what institutions of higher education can do to increase math and science graduation rates, and the problems that high tech companies are facing to fill the needs of their workforce.

I especially look forward to hearing from Mr. Norm Augustine, the retired Chairman and CEO of Lockheed Martin Corporation. Lockheed Martin has a large research facility located in Palmdale, California, which I'm proud to represent.

Thank you all for joining us today, and I look forward to today's discussion.

**STATEMENT OF HON. DALE E. KILDEE, RANKING MEMBER,
SUBCOMMITTEE ON 21st CENTURY COMPETITIVENESS, COM-
MITTEE ON EDUCATION AND THE WORKFORCE**

Mr. KILDEE. Thank you very much, Mr. Chairman. I'm pleased to join my friend and my colleague, Chairman McKeon at today's hearings on the importance of math and science to our future competitiveness.

There could not be a more important topic. I'm looking forward to the testimony of witnesses here this morning. You assembled a very, very good panel, Mr. Chairman. I thank you for that.

Chairman McKEON. We have.

Mr. KILDEE. We thank you. America as a nation woke up when Sputnik was launched on October 4th, 1957. I was teaching high school that day. I remember it very, very well. This achievement by the Soviet Union made us reassess our position in math, science and technology. This event caused the United States to redouble its efforts in the space race and to maintain its place as a world economic power.

The question for us today is clear. Do we need another Sputnik to make us realize the impact that math and science education will have on our future competitiveness as a nation? The problems here are clear and well documented. The percentage of college students seeking degrees in math, science and engineering continues to fall. While women and minorities have increased their participation in math, science and engineering, they are still proportionately under-represented.

The retirement of the baby boomers will leave a professional and technical labor market gap. Both the private and public sector will face problems if the pipeline for mathematicians, scientists and engineers is not widened. These problems are undeniable and certainly need our attention.

The workforce must be knowledgeable and well schooled in mathematics, the sciences, engineering and technology. We will not be able to maintain our economic place in the world without sizable investment in human capital in the areas of math and science.

Mr. Chairman, in closing, I hope this hearing energizes our colleagues to realize and understand the importance of math and science to our nation's economic advantages. Today's witnesses

should spur our discussion not just of the problems we face, but of the solutions we can provide.

And again, thank you, Mr. Chairman.

[The prepared statement of Mr. Kildee follows:]

Statement of Hon. Dale E. Kildee, Ranking Member, Subcommittee on 21st Century Competitiveness, Committee on Education and the Workforce

Good morning, I am pleased to join my friend and colleague Chairman McKeon at today's hearing on the importance of math and science education to our future competitiveness. This could not be a more important topic. I am looking forward to the testimony of our witnesses today.

America, as a nation, woke up when Sputnik was launched on October 4, 1957. This achievement by the Soviet Union made us realize our shortcomings in math, science and technology. This event caused the United States to redouble its efforts in the space race and to maintain its place as a world economic superpower. The question for us today is do we need another Sputnik to make us realize the impact that math and science education will have on our future competitiveness as a nation.

The problems here are clear and well documented. The percentage of college students seeking degrees in math, science and engineering continues to fall. While women and minorities have increased their participation in math, science and engineering, they are still proportionally underrepresented. The retirement of the baby boomers will leave a gap in professional technical labor market. Both the private and public sector will face problems if the pipeline for mathematicians, scientists and engineers is not widened. These problems are undeniable and need our attention.

I know many talented teachers and college professors who are committed to ensuring that we have an educated workforce. This workforce must be knowledgeable and well schooled in mathematics, the sciences, engineering and technology. We will not be able to maintain our economic place in the world without sizable investment in human capital in the areas of math and science.

Mr. Chairman, in closing, I hope this hearing energizes our colleagues to realize and understand the importance of math and science to nation's economic advantages. Today's witnesses should spur our discussion not just of the problems we face, but of the solutions we can provide. Thank you Mr. Chairman.

Chairman McKEON. Thank you, Mr. Kildee. We have a very distinguished panel of witnesses before us, and I again thank you all for being here today.

First we'll hear from Mr. Norm Augustine. Mr. Augustine is a retired chairman and CEO of the Lockheed Martin Corporation, very important in my district back home. I grew up in Tujunga, and Lockheed at that time was in Burbank. In fact during World War II, my aunt was, what did they call them, the riveter? Rosie the Riveter. My Aunt Lil was a riveter at Lockheed. And then when they moved the skunkworks out to Palmdale, that was great for our district.

Though officially retired from the company, Mr. Augustine still serves as chairman of its Executive Committee. During his distinguished career, Mr. Augustine has served as Under Secretary of the Army, chairman of both the American Red Cross and the Boy Scouts of America. I'd like to thank you especially for that. My sons and sons-in-law are all Eagles, all except one. And I think the Boy Scouts do an outstanding job and should be commended every opportunity we get.

He's been a faculty member of Princeton University. His experiences in the areas of engineering and technology place him in a unique position to discuss the challenges this country faces in maintaining its competitiveness in math and science.

Mr. Augustine is also a constituent of my friend from Maryland, Mr. Van Hollen. I understand the gentlemen would like to also add his welcome to Mr. Augustine at this time.

Mr. VAN HOLLEN. Thank you, Mr. Chairman, and let me first thank you and Mr. Kildee for putting together these very important hearings. I think this Committee will probably discuss no more important issue than maintaining our edge and math and science as part of maintaining our global competitiveness. In fact, I think the Nation probably will face very few issues of this importance.

So I just wanted to add my welcome to you, Mr. Augustine. It's wonderful to have you as a constituent, and I want to thank you for all the leadership you provided in the State of Maryland, which was really one of the pioneers I think in looking at the questions of higher education and competitiveness. We've got a long way to go, but thanks to your work, we're headed in the right direction.

I want to thank you for founding the Maryland Business Roundtable for Education and all your leadership there as well.

Mr. AUGUSTINE. Thank you.

Chairman McKEON. Next we'll hear from Dr. Thomas Magnanti. Dr. Magnanti has been a faculty member at the Massachusetts Institute of Technology, MIT, since 1971, and is currently the dean of the Institute's School of Engineering.

During his career, Dr. Magnanti has served as a visiting scientist at Bell Laboratories and GTE Laboratories and as a member of the advisory boards of several prominent educational and research institutions.

Dr. Magnanti has also been involved in several collaborative efforts between education and industry that have sought to engage students in math, science, engineering and technology disciplines. I was talking earlier with the doctor and mentioned that when we were in China, one of the leaders that we visited with over there, he was head of the Microsoft Research and Engineering Department, and he said he had gotten his Ph.D. at Carnegie Mellon. And he said the four top schools were MIT, Carnegie Mellon and then Berkeley and Stanford. And I said, you know, you forgot Cal Tech. Out in my part of California, Cal Tech, we kind of figure Cal Tech and MIT are, you know, right there. I guess we could have quite a discussion.

I understand now Mr. Van Hollen would like to introduce our next witness on the panel today. He has two constituents.

Mr. VAN HOLLEN. Well, thank you, Mr. Chairman. I'm very fortunate to represent a district which, like all of us, has many people who are involved in important issues to our country.

And I mentioned that Mr. Augustine had been the founder of the Maryland Business Roundtable for Education. I'm very pleased that we also have with us today June Streckfus, who is the current Executive Director of the Maryland Business Roundtable for Education. I want to thank her for joining us this morning.

As I said, she is now the executive director of that organization which is playing a very active and effective role in promoting excellence in education in our state, and I am particularly looking forward to her discussion about their experience with Maryland's

scholars in Frederick County. And I know you've seen some striking results through your work in Frederick County.

Prior to joining the Roundtable, which was founded in 1992, Ms. Streckfus was the Director of Government and Education Affairs for Maryland Economic Growth Associates. She has been recognized by the Daily Record as one of Maryland's top 100 women, and the 2002 Innovator of the Year.

We're very pleased to have you this morning. And, Mr. Chairman, thank you for inviting these witnesses as part of a very distinguished panel.

Chairman MCKEON. And I yield to Ranking Member Kildee to introduce our final witness this morning.

Mr. KILDEE. Thank you, Mr. Chairman. It gives me great pleasure to introduce Dr. Nancy Songer, a Professor of Science Education at the School of Education at the great University of Michigan, where I and my two sons received degrees.

Professor Songer's field of expertise centers on reformed-based science education, particularly in urban settings, elementary and middle school science, and the development of learning environments which are sensitive to diversity and gender issues. She is the director of a project called Bio Kids. The mission of the Bio Kids project is to create innovative, inquiry-based K-12 science curricula that utilize current technologies for interactive study.

Student teachers, parents and scientists can participate from classrooms, homes, after school programs or other educational settings. The program has been a major element in responding to the needs of students and staff alike in Detroit public schools.

It gives me great pleasure today to have Dr. Songer before the Committee, and we welcome her testimony and attendance.

And thank you, Mr. Chairman.

Chairman MCKEON. Thank you. Before you begin, I'd like to remind of those little lights in front of you. When—we've given you the magnanimous 5 minutes. And the light will go green. When you have a minute left to go is yellow and then when your time is up, it goes red. Don't worry too much about that. We just hold ourselves to that pretty tough standard.

Mr. Augustine.

STATEMENT OF NORMAN R. AUGUSTINE, RETIRED CHAIRMAN AND CEO, LOCKHEED MARTIN CORPORATION, BETHESDA, MD

Mr. AUGUSTINE. Well, thank you, Mr. Chairman and Members of the Committee. I should perhaps begin by noting that I'm here today representing myself and not any particular organization.

I should probably also note that the issue at hand concerning education I view as a part of a much broader issue of America's competitiveness as a whole. I sought to address that broader issue in the written statement that I'd like to provide with the Committee's permission for the record.

Chairman MCKEON. It will be included, no objection.

Mr. AUGUSTINE. Thank you. This morning I would like to touch on three points particularly germane to this hearing from that statement.

The first of those points is that American companies are finding themselves more and more dependent upon science and technology

for their ability to compete in the global marketplace for the very kinds of reasons you, Mr. Chairman, referred to. That ability to compete is of course what creates jobs in America, which in turn underpins our standard of living.

There have been many studies that have shown that during the last half century, over half of the jobs created in America have been directly due to prior investments in the fields of science and technology, and that's probably not surprising when we think of companies like companies like Microsoft or Eli Lilly or Lockheed Martin. But it's also true to a surprising degree to many other companies. I would cite, for example, a consumer products company. The CEO, the recently retired CEO of Procter and Gamble has said that his company is principally an R&D firm.

The second observation I would like to make is that any lead that a company or a country has in science and technology is inherently precarious. And the reason for that is the rapid change in the field of science and technology. For example, if you take dynamic random access memories, which are the building block of the modern electronics industry, a new generation of those appears every 30 months and has been doing so for many, many decades. Intel has said that over 90 percent of the sales it has today are from products that didn't exist a year ago.

The third point I'd like to leave is that once a lead has been lost, it takes a very long time to regain it, if it's possible to regain at all. The reason for that is the long time it takes to educate particularly a researcher in science and technology. A student needs to decide in ninth grade whether or not he or she wishes to preserve the option to pursue a career in science and technology, and that's because of the hierarchical and integrated nature of a science and technology education. That means, for example, that the students today that are making that decision would be likely to receive a Ph.D. in these fields maybe in the year 2019.

In the past, our companies have tried to offset this delay and these shortages by relying heavily on talent from other countries. And in fact, over half the graduates in engineering schools today with advance degrees are from foreign countries.

That has problems that are arising that I'm sure you're familiar with. But I might also say for a company in the defense industry or the homeland security field, that's not an acceptable solution because of the requirement to have security clearances.

I'd like to read for you very briefly one of the two conclusions from the Hart-Rudman Commission, a commission that the Congress established and it was my privilege to serve on. It was a commission on national security. This was one of its two conclusions: ". . . the inadequacy of our system of research and education poses a greater threat to U.S. national security over the next century than any potential conventional war that we might imagine."

The question arises, what might we do? I've offered a number of recommendations in my written statement. Let me touch on a few things that I think are particularly important.

We obviously need to strengthen our K-12 education, and I think that could best be done by bringing the free enterprise system to that educational system, to introduce competition, competition among schools, among administrators, among teachers, to pay

teachers for performance and pay them in accordance with the very important role they play in preparing America's youth for prosperous lives, contributing lives.

We need to encourage more women and minorities to enter the fields of science and technology. We very much need to permit subject matter experts to teach their fields in K-12 after passing a brief preparatory period in teaching skills.

I believe that we need to initiate something that I've called the American Scholars Program whereby the government would award to perhaps a thousand of the highest scoring scholars in the fields of science and technology, including mathematics, on a standardized national examination, a full scholarship for their undergraduate work, and if they wish to continue in graduate work and excelled, to continue that funding. It would make a huge difference to the talent level in our country.

And finally, I would mention that we need to take steps to make productive the entire career of a scientist or an engineer, because their careers, just like companies' strength in science and technology, obsolesces very quickly. That means we need to put more support and emphasis on the topic of continuing education.

Well, thank you, Mr. Chairman, and I look forward to your questions.

[The prepared statement of Mr. Augustine follows:]

Statement of Norman R. Augustine, Retired Chairman and CEO, Lockheed Martin Corporation, Bethesda, MD

Mr. Chairman and members of the Committee,

Thank you for the opportunity to appear before you today. I should perhaps begin by noting that I am representing only myself and am here because I, like you, care deeply about the future of our nation. Further, I have three grandchildren who will live in the world we are in the process of creating.

In addressing the future quality of life in America one cannot help but notice warnings of what appears to be an impending Perfect Storm. The elements which underlie this possibility are, first, the pervading importance of education and research in the fields of science and technology to America's standard of living, and the disrepair in which we find many of our efforts. Second, the precipitousness with which a lead in science and technology can be lost. Third, the prolonged period of time it takes to recover once a lead has in fact been lost, if indeed it can be regained at all. I would like today to briefly discuss each of these considerations.

A number of studies have shown that over half the jobs created in America during the past half century were the direct consequence of earlier investments in science and technology. That is, the ability to provide jobs for our citizen's and support their standard of living can be seen to depend to a very substantial degree on our nation's competitiveness in science and technology. But modern science and technology do not respect geopolitical borders. We all know that if we buy a camera or television set there is a high probability it was built abroad. But this trend has not stopped with manufacturing. For example,

- A patient in a U.S. hospital today may well have their x-ray interpreted by a doctor in India.
- Visitors to a company located a few yards from the White House are greeted by a receptionist in Pakistan whose image is seen on a flat-screen video display.
- A person in Wichita calling the help-line of a U.S. company is assisted by a technician in India.
- A patient undergoing surgery in an American hospital is operated on by a robot directed by a world-class surgeon seated in another part of the room; a surgeon who could one day just as easily be located in China.

Turning to National Security, the Hart-Rudman Commission, on which it was my privilege to serve, stated in its final report that "... the inadequacy of our system of research and education poses a greater threat to U.S. national security over the next quarter century than any potential conventional war that we might imagine."

It is noteworthy that this was a principal finding of a panel established by the Congress to investigate national security; not research or education.

In short, whether we are addressing the creation of jobs, the provision of homeland security, the supplying of energy, the delivery of health care, or almost any other important challenge confronting our society, much of the solution will have to be found through American preeminence in science and technology.

Turning to the second consideration, the rapidity with which our scientific and technological seed-corn becomes obsolescent, it has been noted that the time between the introduction of entire new generations of dynamic random access memories, the building blocks of the modern electronics industry, is only about 30 months. Intel has said that nearly 90 percent of the products it sells today did not exist a year ago. The “half-life” of published research articles in scientific and technical fields, as measured by the frequency with which they are cited, is about two to five years depending on the field. Similarly, the subject matter reflected in university course catalogs in these fields ranges from three to ten years. Even consumer product companies, makers of such everyday items as soap, toothpaste and diapers, are critically dependent upon their prowess in research and development. The retired CEO of Procter and Gamble has described his firm as primarily an R&D company.

Third, with regard to seeking to recover from any ill-advised attempt to underinvest in research and education, it takes a very long time to produce additional productive research scientists. A youth wishing to become a mathematician, scientist or engineer must decide in ninth grade to take courses which preserve the option to pursue a career in any of these fields. This is a consequence of the hierarchical and interdependent character of a science or technology education. Further, the “leakage” rate in the process of producing credentialed researchers is very high indeed. In the field of mathematics, for example, based on current trends one must begin with 3,500 ninth-graders in 2005 to produce 300 freshmen qualified to pursue a degree in mathematics. Of these, about 10 will actually receive a bachelors degree in the field. Finally, one PhD in mathematics will emerge in about 2019.

How well equipped is America to deal with these challenges? On the positive side, we have built what is generally recognized to be the world’s finest higher education system, but it is noteworthy that over half the PhD’s awarded in engineering in our universities are granted to foreign citizens. Until recently, many of these talented individuals remained in America and became major contributors to our society, but more recently fewer foreign students are enrolling in America’s universities and of those who do more are returning home once their academic work is completed. Further, only 20 percent of bachelor’s degrees in engineering are received by women; still fewer by minorities, with the consequence that this major potential source of talent goes underutilized.

Even in this age of burgeoning technology the number of graduates with bachelor’s degrees in the physical sciences, mathematics and engineering has been declining for two decades. China now graduates about 200,000 engineers a year; India and Japan, 100,000 each; the United States, 50,000. In the U.S., five percent of all bachelors degrees awarded are in engineering. In China, the corresponding figure is 40 percent. In Singapore, the fraction is still higher.

A few years ago, when America did not finish in its traditional first-place in Olympic basketball the uproar could be heard throughout the nation. How should American’s feel about being in 15th place out of 16 nations in the advanced math, based on international examinations of high school seniors? Or about finishing 16th out of 16 in science?

But talent is only part of the issue. The other part concerns investing in our universities the funds needed to benefit from that talent. Our government has done a superb job in recent years of strengthening research in the health sciences, but somehow over the last several decades the physical sciences, math and engineering have been neglected. It too often goes unrecognized that much of the recent progress in the health sciences, has been underpinned by earlier achievements in mathematics, the physical sciences and engineering. Deciphering the human genome, for example, was heavily dependent upon advancements in robotics and computers. The development of modern imaging machines was made possible to a great extent by advancements in engineering and mathematics.

I recently had the occasion to visit factories in Vietnam where the wage of the lowest-level assembly workers was about 25 cents an hour. Factories that had moved from the U.S. to Mexico a decade ago are now moving from Mexico to Asia. But the trend does not end with factory workers: today one can hire eleven well-educated engineers in India for the price of one in America. Further, the exodus that began with assembly workers and then spread to software designers is now moving to the most advanced research laboratories. The U.S. for the first time has a negative trade balance even in high-tech products, and the jobs associated there-

with are fast becoming one of our larger exports. Let me emphasize that this not a partisan issue—it is the result of a decades-long trend that will take decades to fully correct.

What, then, must America do? There is but one answer: We must compete. And we must do so while suffering a disadvantage in the cost of labor. We must be more innovative than ever before; we must have a vastly better K–12 educational system than we now have; we must unburden our companies from excessive regulation, litigation and health-care costs; we must significantly increase our federal investment in research.

I would offer the following eight recommendations as a starting point:

- Bring the Free Enterprise System to K–12 education in America. This system, along with Democracy, is what has made America great and it can make our public schools great once again. We must introduce competition among schools, administrators and teachers. We must lengthen the school year. We must pay teachers for performance and pay them in accordance with their important contribution to society of preparing the nation's youth for productive, rewarding lives. We must establish standards, standards that have consequences. This works in our companies and in our universities and it will work for K–12.
- Provide K–12 teaching credentials to subject-matter experts who successfully complete a brief program to acquire and demonstrate fundamental teaching skills. There is a certain irony that upon retiring from my own career in engineering and business I was permitted to teach in the Engineering School at Princeton but would not have been permitted to teach ninth-grade math or science in most of our nation's public schools.
- Initiate an America's Scholars Program which will fully fund the undergraduate and graduate education in the physical sciences, math, biosciences or engineering of the outstanding 1,000 high school seniors in the nation each year who score the highest on a standardized examination and maintain that high degree of excellence during the remainder of their education.
- Double in five years federal spending on basic research in mathematics, the physical sciences and engineering. It should be noted that the steady-state cost of doing this is, in the overall scale of things, modest, equaling the amount by which health care costs in America increase every two months.
- Provide non-citizen graduates of America's universities in the fields of science and technology special consideration for visas, work permits and, especially, citizenship. Offer expedited entry processing to foreign-born scientists and engineers who seek to work in America.
- Provide a tax credit to corporations that fund basic research in science and technology at our nation's universities.
- Provide tax incentives to companies that fund continuing education for their employees in science and technology. This is particularly important if members of the science and technology workforce are to remain productive throughout their entire careers.
- Revise the capital gains tax law such that, in a manner neutral to overall tax generation, gains on assets held for less than six months are taxed at a very high rate, assets held ten years or more are untaxed, and those in-between are taxed in a continuous fashion between these limits.

Finally, and most difficult to accomplish, America must change its attitude toward careers in science, technology and teaching. Probably everyone in this room knows who Allan Iverson and Shaquille O Neill are. But how many know who Bob Noyce and Jack Kilby are? The latter two arguably affected the lives of Americans in a manner matched by only a handful or so of people who lived in the previous century.

We are living in a time of intense competition, a time in which the quality of life in America will be severely tested. In this regard, I would like to close with a poem by Richard Hodgetts that I used to quote to my colleagues at Lockheed Martin who were chosen to represent our company in intense business competitions. It goes as follows:

Every morning in Africa a gazelle wakes up. It knows it must outrun the fastest lion or it will be killed.

Every morning in Africa a lion wakes up. It knows it must outrun the slowest gazelle or it will starve.

It doesn't matter whether you're a lion or a gazelle, when the sun comes up, you'd better be running.

Thank you.

Norman R. Augustine is the retired Chairman and CEO of the Lockheed Martin Corporation and a former Under Secretary of the Army. He serves on the Boards of Black and Decker, ConocoPhillips and Procter & Gamble and has been a trustee

of MIT and Princeton and is currently a trustee of Johns Hopkins. He was a founder of the Maryland Business Roundtable for Education, chaired the (National) Business Roundtable's Education Initiative and has been Chairman of the National Academy of Engineering. He has served as a Lecturer with the Rank of Professor at Princeton and is a recipient of the National Medal of Technology. He holds eighteen honorary degrees.

Chairman MCKEON. Thank you very much. Dr. Magnanti.

STATEMENT OF THOMAS L. MAGNANTI, DEAN, SCHOOL OF ENGINEERING, MASSACHUSETTS INSTITUTE OF TECHNOLOGY, CAMBRIDGE, MA

Dr. MAGNANTI. Thank you, Mr. Chairman, Members of the Committee. It's a pleasure to be with you this morning. I also have in my testimony addressed I think a somewhat broader set of issues than the purview of this Committee and hope that you might be willing to enter those into the record.

I'm going to speak today about engineering, math and science, but I'm going to be using the word "engineering" in some broad sense to represent all three of those through this. And I'd like to make four points if I could today.

The first I think is rather obvious to all of us. Engineering is essential to our nation's well being and prosperity. Imagine, if you will, America in 1900. America without the pervasive availability of electricity and purified water; without mass communication and transportation; aeronautics and flight; without air conditioning and refrigeration; without contemporary health technologies; without agriculture mechanization; without computers, electronics and wireless communication; and without petroleum and petroleum technologies. Engineering has made a difference to our lives.

Over the last 60 years, as Mr. Augustine has indicated, economists tell us that over half of our economic growth has been due to technology. And closer to home, a recent study done in the Boston area indicates that the eight Boston research universities provide \$7.4 billion of a boost to the local economy. \$7.4 billion of boost to the local economy.

My second point, engineering practice and engineering content is changing. And again, this will echo some of the Chairman's earlier remarks. I think one indication of this is MIT's new president, Susan Hockfield, who has just joined us several months ago, the first woman president of MIT and the first life scientist to lead the Institute. I think this signals something about the changing demographics of our university and something about the changing content of our universities as well.

But we see in engineering practice profound changes. One is globalization, as indicated by our Chairman, in terms of manufacturing and research and development being done offshore as well as in the U.S.

We see employment shifts from larger corporations to smaller companies and more of a focus on entrepreneurship.

We see the United States becoming increasingly a service economy, with 70 to 80 percent of our economic output being in the service industries.

And we see information technology and biology adding to the traditional make/build work of engineering in other substantial ways.

In fact, much of what's driving engineering these days is driven by the life sciences and driven by the ultra small—micro and nano technologies.

A few sobering statistics. The U.S. graduates 75 percent as many engineering and science degrees per million population than it did in 1985. So as a percentage of the population, 75 percent.

India and China graduate three times as many bachelor's engineering degrees; in Asia, eight times as many engineering degrees as the United States. Sixty percent of all bachelor's degrees in China are in science and engineering. Only 30 percent in the United States. And the U.S. graduates 50 percent more MBAs than it does BS degrees in engineering.

You'll see from these comments that the practice and content of engineering is indeed changing. I think you also see some rather troubling and disturbing statistics.

My third point, engineering education in America needs to change. We need improvements in undergraduate education in teaching and learning. We need a better use of technology. We at MIT, for example, have had a program with Microsoft for the past 5 years called iCampus to try to bring technologies to bear upon the educational enterprise.

We need more kinds of active learning, learning that will be exciting to our students. And again, we see this both at MIT and elsewhere in the Nation with more design contests and involvement in hands-on learning. And we need a broadening of engineering education, not only to educate our students in the underlying technologies, but also on aspects of management, business and some of the social and political attributes that we deal with.

To echo comments that have already been made, we also need to attract and support the best and the brightest. We've all heard about the pipeline issue, and I won't try to retread all the statistics there, but we need clearly more women and minorities and attracting them to engineering and science.

We need to promote in K-12 education more interest in science and engineering. I'll come back to that later. And we need more feeder programs that are going to feed both women and minorities into our educational enterprise. For example, we have a 30-year-old program at MIT which attracts about 80 students a year and sends them to the Stanfords and Berkeleys and Cal Techs of the world for their education.

We also need engineers as leaders. About 15 years ago when the national faced a manufacturing crisis, I was involved in starting a program at MIT called the Leaders for Manufacturing Program. And that program is helping us to infuse more leaders into manufacturing in the nation. Perhaps the best example of an engineering leader is sitting to my right, Norm Augustine. But through that program we graduated Tim Copes and Pat Shanahan, VP of Technical Services and Rotocraft Systems at Boeing; Liz Altman, who is the VP and Director of Business Development at Motorola's Personal Communications systems; and Jeff Wilke, the Senior Vice President and head of all operations at Amazon.com. So people have gone into both traditional industries and new economy industries.

And we need a meritocracy and an openness to our environment. I myself am the grandson of an immigrant laborer and a father who worked loading rail cars at night so that he could attend college during the day. Our Associate Dean, Dick Yue, his family escaped from China many years ago, and his life's dream was to come to MIT and to study engineering and science, as did his two brothers.

If you just look at our Engineering Council at MIT, our 14 leaders in terms of our Engineering Council, only six of those 14 leaders are U.S.-born. Eight are foreign-born. And if you look at MIT's eleven Nobel Laureates, four are foreign-born. America profits enormously providing opportunities to all our citizens and to a flow of talent into the country.

And one last item is, we have it at MIT, is our OpenCourseWare Initiative. This is a program for taking all of our courses at MIT, putting them on the web, providing them to the world for free. We now have 1,100 of our 1,800 courses online. There's 20,000 unique visitors every day.

As examples, the chairman of a high school science department in Toms River, New Jersey, uses OpenCourseWare material in electricity and magnetism to excite his students.

Ken Magnum, a high school computer science teacher in Chandler, Arizona uses OCW courses to educate himself and his students and to support his after high school Artificial Intelligence Club.

In Colorado, Dan Stivers uses math courses in OCW to educate his 10- and 12-year-old daughters. There are hundreds of stories like this.

I will conclude with several recommendations. The first is to create an engineering curriculum in K-12 to complement this math and science curriculum and bring the excitement and thrill of actually building and creating engineering artifacts to the world of K-12 education, using tools like OpenCourseWare.

Second, develop more active learning approaches for engineering and science as well as an exposure to engineering practice to broaden engineering education. Here I see a role for both the Federal and local governments, industry and universities.

Third, create and support professional graduate programs in engineering as an analog to those of business, law and medicine.

And finally, two broader recommendations that deal with the ecosystem more broadly and not necessarily the content of today's activities.

My fourth recommendation, create a National Innovation Education Act, an NDEA for our times. We talked about Sputnik attracting us to students. To provide an NDEA that would provide portable graduate fellowships.

And finally, develop laws and policies to attract and retain international talent. For example, provide automatic green cards to all foreign-born Ph.D. graduates in the U.S.

Thank you for providing me this opportunity to share some thoughts with you, Mr. Chairman and Members of the Committee.

[The prepared statement of Dr. Magnanti follows:]

**Statement of Thomas L. Magnanti, Dean, School of Engineering,
Massachusetts Institute of Technology, Cambridge, MA**

Thank you for the opportunity to speak to you on a topic that is so important to all of us. By way of background, I am the Dean of Engineering at MIT where I have been a faculty member for 34 years. For most of my career at MIT, I have been a member of the Sloan School of Management, and many of my activities before becoming Dean involved developing professional master's programs at the interface of engineering and management. Since becoming Dean six years ago, I have focused much of my attention on improving undergraduate education and diversity in the School. I have also, in recent years, become increasingly concerned by the tremendous forces of change in technology, in society, and in the world, and the impact, challenges, and opportunities these present to engineering, to education, and to our nation's leadership and competitiveness.

I'd like to cover four areas today:

1. Reemphasize the significance of engineering to the nation and to the world;
2. Outline some of today's challenges and how engineering and science education are changing;
3. Suggest some areas in which engineering and science education need to change; and
4. Offer some recommendations.

The significance of engineering to the nation and to the world

Less than two weeks ago, we inaugurated a new president at MIT, Dr. Susan Hockfield, and I would like to borrow the words she used to describe MIT's values as a description for those of engineering generally. She listed them as rigor; implacable curiosity; disciplined creativity; an appetite for good, old-fashioned hard work; and a passionate, enthusiastic, can-do, hands-on, fix-it-now attitude.

Keeping that description in mind, I would ask you to imagine a world without the fruits of engineering: a world without the pervasive availability of electricity and purified water; without mass communication and transportation; aeronautics and flight; without air-conditioning and refrigeration; without contemporary health technologies; without agriculture mechanization; without computers, electronics and wireless communication; and without petroleum and petrochemical technology. The industrialized world at the turn of the 20th century was just such a world. By creating, developing, organizing, and managing complex technologies and products, the engineers of the last hundred years shaped our nation and the world¹, altering the essential fabric of society and dramatically improving the quality of life. In purely economic terms, during the last 60 years, over half of the growth of the U.S. economy has been due to technological innovation. Our universities have played a major role in this development. In the year 2000 alone, Boston's eight research universities provided a \$7.4B annual boost to the regional economy². Silicon Valley and the Research Triangle in North Carolina provide other powerful examples of how universities impact the regional and the national economies.

As we face some of the most difficult challenges of our day in the physical, economic, human, political, legal, and cultural realms, we will increasingly depend on engineering to provide the tools and the solutions; indeed to help ensure the continual progress, health, and prosperity of our country in the 21st century.

The rapidly changing environment of engineering and the challenges we face today

Engineering in the 21st century faces an environment that is very different from even a decade ago. The practice of engineering is changing: with globalization of manufacturing and research and development; employment shifts from large to smaller entrepreneurial firms and to non-traditional, less technical engineering work (management/finance/policy); movement to a knowledge-based U.S. "service" economy; diminishing half-life of engineering knowledge in many fields; and introduction of new interdisciplinary fields as well as the growing impact of information technology and biology on the traditional make/build work of engineering.

In research, engineering is poised to bear the fruits of revolutionary developments in the life sciences and the ultra small (micro- and nano-technology) and to benefit from continuous but sometimes disruptive advances in information technology. Emerging opportunities often cross (and blur) traditional disciplines, and flat government and industry funding for science and engineering, as well as the increased cost of space and facilities, are stressing the university system.

¹The U.S. National Academy of Engineering's list of "Greatest Engineering Achievements of the 20th Century."

²"Engines of Economic Growth: The Economic Impact of Boston's Eight Research Universities on the Metropolitan Boston Area," March 2004

To develop engineers prepared to address today's challenges, engineering education faces major dilemmas. As the world becomes increasingly technologically driven, students need to be more deeply grounded in underlying science, mathematics, and engineering disciplines and require greater depth in their chosen field of expertise. Simultaneously, society has a strong need for engineer/leaders and engineer/entrepreneurs who have a broad understanding of the context of engineering and business, and are well grounded in teamwork, organizations, and leadership. Concurrent with increased demands and rapid, technological changes, this period is also marked by a limited net resource growth.

Longer-term trends and outlook relative to maintaining our nation's leadership in engineering are ominous. For 20 years, the U.S. share of high tech exports has declined. While the demand for workers highly trained in science and engineering has continued to increase, in terms of engineering bachelor's degrees per million population, we grant only 75% as many degrees as a country as we did in 1985. Today, India and China graduate three times, and Asian countries altogether eight times, as many bachelor's degrees in engineering than the U.S. While 60% of all bachelor's degrees in China today are in science and engineering, only about 30% of those in the US are. In fact, as a nation, we graduate 50% more MBA's than SB's in engineering.

Recognizing the tremendous challenges and opportunities, leading universities have made significant investments in engineering. Harvard and Princeton announced major financial commitments to engineering; Stanford is investing heavily in a new Engineering and Science Quad; and universities such as UCSD and Purdue are adding large numbers of new engineering faculty and investing in high tech infrastructure. Over the last five years, MIT Engineering has created two new divisions, in Engineering Systems and Biological Engineering, with close to 50 faculty members. We have just completed a major new complex, the Stata Center, which houses the Computer Science and Artificial Intelligence Laboratory, the Laboratory for Information Decision Systems, and the Department of Linguistics and Philosophy. Throughout MIT's campus, there is more excitement about education innovations today than any time in the 34 years I have been at MIT. And yet, what we have done is only a tiny fraction of what we need to do meet the many challenges.

Engineering education in 21st century America needs to change

Because the world is increasingly technically dominated, we need all the engineering talent we can get, not only as individuals in engineering professions, but also as technology conversant decision-makers and leaders in all spheres and echelons of society³.

Maintaining engineering as a meritocracy:

Engineering has always been a meritocracy, perhaps the ultimate meritocracy, providing a road to upward mobility. I myself am the grandson of an emigrant laborer and the son of a father who loaded rail cars at night to support his young family while attending classes during the day to be the first in his family to attend college. Our Associate Dean of Engineering, Dick Yue, provides another example. Dick's family escaped Communist China as refugees. Eventually all three boys in his family came to MIT, earning multiple undergraduate and advanced degrees in engineering. (Dick's sister went through Wellesley and Yale and is now a surgeon in Seattle.) We need to ensure that engineering, mathematics, and science education continues to provide opportunities for people like Dick and me and for all members of our society. As President Hockfield said in her inaugural address, it doesn't matter where you come from, what you look like, who your parents are, or how much money you have, the only thing that matters is whether you can do the work. To be the best we can be, the diversity of the engineering workforce and leadership of the engineering profession must grow to match the growing racial, ethnic, and cultural diversity of the United States. We need to attract people of talent and high capability broadly, and especially more underrepresented minorities and women, to

³A recent letter from an MIT alumna from San Antonio provides an illustration of how MIT-educated technologists are impacting her local community outside of their own careers: one alumnus is the architect of the revitalization of the vocational/workforce programs in local high schools; another graduate is active in 21st century career track training, and distance learning to reach the huge sprawl of San Antonio; a graduate in Materials Science and Engineering heads the Education Committee of the San Antonio Manufacturers Association which is about to graduate the first high school seniors from the Manufacturing Technology Academy there; a young alumnus is enthusiastically working with the Brownsville community to help develop a research/incubator facility to help that community grow beyond the maquiladoras as an economic base.

science and engineering, drawing from all segments of society, independent of gender, race, and family background.

While more women and underrepresented minorities have entered science and engineering programs in recent years, concerning numbers of them drop out or switch out before graduation, and the total number of degrees granted to them are not nearly commensurate with population demographics. The situation at the graduate level is even more disturbing. The PCAST 2004 Report noted the worrying levels of “pipeline leakage” among women and underrepresented minority students. Much smaller percentages of these student groups continue on to complete science and engineering graduate degrees, leaving underdeveloped an important segment of the U.S. talent pool.⁴

A most important factor in this context is the high cost of science and engineering education to the student and to the university. We do not want to lose the talents of some of our best and brightest citizens because they cannot afford a college education. The implications can be dramatic. In a recent program to encourage underrepresented minority student applications to graduate school, students listed financial support as a primary concern in the decision to apply to graduate school.⁵

Improvements in undergraduate teaching and learning:

While retaining a strong foundation in the fundamentals, science and engineering education needs to be more exciting and provide more hands on experience and context. MIT, which was a member of the ECSEL coalition, has worked actively to improve teaching and learning in our science and engineering programs. MIT’s iCampus project has focused on the development of educational technology systems for science and engineering education. MIT’s new Undergraduate Practice Opportunities Program enhances the development of professional “soft” skills our students will need in engineering practice, within a curricular context of real world case studies and active learning. Across engineering departments at MIT and nationally, inclusion of engineering design experiences using real world case studies and the use of active learning pedagogies have improved the undergraduate educational experience. The momentum for curriculum reform to address teaching and learning and real world practice is strong. Yet more could be done.

Providing engineering support and feeder programs:

Beyond making changes to the undergraduate curriculum, institutions can and have done more to support students who enter science and engineering programs to complete them. Most institutions now offer counseling, tutoring, and mentoring programs for undergraduates. Others have developed communities of learners to provide support networks for students. One example at MIT is its 30-year-old Minority Introduction to Engineering Entrepreneurship and Science (MITE2S) pre-college preparatory program.

Finally, more should be done in our K–12 to promote interest and motivation in science and engineering. Recent education research has highlighted the importance of a positive classroom learning environment and active learning methods for improving K–12 student academic achievement and motivation. Engineering would be a wonderful context for such active learning and a great motivator not only for technology, but also science and math.

Professional master’s level education programs:

Graduate programs that intertwine technical education with professional practice improve graduates’ ability to productively contribute as members of the U.S. technology labor force and to participate in global technology businesses and research. Such programs could also address the “pipeline leakage.” As noted by the PCAST Report (June 2004), the problematic trends could be stemmed if new graduate programs could capture these students’ interests and more closely meet their career plans.

MIT has been a leader in developing professional engineering degrees to meet industry needs, including its Leaders for Manufacturing (LFM) and System Design and Management Programs, exemplars that unite technical and management education with professional real world content and experiences. LFM graduates have become leaders in U.S. technology based companies, ranging from mature industries (such as Tim Copes and Patrick Shanahan, Vice President, Technical Services of Boeing Commercial Aviation Services, and Vice President and General Manager of Boeing Rotocraft Systems; and Liz Altman, Vice President and Director for Business

⁴At the doctorate level, women receive only 10–12% of engineering degrees awarded nationally, African Americans 2% and Hispanics 4%. (National Science Foundation WebCASPAS database, NSF Survey of Earned Doctorates/Doctorate Records File, 2002 numbers.)

⁵MIT Converge Program, participant survey, 2004.

Development of Motorola's Personal Communications Sector) and new economy companies (Jeff Wilke, Senior Vice-President at Amazon.com).

Openness:

In engineering and science, we need to sustain an environment of openness to productive collaborations across disciplines and across institutions and organizations in the public and private sectors. We also need to maintain an intellectual openness to the flow of international students and scholars who contribute so much to our universities and economy. As examples close to home: (a) of the 11 living MIT faculty who have been awarded the Nobel Prize (8 current and 3 emeritus), 4 were born outside the United States⁶; (b) I chair the Engineering Council at MIT, an advisory/governance body made up of leaders of our Engineering departments and divisions. Of the 14 members, all but 6 are foreign born; (c) among MIT Engineering faculty 40 and under, 50% are foreign born, while that percentage is only 28% for faculty over 60. Nationally, 8% of bachelor's degrees, 46% of master's degrees, and 55% of doctoral degrees in engineering are now granted to non-US students. As the economies and higher educational institutions of these non-US countries develop, there is a need for us to continue to attract and retain this critical talent flow.

Openness is also a powerful way to raise the quality of education in our country at all levels. In April 2001, MIT announced that it would make all the course materials used in the teaching of its undergraduate and graduate subjects available on the World Wide Web free of charge, to any user anywhere. Four years later, this MIT OpenCourseWare project has put online 1,100 out of an eventual 1,800 courses. The OCW materials attract more than 20,000 unique visitors each day. Among these are self-learners, educators, and students at all levels: the chairman of a high school science department in Toms River, New Jersey, now utilizes OCW materials, and the video lectures of MIT Professor Walter Lewin about electricity and magnetism, to get his students excited about physics. Kenn Magnum, a high school computer science teacher in Chandler, Arizona, has utilized materials from several OCW computer science courses to educate himself and his students. With more than 100 course offerings from the MIT Department of Electrical Engineering and Computer Science, Magnum sees MIT OCW as an invaluable professional development tool. And he is referring students in his after-school Artificial Intelligence Club to OCW courses on Artificial Intelligence and Electric Power Systems. In Colorado, Dan Stivers, the father of 10- and 12-year-old daughters, is using the lectures and course materials of noted MIT mathematics professor Gilbert Strang to teach his daughters. These are just a few examples of hundreds of stories from around the U.S. (and the world) about the impact OCW is having.

Recommendations

I have spoken about the areas in which engineering and science education need to change. Let me now offer a few recommendations for comprehensive approaches that could go a long way in addressing these needed changes and ensure our nation's continuing leadership, prosperity, and security:

1. Create a National Innovation Education Act, including an "NDEA for our times" with government supported portable graduate fellowships for students in math, science, and engineering⁷.
2. Develop laws and policies to attract and retain international talent. To harvest our national investments, we should provide every foreign born Ph.D. graduate in the US in science and engineering with an automatic green card⁸.
3. Create an engineering curriculum in K-12 to complement, enhance, and enrich the curriculum in math and science. Let's bring mathematics and science and the thrill of teamwork and technology to life by making engineering part of the K-12 curriculum. Promote connections between K-12 communities and top science/engineering universities through projects such as OpenCourseWare.
4. Develop more active learning approaches in engineering and science as well as exposure to engineering practice to broaden engineering education, with the development of such educational innovations funded by government, in partnership with industry.
5. Create and support of professional graduate programs in engineering leadership, as an analog of professional programs in business, law, and medicine.

Thank you for the opportunity to meet with you today and thank you for all you are doing to enhance mathematics, science, and engineering education and in doing so to contribute to the nation's well being.

⁶Ketterle (Germany), Khorana (India), Molina (Mexico), and Tonegawa (Japan)

^{7,8} These recommendations have been embraced by leaders from industry and the academy (see the December 2004 Council on Competitiveness report, "Innovate America").

Chairman McKEON. Thank you very much. Ms. Streckfus.

**STATEMENT OF JUNE E. STRECKFUS, EXECUTIVE DIRECTOR,
MARYLAND BUSINESS ROUNDTABLE FOR EDUCATION, BAL-
TIMORE, MD**

Ms. STRECKFUS. Thank you, Mr. Chairman, Members of the Committee. I'm June Streckfus, Executive Director of the Maryland Business Roundtable for Education. And as you heard, it was created by Norm Augustine in 1992, and it takes time to get results, but we're starting to see some really wonderful results occurring in our state.

Ed Mitchell was our second chair, of Pepco and Chip Mason is our current chair, of Legg Mason, so we've had strong business leadership to stay the course and these business leaders had a long-term commitment to support education reform in Maryland, but with a strong focus on making sure that student performance was improving. We believe that we work at the intersection of academic expectations, economic success, and a thriving workforce.

We were founded based on the nine principles of the National Business Roundtable, and at the core of that were standards, assessment and accountability, and those words are very familiar now to this Committee. And we now have really wrapped our arms around No Child Left Behind in Maryland and are working to find ways to ensure that it's implemented in every school and for every child in our state.

We have a widespread commitment that includes K-12, prenatal-5, which is housed with the Maryland Business Roundtable, a nonprofit group, and higher ed and the business community. Our focus is to make sure that all kids in Maryland are prepared for a future and a wonderful future for themselves. But our problem is that we have 1.4 million in the workforce in Maryland. Thirty-two percent, particularly like at NASA and Northrop Grumman and Lockheed Martin, are boomers, and the desperation from those three alone and their support for the for the Maryland Business Roundtable is overwhelming.

They'll be beginning to feel the effect of that as early as 2006, and we're really at functional full employment in Maryland for 2 years now, but we have 140,000 open jobs and 130,000 unemployed. And 60 percent of our corporations are prevented from upgrading technologically by low educational and technical skill levels of our workers.

So what we've put in place in Maryland is a more rigorous high school curriculum with new high school assessments. And we have just passed, students entering in 2005, the fall of 2005, will be required to pass the tests to get their diploma. So we're beginning to feel that rub.

One half of the students in Maryland hit the mark in English, math and science this past year. So we looked at what was business uniquely positioned to do in this process, and we created a campaign in 1999, and we had been working on a lot of policy up to that point, but we created an on-the-ground campaign called Achievement Counts.

At the core now of that is the Maryland Scholars Program. We were funded 2 years ago as one of the first five states in the coun-

try to put that program in place, and we are part of the national network of 15 states. The Scholars program is a step-by-step pathway for achieving future success, because we want all kids, not just a few, to complete that course of study.

As you now, the single most significant determiner of success in college and the workplace is the quality and the intensity of the coursework. It's a very prescriptive program. It's primarily, and most of our districts say Scholars is for Maryland a math and science program, because we're requiring math through Algebra II. Our state requirement is through Algebra I.

We are encouraging that all students take Algebra I by middle school preferably, but by ninth grade. That Algebra II is expected of all of our Scholars, because we know it's a benchmark course for highly paid jobs. McCormick Spice, for instance, just put in a new math test for their entry level people who are high school graduates, and a big chunk of that is Algebra II.

So when we do focus groups with students, they say—we ask them what they want out of life, and they want a job with benefits. When I was in ninth grade, I really didn't know what a benefit was. But they're hearing from their parents that if they take a day off, they can't go on that trip or they can't do something because they aren't getting pay for that day, or they don't have health care benefits and they can't take them to the doctor.

So, benefits is very important. So that's our big pitch with our campaign. If you want a job with benefits, if you want a job that will pay well, you're going to have to complete a course of study that will allow you to get those jobs. And then the other basis for the Scholars program are three lab sciences completed in high school: Biology, chemistry and physics preferred.

We have a speakers bureau of 2,000 businesspeople who speak to the students at the beginning of ninth grade, letting them know that all 4 years matter, that just getting by isn't good enough, and that we talked to 73 percent of the students in Maryland last year in ninth grade, and our board told us that this year we need to get to 100 percent because of the urgency that they feel.

We answer the questions for kids, why should I care? What's in it for me? And why should I work hard? And to get to another issue that this Committee deals with, when we ask them what's the most important factor that limits their thinking about the future and about college, and it is still scholarship. And the Pell Grant link, the increase of Pell Grants for the Scholars is a very important step to help kids realize that they can get there and they can do it.

We are sending strong messages to kids early on that we link for them achievement in school to success in life. We deliver it early, often and by multiple influencers. We have a teen magazine that one of our—our Daily Record magazine works with us to produce 90,000 of them for distribution. We've just created a teen website, "be what I want to be," that let's kids know what workers do all day, how they get their job, and what do they make.

Our results in Frederick have been stellar. That's our first Scholars country. Fifty-five percent more students in poverty completed Algebra I by ninth grade, and that's 70 more students. In chemistry, 57 percent more African Americans completed chemistry this

year over last, and 80 percent more Hispanics completed a fourth science, which we think is a very important indicator.

How we've gotten there, it is a complex interplay between academic and nonacademic factors. We got the results because we have agreements with the local districts that there is a set of closely watched metrics that include math and science that we will not budge on. And as a result, they're watching those metrics and they're problem solving around why more students are not taking those courses.

Access to the coursework is important; a belief that all students can do it is important; establishing smaller learning communities, for instance, our Algebra I classes in Frederick are smaller for children of poverty and children of color; and real people from the real world giving real good advice we believe is a critical success factor.

And this year, we are developing a strategic partnership with higher ed to bump up those numbers even more. So we believe that students can do it if adults stand firmly behind them. And we're very, very happy with the first year—second year results from Maryland.

Thank you.

[The prepared statement of Ms. Streckfus follows:]

Statement of June E. Streckfus, Executive Director, Maryland Business Roundtable for Education, Baltimore, MD

The Maryland Business Roundtable for Education (MBRT) is a statewide, non-profit coalition of leading employers that has made long-term commitment to support education reform and improve student achievement in Maryland.

Since 1992, the Maryland Business Roundtable for Education has played a major role in transforming education. Led by an outstanding Board of top corporate CEOs, MBRT provides a consistent, strong voice: pushing for achievement of high standards; demanding a system of education that prepares all students for the rigor of college and the workplace; building strong, effective partnerships with all those who have a stake in educational excellence and a quality workforce; and challenging and motivating students to perform at high levels.

In Maryland, the bar has been raised on what students are expected to know when they graduate. State Superintendent Grasmick and the Maryland State Board of Education have set challenging academic standards that are rigorous, but reasonable, and have strengthened graduation requirements. Students entering high school in 2005 will be required to meet these standards in order to receive a diploma. Yet, nearly half of Maryland's high school students did not meet the standards in 2004.

Many of today's high school graduates are entering the "real world" seriously lacking the knowledge and skills they need to be successful in college, the workplace, and in life. This not only limits their chances to lead productive, rewarding lives, but it profoundly diminishes the economic health, leadership potential and future prosperity of our communities, our state, and our country.

MBRT's "Achievement Counts" campaign is an award-winning, comprehensive campaign that mobilizes the community at large to encourage students to achieve academic success. Each strategic and interwoven component of Achievement Counts provides students with strong messages delivered early, often, and by many.

Maryland Scholars—Letting students know that choices matter, courses matter

Speakers Bureau—Showing students that hard work in school pays off in life

Teen Website—Engaging students in career exploration and academic preparation

Parents Count—Helping parents help their children succeed in school

We believe that the student voice is paramount not only to the success of Achievement Counts but to the education reform movement in general. Too often, without intending it, adults in school systems and in school policy positions have missed out on a powerful source of energy for academic improvement—students' desire and ability to be responsible partners in their own learning.

We conduct systematic research with students, create ways for students to participate in designing the program and crafting the messages, and empower students to be more directly engaged in guiding their learning and shaping their future.

Through the newest component of Achievements Counts—"Maryland Scholars"—MBRT, in partnership with the Governor and State Superintendent of Schools, provides middle and high school students with compelling information about the rigorous math and science coursework they need to take and complete in high school in order to be successful in life—whether they go to college or directly into the workplace.

Maryland Scholars Course of Study:

4 credits of English

3 credits of Math (Algebra I, Geometry, Algebra II)

3 credits of Lab Science (Biology, Chemistry, and Physics preferred)

3 credits of Social Studies (U.S. History, World History, Government)

2 credits of the same Foreign Language

Through Maryland Scholars—part of a national initiative funded by the U.S. Department of Education through The Center for State Scholars—more than 1,500 business volunteers were recruited, trained, and managed. This year, these volunteers made 3,000 interactive classroom presentations in 204 schools in 14 school districts to more than 70,000 middle and high school students (73% of the state's 9th graders and 27% of the state's 8th graders). Plans for 2005–2006 include reaching 100% of Maryland's high school freshman through this program.

Maryland Scholars was piloted in two districts (Frederick and Harford counties) in the 2003–2004 school year. A comparison between baseline and year-one data show significant increases in the percentage of students completing Algebra I (by 9th grade), Algebra II, Chemistry, Physics, and a 4th science course—particularly among low-income and minority students.

In Frederick County, for instance, in the span of one year: 55 % more students living in poverty completed Algebra I by ninth grade; 57% more African American students completed Chemistry; and 80 % more Hispanic students completed a fourth science credit.

What caused this dramatic increase? High expectations, creating an atmosphere of access to rigorous courses, making it feel possible for all kids, establishing small learning communities, redesigning how rigorous courses are offered to accommodate slow learners, extending learning time, providing students with credible reasons, good information, targeted support, and a vision of what is possible for them.

As I have traveled to nearly every school district in Maryland over the past two months, superintendents, administrators, teachers, parents, and employers are speaking candidly and acting resolutely to ensure that all students are well grounded in English, math and science. We are participating in honest dialogue on barriers and shortcomings and innovative thinking about policies and strategies that will improve teaching and accelerate learning.

At a time when No Child Left Behind is demanding academic success for all children and the State has raised the floor on what we expect student to know, many Maryland school districts are raising expectations even further. In all my years in education—including some as a teacher and 14 as a business advocate for education reform—I have never seen such widespread commitment, belief, focus and determination that all children must be better prepared for the future.

And through our partnership with Maryland's K–16 Council, higher education is playing, and must continue to play, a crucial role in improving student achievement by: preparing teachers who are competent to teach rigorous math and science content; providing academic support to struggling high school students; offering incentives and rewards to encourage students to complete rigorous coursework, including needs-based scholarships; and facilitating processes that maximize the analysis and use of crucial data.

We are working at an intersection of academic expectations, economic success and a thriving workforce; creating a new model of interaction among high schools, students and employers; and attempting to deliver education in a 21st century context with 21st century content and 21st century tools.

Students can do it if adults stand firmly behind them.

Chairman McKEON. Thank you. Dr. Songer.

**STATEMENT OF NANCY BUTLER SONGER, PROFESSOR OF
SCIENCE EDUCATION AND LEARNING, UNIVERSITY OF
MICHIGAN, ANN ARBOR, MI**

Dr. SONGER. Chairman McKeon, Ranking Member Kildee and Members of the Subcommittee, thank you for this opportunity to discuss the challenges to American competitiveness in mathematics and science.

Collectively, the information we have so far indicates that perhaps never before has the issue of student preparedness in math and science been so complex and important. Congressman Kildee asked if we needed another Sputnik, and I believe this is our wake-up call, our Sputnik moment, as Governor Romney mentioned in testimony earlier this week.

What can we do to improve American students' global competitiveness? Based on my work in the last 9 years in one of our nation's most challenged school districts, the Detroit public schools, I will share two stories and three suggestions.

First, I recently asked a handful of Detroit public school teachers to list challenges to helping Detroit students to be globally competitive. The teachers list nine factors, but I'm going to only focus on two of those. The last two the teachers mentioned were: Eight weeks or more of standardized test preparation in every academic year, and approximately 7 weeks of testing windows, where a testing window are times when tests are given at some point during the week and therefore regular classroom schedules are disrupted for the entire week.

Of the 36 weeks of instructional time in the academic year, approximately 15 weeks therefore are spent in test preparation, test taking and related activities. Detroit teachers, this means, are using approximately 40 percent of their instructional time in test-related activities. This leads me to ask the question, are we currently doing all we can to support American students' preparation and learning of math and science with only 60 percent of the possible instructional year?

My second story refers to my work a few years ago in Japan. As a part of a National Science Foundation research study, I examined the teaching and learning practices of Japanese classrooms as compared to American classrooms. We discovered several interesting findings, including: Japanese science instruction relied less on textbooks than American science instruction, and the Japanese science curriculum was much more focused and coherent than the American curriculum.

To illustrate the focus, the Japanese eighth grade science textbook covered eight topics, compared to an average of more than 65 topics in American eighth grade textbooks.

Concerning coherence, concepts in ecology are introduced to 7-year-olds and then built upon and revisited by 10- and 14-year-olds to deepen students' conceptual understandings.

Here in the U.S., are we currently doing all we can to support American students' preparation and learning of math and science when we provide only a weak opportunity for these students to develop deep understandings of essential science and math concepts, and a hit-and-miss approach to teaching and learning?

So what have we learned? I provide three suggestions.

My first suggestion addresses the issue of instructional time. We need to counter the growing trends seen in Detroit and elsewhere where teachers are told to stop teaching the curriculum 2 months or more prior to standardized tests. While increased accountability is very important, the cost of 15 weeks of test preparation and test taking is too high, and it outweighs the need for accountability evidence.

We need the Federal Government to promote smart and efficient testing systems that will reduce the need for multiple national and state assessments each year. We need tests that are strong measures of critical thinking as opposed to tests that emphasize declarative knowledge. And we need models of test preparation and test taking that respects the preservation of instructional time to allow the development of deep conceptual understandings.

Second, rigorous standards rigorously applied are important, but they're not sufficient to promote systematic exemplary teaching and learning practices in American classrooms. Educational research helps us know how people develop deep conceptual understandings. We know that understanding science and math involves increased time on topics, systematic guidance in developing more complex ideas, and an ability to revisit and deepen understandings in a systematic manner.

Applying these practices to science instruction within Detroit middle schools has resulted in increasing the Detroit public school students' state science test scores by 10 percentage points, thus reducing the gap between the statewide and Detroit passing averages from 30 to 20 percent.

While national standards have begun to provide the needed systematicity, these are not nearly enough. We need continued Federal funding to support research to provide convincing empirical evidence of successful programs and to scale these programs to thousands of schools or more. Pockets of success are wonderful, but to take on global competitiveness, we need much more than national standards and a handful of exemplary cases.

Third, the crisis of global competitiveness is particularly severe in urban schools. If we are serious about improving our global competitiveness across the nation, it's essential that we marshal our resources toward all science and math students, and in particular the 30 percent of our nation's children in urban settings. With the increasing role and importance of science, math and technology in our future, we cannot afford to continue to provide an inferior education to urban children.

In addition, what kind of future do we envision in 20 years without the brainpower of a third of the possible scientists, mathematicians and engineers?

In Detroit, like other districts nationwide, we have excellent teachers and pockets of success. However, what is needed is so much more than my anecdotes. Global competitiveness is a crisis of substantial magnitude. I believe we know a great deal about what works and what we need to do. The question is whether or not we're serious about confronting this challenge.

Thank you.

[The prepared statement of Dr. Songer follows:]

Statement of Nancy Butler Songer, Professor of Science Education and Learning Technologies, University of Michigan, Ann Arbor, MI

Chairman McKeon, Ranking Member Kildee, and members of the Subcommittee, thank you for this opportunity to discuss the challenges to American competitiveness in mathematics and science. It is a pleasure to appear before you today. My remarks draw from my work focusing on preparing students to be competitive in science, particularly students within high-poverty urban school districts such as in the Detroit Public Schools.

As is well known, the status of American students' global competitiveness in mathematics and science is catastrophic and declining. A very small percentage of the doctorate degrees in mathematics, science and engineering are being awarded to American students. Comparative international standardized test results in mathematics and science often show American students performing in the top half in fourth grade but dropping considerably by the eighth grade and beyond (Schmidt, McKnight and Raizen, 1996; Gonzales et al, 2004). Consistently, international tests demonstrate that American science and mathematics students underperform on achievement tests relative to peers internationally.

In one recent international test specifically designed to measure fifteen year old students' problem solving and reasoning abilities as applied to real world problem situations, students in 28 of the 40 countries outperformed American fifteen year olds in math and problem solving. Students in 22 of the 40 countries outperformed American fifteen year olds in science (OECD, 2004).

Collectively, the indicators suggest that perhaps never before has the issue of student preparedness in math and science been so complex and important. Our status right now is like standing on a dangerous cliff, a precipice, looking towards a future with grim consequences for our economy and our nation.

A Particular Focus on Urban Science and Mathematics Education

My work over the past fifteen years involves large-scale projects to improve the competitiveness of American science students. The past nine years have focused exclusively on American students in one of our nation's most challenged school districts, the Detroit Public Schools. My focus in Detroit leads me to suggest, first and foremost, that in our challenging work ahead, we place considerable focus on urban students. While the underperformance of American students relative to peers internationally is dire, the performance of American urban students lag behind national averages by twenty percentage points or more, a difference that is nearly the equivalent of one U.S. grade level (Songer 2004; Ravich, 1998).

Our nation's urban schools enroll approximately 2.3 million students or 30 percent of all public school students in the United States. Urban students account for about 40 percent of the nation's poor and 45 percent of the nation's minority students. In Detroit, our students have nearly three times the average poverty rate of the state of Michigan (70 percent free/reduced lunch as compared to 26.7 percent state average) and 94 percent are ethnic minorities. Nationwide, the proportion of American students enrolled in urban schools is growing. Therefore if we are to fix the problems of global competitiveness in math and science within the United States, we must combat these issues in districts where there is the potential to have the greatest impact, such as in the Detroit Public Schools.

Reversing the Trends

What can we do to reverse the trends of global competitiveness? Much is known about how to combat these issues. Research has provided us with tested strategies to alleviate these problems and to reverse current trends. Some of the well-documented strategies include:

- Teachers make a difference. We need to continue efforts to increase the professionalism of K-12 public teachers such as are commonplace in many Asian countries.
- Strong school leadership is essential. We need to continue efforts to evaluate and support high standards for school administrators.
- Strong evidence of student learning and "what works" in schools is needed. We need accountability evidence for teachers, school administrators, parents and other key stakeholders.
- Rigorous standards make a difference. We need to continue to improve our national standards, and to apply them rigorously.

Our work in Detroit supports the importance of professional teachers, school leadership, evidence and rigorous standards. These strategies are essential to increase students' competitiveness in mathematics and science, but they are not sufficient. Nor do they comprise the complete list of what we have learned in the past fifteen years. Let me elaborate through two stories.

Story One: Reflecting on Detroit Teachers' Viewpoints

In preparation for my testimony today, I asked a handful of Detroit Public School teachers to list particularly daunting challenges that impeded their ability to prepare their students to be competitive in math and science. The list the Detroit teachers provided is as follows:

- Below grade level reading abilities
- Truancy from school
- Teachers' low comfort levels with math and science leading to reduced time on challenging material (most common in elementary classrooms)
- Lack of consistency in what is being taught across the district
- Timely dissemination of information across the district
- Financial resources
- Parental support and parental help with homework
- Eight weeks or more of standardized test preparation, and
- Approximately seven weeks of testing windows (for MIP, MEAP—Michigan state standardized tests and Terra Nova tests. Testing windows are times when tests are given at some point during that week and therefore regular classroom schedules are disrupted for the entire week).

While all of the points raised by Detroit teachers are important, I draw your attention to the last two items. Of the 180 days or thirty-six weeks of instructional time in their academic year, approximately fifteen weeks are spent in test preparation, test taking and related activities. Collectively, Detroit teachers are using approximately forty percent of their instructional time in test taking and test preparation. As these numbers are suggestive of numbers systematic across the school district, we can estimate that Detroit Public School students have available only sixty percent of their academic year for instructional activities.

In general, I am supportive of the federal government's role in encouraging greater accountability and high academic standards in education. I also recognize that time spent in test preparation and test taking is often higher in urban schools than in suburban schools.

Nevertheless, the numbers from the Detroit teachers illustrate a pattern we are observing across the nation, that of test-related activities "crowding out" available time for instruction. Personally, I found the Detroit teachers' numbers shocking, and I was left with many unanswered questions. How widespread is this phenomena? What evidence do we have of its impact on student comprehension of science and mathematics material? Is there enough instructional time to ensure American students can solve arithmetic problems, ask scientific questions, or gather scientific evidence to perform a scientific experiment? Most importantly, are we currently doing all we can to support American students' preparation and learning of math and science with only 60 percent of the possible instructional year?

Story Two: A Study of the Comparison of Japanese and American Science Classrooms

My second story refers to my work a few years ago in Japan. As a part of a National Science Foundation research study, I examined the teaching and learning practices of Japanese classrooms as compared to American classrooms. We discovered several interesting findings:

- Many of the topics taught in K–12 science are the same in both countries (e.g. electricity, motion, food webs).
- In addition, there were many similarities between exemplary American classrooms teaching practices and the Japanese classrooms we observed.
- However, Japanese science instruction relied less on textbooks than American science instruction. Japanese instruction placed more instructional time on experiments in science, and
- The Japanese science curriculum was much more focused and coherent than the American curriculum. To cite one example, the Japanese eighth grade science textbook covered eight topics compared to an average of more than 65 topics in American eighth grade textbooks (Linn, Lewis, Tsuchida and Songer, 2000).

Cross-cultural comparisons are often difficult because it is easy to oversimplify both similarities and differences. For example, American science instruction varies considerably from teacher to teacher and from city to city, and this variety is much more pronounced than what we observed in Japanese classrooms. Such variety makes it difficult to speak about what constitutes the practices of a "typical" American classroom.

Despite the variety among American classrooms, our study suggested that, in general, Japanese students were spending longer amounts of instructional time on each science topic than their counterparts in America. In addition, there was tremendous consistency in the teaching and learning approaches used in the Japanese class-

rooms with a strong emphasis on many of the practices that American educators see as exemplary. For example, concepts in ecology are introduced to seven year olds and then built upon and revisited by ten and fourteen year olds to deepen students' conceptual understandings of the concepts. Japanese students' science activities nearly always includes the exemplary practices listed below even though these same practices are inconsistently present in American science classrooms:

- Connecting lessons to students' interests and prior knowledge
- Eliciting student ideas then planning scientific investigations
- Conducting investigations
- Systematically analyze or organize information
- Reflect and revisit hypotheses and predictions
- Connect to next lessons and identify unanswered questions (Linn, Lewis, Tsuchida, Songer, 2000)

Perhaps as a result of my inquisitive nature, once again these study results left me with many unanswered questions. Despite widespread understanding of how children learn and the exemplary practices that lead to deep conceptual understandings of scientific concepts, why are these practices commonplace in Japanese classrooms but only present infrequently within the American educational system? Are we currently doing all we can to support American students' preparation and learning of math and science when we provide only a weak opportunity to develop deep understandings of essential science and math concepts and a "hit and miss" approach to teaching and learning?

What Have We Learned?

I conclude my testimony with three suggestions representing what we have learned about how to reverse the trends that are contributing to the inability of American students to compete with Japan and other industrialized nations in mathematics and science.

My first suggestion addresses the issue of instructional time. We need to counter growing trends seen in Detroit and elsewhere where teachers are told to stop teaching the curriculum two months or more prior to standardized tests. While increased accountability is important, the cost of fifteen weeks of test preparation and test taking is too high, and it outweighs the need for accountability evidence. We need the federal government to promote smart and efficient testing systems that will reduce the need for multiple national and state assessments each year. We need tests that are strong measures of critical thinking as opposed to tests that emphasize declarative knowledge. And we need models of test preparation and test taking that respect the preservation of instructional time to allow the development of deep conceptual understandings.

Second, rigorous standards rigorously applied are important but they are not sufficient to promote systematic exemplary teaching and learning practices in American science and math classrooms. Educational research helps us know how people develop deep conceptual understandings of concepts. We know that understanding science and math involves increased time on topics, systematic guidance in developing more complex ideas, and an ability to revisit and deepen understandings in a systematic manner. Applying these practices to science instruction within Detroit middle schools has resulted in increasing Detroit Public School students' state science test scores by ten percentage points, thus reducing the gap between statewide and Detroit passing averages from 30 to 20 percent (Songer, 2004). While national standards have begun to provide the needed systematicity, these are not nearly enough. We need continued federal funding to support research to determine best means for determine successful programs and to scale successful programs to thousands of schools or more. Pockets of success are wonderful, but to take on global competitiveness we need much more than national standards and a couple of handfuls of exemplary cases.

Third, the crisis of global competitiveness is particularly severe in urban schools. If we are serious about improving our global competitiveness across the nation, it is essential that we marshal our resources towards all science and math students and in particular improving science and math education among the 30 percent of our nation's children in urban settings. With the increasing role and importance of science, math and technology in our future, we cannot afford to continue to provide inferior education to urban children. In addition, what kind of future do we envision in twenty years without the brainpower of a third of the possible scientists, mathematicians and engineers?

In Detroit, like other districts nationwide, we have excellent teachers and pockets of success, however what is needed is so much more than my anecdotes. Global competitiveness is a crisis of substantial magnitude. I believe we know a great deal

about what works and what we need to do. The question is whether or not we are serious about confronting this challenge.

Thank you.

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Chairman McKEON. Well, thank you very much. There's lots of thought-provoking meat in what you've given us here today. I referred to the trip that we took to China. And while we were there, we met with government leaders, we met with industry leaders, we met with education leaders, we met with students, we visited schools. And our purpose was to see what they are doing in education and how we can prepare ourselves to compete, because we are in a big competition.

And they agreed I think pretty much universally that their students did better than our students in math and science, and that our students did better in creativity and in the soft skills. And I think a lot of that, as I was thinking about it, is cultural.

They pointed out to us that there they have one child, they have two parents and four grandparents focus on that one child, and a lot of pressure put on that child because for them, I mean, our poor in this country would be considered a whole lot better off than their poor in their country. And somebody can drop out of school in our country and still kind of get by.

Over there, their poverty is so deep that the only way for them out is education. And they have this tremendous competitiveness. If they don't do well on that test in their junior year of high school—in some places the screening starts much earlier—but if they don't do well, they don't go to university. If they don't go to university, their life is not very good.

So they understand culturally how important and how education is everything to them. And they don't look at a high school education or even a bachelor's or even a master's. In fact, Harry Shum I think was his name, the head of the Microsoft research and development lab over there, who was born in Beijing, educated in Hong Kong, came here to get his higher education degrees, said when he got his Ph.D. his parents said, wonderful. Now you can start your post doc. I mean, to them, it's—their goals are so much higher than ours, so it's a really, really tough thing.

Derrick Bock, a professor at Harvard, wrote recently that in contrast to nearly every other sector of the economy, the actual meth-

od of instruction in college hasn't really changed in over 40 years. "I see lots of good things happening in school, K-12, universities, colleges, proprietary schools, lots of exciting things happening. But I notice that some of the schools have not changed a whole lot," as he says in his book, "in over 40 years."

If schools aren't willing to change, if they're not willing to change their methods, adapt so that they can be more effective and efficient, how are we going to be able to compete? How are we going to expect our students to be creative, innovative and to do well if the schools are not adapting to new methods and new ways? What can we do to change this culture and this environment? Anybody?

Dr. Magnanti. Mr. Chairman, if I may. One, I would echo some of those concerns. Clearly the concerns about people in China, India seeing education as the road to upward mobility, as we had in this nation for a long, long time. I would suggest that, at least as I see it, many of our universities are changing at this point in terms of their educational pedagogy. And again, I'll just give an example or two from MIT, but I think I could cite examples from many.

One program that we have right now is called Eye Labs or Web Labs. These are laboratories at a distance. So in order to use laboratories more effectively, you can sit at your computer, you can actually run, physically run a laboratory, whether it's a wind tunnel, it's a MEMs testing device. And the notion is to provide 24/7 access to that lab, to integrate laboratories more effectively with the lecture material that we have in our classes, and also then to provide more access to those facilities so that we can have students at high schools having access to those facilities, students at universities having access to facilities at corporations that we can't afford to have in terms of our activity. That's one example.

I think another example is one of our signature courses at MIT, an introductory computer science course, which about two-thirds of all the students at MIT take. That course is now taught without lectures. It used to be it was taught in big, 300-person lecture halls, a very sort of impersonal lecturing. It's now taught with voice annotated Powerpoint slides done then in small sessions of recitation sections which the students are interactively more actively with the professors and getting more engaged with the professors.

So I actually think that what's happening right now, at least at the university level, is we're seeing a bit of a sea change. I think we did fall asleep for many years in terms of changing the pedagogy and changing what we're doing. But I see, not just at MIT, at Michigan and many of our other universities, significant changes in the pedagogy that we're developing. And I think it's—we need government and industrial support to help us make that transition. But I think it is a time of transition right now.

Chairman McKEON. My time is over, but what kind of—you need government support. In what way?

Dr. MAGNANTI. Well, I think we could use government support for providing the infrastructure, for this technology infrastructure.

Chairman McKEON. Money.

Dr. MAGNANTI. Some money, in terms of money for the infrastructure. I think we could also provide opportunities for govern-

ment, universities and industry to get together to create local consortiums that could help us to have better access to shared facilities between the universities, local industry. I think there's actually a wide variety of ways in which we can do such things.

Chairman MCKEON. Thank you very much. Mr. Kildee.

Mr. KILDEE. Thank you, Mr. Chairman. When I was teaching in Flint, Michigan, AC Division of General Motors, now Adelphi, separated from them, and DuPont, from time to time would raid the public schools, the high schools particularly, for math teachers and science teachers and we'd lose them to the private sector because they could offer them, you know, more money. They never tried to raid me. I was a Latin teacher and they never approached me for any need at Adelphi or DuPont.

How can we address this? Because there is a temptation to go into the private sector rather than have a great crackerjack science or math teacher stay in the public school system. Any of you have any response to that?

Mr. AUGUSTINE. Well, I'd be happy to touch on that from the business perspective. Currently we need to make the rewards of a teaching career much greater, both financially and socially and culturally. We clearly badly underpay our teachers, the best of our teachers. And that's something that as a nation I think we need to deal with.

But I think that's not the only issue. We need to make teaching where it's a very attractive career, that people take pride in it. And then people will stay in that career. It is true that business seeks the most talented people it can find anywhere, and it probably will continue to do that, and we probably wouldn't want it to do anything else. So I think the solution is not so much to change business but to change our dealing with the career of teaching.

I taught a brief period myself, and I discovered teaching is very hard work. Very hard work. And people who have not tried it I think don't fully appreciate that. So I think there are things that can be done.

I think there are also things that companies can do, for example, in the university level. I would like to see tax consideration given to companies that fund research in universities. I think that would be a win-win for everyone. But those are the kinds of things one might do.

Mr. KILDEE. Dr. Songer, you're experienced with the Detroit school system. Do you have any comment on that? Do they retain their math and science teachers there?

Dr. SONGER. In Detroit? No. We are not terribly successful in retaining the good teachers, and that's true for urban districts nationwide. Recruiting teachers to teach in urban settings is very challenging, because the teaching environment is such a challenging teaching environment.

I think that the key here that is common across the education community is that we really need to focus on the professionalism of teachers, which is what Mr. Augustine was talking about. It's just—the teaching profession has lost its glamour. And, it's not only challenging, it's not safe, it's not fun, it's not rewarding. And that—it's really frustrating for us that are promoting teaching as a profession to have to face the challenges that we see when actu-

ally the rewards of teaching, just the teaching itself, are very, very valuable for many people. And I think people go into it hoping that that will be consistently a part of their job. And what happens is, some of these other issues just overshadow their ability to really enjoy the pleasure of the teaching.

So I think the professionalism of teaching is just an issue we can't get away from. We have to work with that in a serious way.

Mr. KILDEE. And if a student is not getting involved in math and science in the K-12, they're not likely to have an epiphany when they're in college, are they?

Dr. SONGER. Absolutely. It's the pipeline issue where we want to keep them engaged from middle school on. The standardized test scores show that in fourth grade, for example, American students are doing very well in math and science. By eighth grade, the declines have gone down. By 12th grade, we're in about the lowest 10th percent in terms of industrialized countries.

So, we do need to get in early and keep it engaging for a longer, sustained period of time.

Mr. KILDEE. Dr. Magnanti?

Dr. MAGNANTI. If I could just add, I'm echoing Mr. Augustine. I think salary is an issue, but I think a rewarding career path I think is an issue. And I think for perhaps modest sums of money, one could think about providing funds for teachers to spend summers at corporations, to spend summers at universities and get them engaged so that they continue to be engaged with the underlying math, science and engineering activities, so they can then bring that back to the classroom.

I think there's some ways of making it just a much richer career for these people, so that they'll be more excited about being teachers and would provide I think a little bit more incentive for them to participate in the teaching enterprise.

Mr. KILDEE. Thank you very much. Thank you, Mr. Chairman. Chairman McKEON. Mr. Osborne.

Mr. OSBORNE. Thank you, Mr. Chairman. And I'd like to thank members of the panel for being here today. We appreciate your presence very much. Mr. Augustine, you mentioned that we need to strengthen K-12 education. You talked about the value of competition and maybe doing something to compensate teachers better. I'm assuming merit pay or something like this. Do you have any specifics on the compensation of teachers? Because oftentimes you run into the teachers unions and various regulations that make this very difficult. Have you heard of anything or do you have any ideas that would be helpful?

Mr. AUGUSTINE. You're quite correct that it's a very difficult issue to deal with. The teachers union issue and tradition. But I think we're dealing with a problem here that goes beyond the band-aid stage. We need major surgery. And I think we're going to have to do some things that we don't like at all perhaps if we're to accomplish what we want.

It's often pointed out that how do you evaluate a teacher? Is it just the results of the students on a standardized test? And I would certainly hope not. In business, we reward people based on their contribution. And when we measure contribution, we use, to take an analogy, I grew up in the West in rodeos. The rider of a bull

gets two scores. One is how hard the bull bucked, and the other is how well they rode. And one has to take that into consideration.

If you're teaching in an inner city school with children that haven't had great opportunity, the fact that you may be in the bottom 20 percent, but instead of the bottom 2 percent, you should be given credit for that. And I realize this is not an exact science at all. But in the business world, we exercise judgments every day as to who gets to keep their job, who gets promoted and what they get paid, and it's made America's business thus far as successful as any in the world. And I believe in the free enterprise system. It works in our universities. I think it could work in K-12.

Mr. OSBORNE. OK. Thank you. And Dr. Magnanti, just a very quick question here. You mentioned that we are now producing 75 percent of the Ph.D.s that we were in 1985 per unit of population, and more MBAs and that type of thing. Do you have a quick answer as to why you feel this is the case?

Dr. MAGNANTI. Well, one I think is just monetary return. I think if you look at salaries and the like, our chairman quoted some salaries for various professions, but if you think of salaries for MBAs versus engineers, they're quite stark in terms of the difference in terms of salary. So, part of this is an issue I think of all of us honoring and having a better sense of economic value of our engineering workforce. I think that's certainly one issue.

And I think also is providing the right instruments and incentives to make engineering exciting. And I think if we could develop some long-term important national initiatives that we could work on, the Sputnik of our era. Governor Romney mentioned some of these, whether it's energy and greater energy independence or greater activity in terms of the energy sector, but some exciting national imperative that we could work on as a nation, again, to sort of try to attract talent to the engineering and sciences. I think that would be one useful instrument for trying to do this.

Mr. OSBORNE. OK. Well, I noted you also mentioned a shift toward entrepreneurial smaller companies. And sometimes a blend of engineering and technical know-how with MBA skills serves those companies well.

I'd like to move on to Ms. Streckfus and Dr. Songer. I'm assuming, I'm just guessing from listening to you that I think Ms. Streckfus mentioned that you had embraced No Child Left Behind. And Dr. Songer, I gathered from listening to you that maybe you didn't embrace it very much, and wanted to—and that may be a generalization on my part. But at any rate, you know, testing is part of No Child Left Behind, and if you have any comments there, I'd be interested in having you flesh out your thoughts a little bit, either one of you, as to how you feel this is working.

Ms. STRECKFUS. In Maryland, we believe that you need to measure and need to have focus and need to have data, and that the only way you can do that is through assessments. And we believe that there's value with state assessments, because prior to this, we really didn't know what Algebra I was in any district in Maryland or in any school in Maryland. So what No Child Left Behind has pushed on is to make sure if we're assessing in that area, we need to have rigorous standards, and then the assessments need to reflect accomplishment of those standards.

We hear the argument frequently that there's a lot of focus on how to take the test, that everything stops in a classroom prior to that. We've just met with 20 superintendents district by district in Maryland. I have never seen—and I taught school in '68, so I've been with this for a long time—I've never seen such focus, such look at what are we going to do to get all kids to hit the standards, a concern about adequate yearly progress, but not an overwhelming concern. The concern is more around how are we going to get more students to these higher levels of learning.

So, could you go to an extreme with No Child Left Behind and testing and—yes. Do you have to constantly be vigilant to make sure that that doesn't happen? Yes. But bottom line, what we're trying to do with that legislation and how it's being enacted in Maryland I think is a model for what Maryland Business Roundtable would like to see continue.

Dr. SONGER. I would just like to add a few comments to what Ms. Streckfus said. In general, I'm actually very supportive of the ideas behind No Child Left Behind. I think it's a wonderful way to get the conversation going about the need for high standards and accountability, and those are exactly the right conversations we need to have.

I think the problem is that whenever you put any piece of Federal legislation into place like this, the way it's manifested is sometimes difficult. And unfortunately, the piece of my testimony that I spoke about is only a small section of the piece in the written testimony that talks about No Child Left Behind and some of the things and ideas behind it. And actually, I believe that in some ways this is exactly what we need to be doing right now. We need to be raising—having high standards and putting pieces into place that will allow schools to be accountable and to reach those high standards.

I think it's just that in the process of implementing these things, sometimes some of the details overshadow the general idea, and I think that's what's happening in Detroit when they're spending so much time in test preparation because the stakes are so high for them.

Mr. OSBORNE. Thank you. And I yield back, Mr. Chairman.

Chairman McKEON. Mr. Holt.

Mr. HOLT. Thank you, Mr. Chairman, and I thank the witnesses. It's hard to think of any more important topics than what we're covering today. It's particularly dear to my heart as a scientist, as a physicist, along with my colleague, Mr. Ehlers. We often talk about this and point out that the low comfort level with science and math goes beyond just teachers. It's in society at large, which creates something of a chicken-and-egg problem if we're trying to build interest and support for science and math teaching throughout the schools.

There's a lot to be said about standards. I was interested to learn just this morning that a survey of the graduation exams, high school graduation exams, in a number of states, find that to pass the math tests, students have to demonstrate math skills that in other countries would be taught in the seventh or eighth grade.

But let me refer back to some work that I was involved in, well now nearly a half dozen years ago. I served on the John Glenn

Commission, the National Commission for the Teaching of Math and Science. I think we did a good job. We focused on teachers, the teaching of math and science. There's a lot that can be done with curriculum. There's a lot that could be done with parents. There are lots of other things, but we decided to focus on teachers.

And I just wanted to quickly run through the recommendations from that commission. Some of you may be familiar with them. And in the little time that will then be remaining, I'd appreciate your comments, and if there isn't time this morning, your subsequent comments.

Goal one was to establish an ongoing system to improve the quality of math and science teaching in grades K-12. So it called for summer institutes, continuing education, that sort of thing. Not just occasional in-service days, but school districts reward and incentive programs and that sort of thing.

We called for increasing significantly the number of math and science teachers, partly by identifying exemplary models of teacher preparation, working with the schools of education, finding ways to attract additional qualified candidates, partly through such things as selecting 3,000 annual academy fellows, teaching academy fellows.

We called for improving the working environment in the schools, which would focus on induction programs to help beginning teachers of math and science become acclimated, so that we wouldn't lose so many new teachers. As you know, most teachers don't last beyond 5 years, and that's at least as true in math and science as in other areas.

Part of this improving working environment, we called for business partnerships. And that gets to a key point that I hope in your subsequent comments today you'll address as really what is the role. I mean, we hear an awful lot of complaints or horror stories from business and industry. Part of what we're looking for is what's their role in addressing this.

I think we need to provide incentives to encourage math and science teachers to remain in the field as well as to enter in the field, and of course, salaries.

So that's a quick summary of what the John Glenn Commission recommended. Do those recommendations still hold up?

Mr. AUGUSTINE. If I might, I would comment briefly. I think they are very sound indeed. And I would like to just site one example of a business partnership that some years ago in a company I then served, Lockheed Martin—or actually, it was Martin Marietta at the time—we wondered how we might help in K-12. And we concluded that the most leverage was to be had by helping teachers, exactly as you site. And the reason is that teachers have such impact on people, and if they affect a few students each year during a career, it adds up.

And we began a program of fellowships during the summer for outstanding teachers to go to a university that we had an affiliation with and spend part of the summer in a summer program trading ideas on teaching, taking courses on the latest trends in science and mathematics. And we tried to do it so it would be very pleasurable, not on the cheap, something that people would really look forward to being able to do. And I think that's an example of

the kind of thing that I assume your commission was referring to that could make a difference.

I would just have on caution, and that is that, particularly at the university level, there's also the danger of too much involvement of the business community in education, a danger that it begins to exert pressures on what you teach. And one has to guard against that, too.

Thank you.

Chairman McKEON. Thank you. Mr. Ehlers.

Mr. EHLERS. Thank you, Mr. Chairman. I really want to thank you for calling this hearing. This is an extremely important topic. I'm of course prejudiced on this. I have spent a good many years of my life in this starting in 1966 when I became concerned about what was then called scientific illiteracy. And I asked myself what a simple little college professor could do, and I started a special course for future elementary school teachers, teaching them physical science and how to teach science in the schools. And that started a lifetime interest.

But I'm very pleased with the hearing for another reason, because I started in 1996 in the Congress to make this my No. 1 priority, and literally I was a voice crying in the wilderness. I could not get attention, very little support. No one believed me. And today, every week I read a quote in a newspaper or a magazine from a leading industrialist saying this is the No. 1 problem in our country, as our panel has said.

I'm going to act more like a witness than a questioning congressman, because I want to reinforce some of the points that were made. I may start preaching, too, and I hope you'll forgive that, too.

But first of all, I agree with my colleague, Rush Holt, my fellow physicist. The Glenn Commission did good work. It was a real disappointment to me that the report essentially fell with a dull thud on American society and has not really been followed as it should have been.

I believe we have a major crisis in this country in math science education. And I call it a major crisis because it is causing a major crisis in innovation and manufacturing in this country. And you've heard the figures from Dr. Magnanti, and I'm sure all the witnesses are aware of that. Things look very grim for our prospects in global competition if we don't improve in our math science education.

I'm tremendously pleased with the growing interest in it. I've been asked and gave three speeches already this week on the topic. So people coming to Washington are actively interested in it and want to hear what's going on.

One key factor I didn't pick up here which I think has to be included is starting early. I have concentrated my efforts on the K-12 system, and primarily K-8, because that's often neglected. And if we don't get students coming out of the K-12 system with the necessary background, they are simply not going to pursue science, technology, mathematics, engineering at the college level, because it would take them 5 years, maybe even longer, to get caught up and get out. So we really have to make sure they have the background.

Another problem is math and science tend to be sequential, particularly the physical sciences. If the students get off track or miss something at some point, it hurts them for the rest of their educational track. And so there are I think strong arguments for developing common themes in all math and science curricula throughout the country. I know the Federal Government can't control the schools, can't control the curricula, but at least can we agree on certain ideas, principles, concepts that must be taught at each grade level, so that when the students transfer, as they often do, they don't lose the track and the sequential nature of this?

Another problem I've encountered in my experience that fairly often, math and science are considered optional in the early grades, particularly elementary school, but sometimes even in the high school, and I fail to understand that. And I have experienced that with my own children. My son loved science. He was in a school that had an excellent science program, went through 4 years of it. In fifth grade, he wasn't getting science. So I inquired of the teacher, and she says, well, we just have too much to do in the fifth grade. We have band gets added on and this and that and the next thing. And we just don't have time to teach science. And I said, well, my son is disappointed. He enjoys it. Well, we have this good science kit. We'll let him work on it in his spare time. He's a bright student. He has extra time, he can do it.

So I went to see the principal and talked to him about it. He says, oh well, teacher doesn't like science, she doesn't like to teach it, there's not much I can do about it. And I said, well, if you have a teacher who decided not to teach reading or some other subject, wouldn't you do something about it? Well, yes, but, you know, science isn't that important.

We have to get away from that attitude. And that's not an isolated example either. School boards in general do not give full support to it.

One of you made the comment that it's very important to have real people giving real advice. I heartily concur. In all the speeches I've given from coast to coast on this to scientists and engineers and mathematicians, I encourage them to go to the school nearest them and volunteer, not on a regular basis so much, but just say, look, I'm an engineer. It's really exciting to me, and I want to make sure your kids understand what engineering is so that they can make a good choice about it. And I think this can have a real impact on students.

And perhaps my own life is an example of that. I grew up in a small community. I never met a scientist. I had some interest in science but no one to talk to. And in high school, I ended up sitting in a diner next to someone one time. We started talking. He was a mechanical engineer at Ford Motor Company. We had a 15-minute conversation about what he did, and I thought, that sounds neat. I was working part time as a mechanic. I loved to work on cars. Maybe I should be a mechanical engineer. So 2 years later when I went off to college, they asked what's your major? I said mechanical engineering. On the basis of a 15-minute conversation with an engineer in a diner, someone I never knew.

And I think it's very important for scientists, engineers, mathematicians to get out in the public, talk to kids, and not go to the

school with the attitude, I'm going to tell you how you should teach this. Just the attitude, I want your kids to know how much fun it is. And kids do enjoy it in the elementary school.

Dr. Songer, my fellow Michigander, you commented about the one-third of students in urban areas, and that's a very real problem. We have to deal with that. But I also want to remind everyone here and the Committee Members, let's not forget the half of our population that is female. America I think has a unique cultural problem. Because in other countries—China, Russia, Europe—by and large, half of the science students are females. In America, there's a cultural disposition that women should not do that. And I encountered it first when my daughter was—who had gotten A's in math all the way through elementary school and got to high school algebra, the first test was an A. The second one B-minus—or B-plus. The next one B-minus. I had a little talk with her and said, what's going on here? And she says, well, you know, girls can't get math. That's the peer pressure in America. That's the culture in America. And we should tackle that.

Fortunately, it's changing. But today still, women graduating as engineers, I believe they're 7 percent of the total. There's no reason it shouldn't be 50 percent. And we as a nation have to work on that.

My final point, I think three things we have to work on. No. 1, in my experience working in the schools, and I've worked in a lot of elementary schools as well as teaching at the university level for 22 years, in my experience, the single greatest factor in the success of the student is to have at least one interested and involved parent. It's very hard for the government to impact that. But it's something we absolutely have to communicate. If you have that, then the teachers in the schools have an opportunity. If we don't have an interested, involved parent, it's very difficult for the schools or the teachers to have an impact.

Second, we need qualified, well trained teachers. We've talked about that enough. And your comment, Norm, about summer opportunities for them and things industry can do to help, that's also true of government labs, it's true in a number of things. Very valuable experience for teachers at the high school level and perhaps even elementary.

And last, we need good curricula. I think that's the least of the problems now. We do have good curricula out there, but most schools are not using them, because school boards don't want to pay the extra money for the equipment that a good program has. Teachers don't know how to manage the equipment, and one other thing in my experience, the single biggest factor in the success of a good science program in a school was to have a go to person, so if the guppies die, the beans don't sprout, the teacher can go to that person and say, oh, my guppies died. What did I do? And he's, no problem, and she has new guppies the next morning.

If you have that, in my experience, the program succeeds. If you don't, the program founders in a few years, and they go back to the traditional textbook approach.

Thank you for your generosity and time, Mr. Chairman. But I just had to get my little sermon off my chest. I'm the son of a minister, and you can probably tell that. Thank you.

Chairman MCKEON. Thank you, Mr. Kind.

Mr. KIND. Thank you, Mr. Chairman. Mr. Chairman, I do want to thank you for holding what's perhaps the most important hearing that we're having this year, and hopefully we'll have an opportunity for some future hearings on this topic area. And I want to thank all the witnesses for your testimony and for all the good work you're doing in the subject area.

I had the pleasure of joining the chairman on the delegation that went to China over the Easter recess, and I think all of us came home with a profound sense of anxiousness or urgency in regards to what our own country is doing to better prepare our students and workers for the competition of the global marketplace.

Just this morning I attended Progressive Policy Institute Forum over at Union Station that had Thomas Freedman there, who wrote the recent book, *The World is Flat*. It should be required reading for every member of the U.S. Congress in regards to what's happening today and where we're going with the global economy. And you get the impression that both China and India are making a huge investment in their education infrastructure, especially emphasizing the math, science and engineering fields. And this debate that we've been having in this country in regards to trade agreements or just globalization generally, I'm convinced is not so much a race to the bottom of cheap labor or no environmental standards and jobs being outsourced as it is today a race to the top. And China is a country that's not content in being good at just copying and mass producing. They want to be on the cutting edge of science and technology and medical research.

And they're catching up very quickly. And that forty, fifty year cushion that we've had since the second world war because the rest of the world lay in the ashes of ruin has changed. The other countries are modernizing. They're investing, they're catching up. And we're seeing that now in the students and the skills that they're producing in those countries. And yet you feel a sense of frustration in regards to what it's going to take for our country to wake up. With industry leaders, policymakers, people in academia who I think get this already, but Dr. Magnanti, I'm not sure what the spark is going to be, what the new inspiring vision will be to really ramp this all up to where I think we need to go.

And, Dr. Songer, we're hearing a lot about the Sputnik analogy. And I think it's true. We are at a Sputnik moment. But it's frustrating, because just saying we're at a Sputnik moment doesn't make it so, because there's nothing tangible or visible or something we can grasp and embrace to wake us up, as Sputnik did, when oh my God, we're losing the race to space. And it got everyone's imagination, and everyone got it immediately, and we marshalled the resources then, back then, to deal with that situation, and it worked. And yet we're missing the Sputnik moment, and I'm not sure what it's going to take in order to do it. Thomas Freedman thinks it's going to be energy independence could be the vision and the excitement to spur a lot more interest of our students to enter these areas.

And there is cultural differences, Mr. Chairman, that you recognize in regards to the emphasis of education in China with the parents and grandparents. And Tom Freedman is out on tour, and in

his book is fond of saying that when we were growing up as kids sitting at the dinner table, parents would always admonish us by saying, make sure you eat everything your plate, because there are kids in China and India that are starving.

Now today the message from the parents should be, hey, kids, make sure you study very hard, because there are students in China and India that want your jobs. And I don't think we have that sense of urgency with our own parents and the kids and the active involvement which is crucial to the education success that these kids have.

I've recently reintroduced legislation that I had in the last session of Congress we just reintroduced this year, H.R. 2325, the 21st Century Innovation and Creativity Act. And it would establish competitive grants from the National Science Foundation, the Department of Education to increase education and job training opportunities in the math and science and engineering and technology fields.

The goal is to be more innovative and creative in attracting students into these fields. Schools can provide students with scholarship stipends, for instance, to deal with the cost. They can expose students to different industries through internships, mentorships, fellowships, part time work. It also aims to increase the number of traditionally underrepresented students in these fields.

Schools could also use the money for research equipment, facilities construction, repair and upgrading of your own infrastructure, which I think is desperately needed out there, create interdisciplinary programs in these fields that deal with industry and the rapid changes that are occurring there.

I just think we really do need to ramp this up. And unfortunately, this year we've wasted almost five-and-a-half months talking about how to dismantle the New Deal when we really should be talking about the New, New Deal we should be offering the American people, and especially our students in getting into these fields. And we're not.

And I appreciate the Chairman's and so many other Members' interest on this Committee, and hopefully we'll be able to find some common ground and work together and work with something in a bipartisan fashion, because I'm afraid if this Committee doesn't do it, the other Members of Congress are stuck on their own issue areas and on their own important topics, that I don't see it getting done at all, unless the leadership is going to come from this Committee.

Just a quick question to the panelists. I mean, you guys are experts in what we're dealing with. But if you had to assign a grade to our country right now in regards to what we're doing to prepare the next generation for the competition of the global marketplace, and even more specifically, what we're doing in the math, science and engineering fields, what grade would you give us right now on an A to F scale? Mr. Augustine, do you want to give that a shot?

MR. AUGUSTINE. It's very difficult, because the system is bimodal. The best is very good and much of the rest is very poor, but to try to go along with the spirit of your question, it's probably somewhere between a D-plus and a C—D, Dog, plus—and a C-minus.

Dr. MAGNANTI. I make it a practice not to give out grades unless I have the exam in front of me. So I like to, you know, sort of—

Mr. KIND. And we're not looking for any grade inflation here either.

Dr. MAGNANTI. Let me just offer maybe two comments. One is, Mr. Augustine played a central role in the Council on Competitiveness deliberations, and you may have seen the report, Innovate America. But very consistent with your comment in terms of your legislation, that council recommended the creation of a National Innovation Education Act that would be comparable to the NDEA. And you could argue whether it was Sputnik or whether it was the NDEA, but the NDEA played a prominent role for people like myself of going to graduate school and studying math and science. And that committee recommended 5,000 portable graduate fellowships. And would be a statement by the government that's saying science and engineering is important and we want to invest in it. So one could think of that.

I think at the K-12 level, and I'm reluctant to say anything with an expert like Dr. Songer here in terms of an education expert, but educators tell us that people learn best when they're learning by doing and action learning.

And I would say that if we could think about this math and science, bringing it more to life, and ask a simple question: Why do students like math and science? Some of them like math and science because they have attitudes, they've just got attitudes for doing this. Some do it because they're attracted to it, because it's exciting.

And I think one of the things we can do is try to make math and science more exciting by making it more relevant, more learning by doing. I think in part we could do that by adding some engineering to math and science we're teaching in K-12, and also think of this as a system of embracing engineers in your local community to come in and help with those courses, to provide the role models that Mr. Ehlers was talking about. I think there's a sort of systematic way we can think about that of really infusing some new life into the K-12 system and really making it exciting for these young people.

Mr. KIND. Ms. Streckfus, Dr. Songer, can you offer any grades to give us a sense of where we are?

Ms. STRECKFUS. I was fortunate enough to attend the National Education summit a few weeks ago, and the data that was presented by the Governors and by Achieve is that for 100 students who enter ninth grade in this country, about 16 are completing a 4-year degree by four to 6 years into the higher ed stream. So with that in mind, I would have to say D.

Dr. SONGER. I just want to add to Dr. Magnanti's comments. I think there are real pockets of success, and those pockets are A. I mean, when you look at the places where things are working, they're doing more of these hands-on science, they're doing really engaging math that applies to people's lives, it's very exciting. The problem is that in any one child's trajectory of K-12 education, they might get one or two of those, and that's not enough to sustain them in becoming a science or math major in all cases. Sometimes they get that 15-minute conversation that makes a big dif-

ference, but a lot of times the pockets of success they get in their own life is not enough. So the overall system I would say is a D.

Mr. KIND. Thank you. I thank you again, Mr. Chairman.

Chairman MCKEON. Dr. Price.

Dr. PRICE. Thank you, Mr. Chairman. I appreciate the opportunity to ask some questions. I apologize for being late and missing your opening statements. By way of introduction, I'm a physician, which in some circles makes me a scientist, in most circles not. And as an orthopedic surgeon, even in the physician community, I'm not a scientist. But I believe that there are very few things that we will deal with that are as important as the topic that we're discussing today.

As a physician and a surgeon and one of those that likes to see what you're trying to fix and then be able to prove that you fixed it, it's a very simplistic way to look at things, but there are wonderful ideas flowing around here from your testimony and others who have spent, if not a lifetime, a number of years trying to increase the visibility and the importance from a policy standpoint of science and math education.

My concern, my belief is that it is cultural, as has been stated, and I don't mean from a diversity standpoint, I mean from an American culture. We don't have a culture now that seems to encourage young people to get into math and science. I think we did at one point. I don't know what it was that necessarily changed, because it wasn't Federal involvement. It certainly wasn't money from the Federal Government that inspired the United States to be No. 1 in the world from a scientific and math standpoint for years.

So I—there's somewhere a spark that I think ought to be identified. I'm not bright enough to figure it out, but that ought to be identified that will allow us then to open up those doors once again.

So my question to you is probably more expansive than you want to answer, and there isn't anybody recording this, so you can feel free to say anything you like, and we won't tell anybody, I promise. If you, in your wildest dreams, if you could do one or two things that would create that spark, and I'm not talking about specific programs, but something to change the culture, because I sense that the culture in China and India is not one that is like ours that is making it so it's difficult to find those kids who are interested.

What—is there a spark, or am I tilting at windmills here?

Dr. MAGNANTI. At one point, somewhat facetiously, I suggested that we have this intelligent program called L.A. Law. We needed one called Detroit Manufacturing. And it's somewhat facetiously, but I think in some ways to have some public expression that celebrates math, science, engineering, however you want to think about it, and to have again a public expression of that in a way that young people find exciting.

And so I can imagine something of that order. I can imagine a public campaign that we could all undertake with the educational system working, the government working with industry to try to make the case that math, science and engineering is exciting to the world. And I can imagine a wide variety of ways in which we could map that out.

But I think something that truly sparks the Nation in that sense would be useful.

Ms. STRECKFUS. We did focus groups a few years ago with parents, and what we found was that parents didn't want their kids to be like academicians. They thought they were boring. They thought they didn't have fun. I'm sorry. These were just our findings, and this isn't recorded, right?

[Laughter.]

Ms. STRECKFUS. But it was a major obstacle in getting parents, in the conversations that we had in the focus groups, in getting parents to see the value in high levels of math and science, because they thought their kids would be in a cubicle. They thought, you know, they wouldn't have social interaction, particularly the girls wanted that when we talked to the students.

So, part of what I think needs—and what we're trying to do with our teen website is to frame exciting opportunities of the future. What will it be like in 20 years, and do you want to be part of a team that will be able to do that? For instance—

Dr. PRICE. Excuse me. Why didn't the generation—why didn't a generation ago, why didn't those parents say, I don't want my child to be in a cubicle? I mean, what's different now that makes it so that the parents of a generation or two ago said that this is a great idea, and now not?

Ms. STRECKFUS. All kids, all kids are different, what No Child Left Behind is trying to do. And there's still that small group that is interested, that wants to do. But we need in this country to get many, many, many more students to high levels of math and science, not just if they're going in a career for math and science, but if they're going to live in a world where they have to think about their own health care.

Dr. PRICE. We all agree about that.

Ms. STRECKFUS. Yeah. So I think that what we were trying to do is to work with Hopkins to look at these world health problems that will be solved in 20 years, and if you want to be part of a team that will do that, this is the kind of work that you're going to have to do while you're in K-12 or higher ed to be part of that exciting team.

Dr. SONGER. When they look at or talk to scientists about why they became scientists, they almost always have some seminal experience where they've experienced the science in a very meaningful, personally meaningful way. So I think that has to be the spark. And how we get that on a wider scale is a really good question, because it's very hard sometimes to provide those kinds of really engaging experiences where you delve deep into a topic within the traditional formal schooling that we have right now.

So, does that mean it has to be part of a community experience, or you know, some kind of program that AAAS sponsors? I'm not really sure. But I think that the key idea that we'd want to remember is that it is that engaging personal experience that will be make a difference.

Dr. PRICE. Mr. Augustine?

Mr. AUGUSTINE. May I just try to address your specific question of what has changed? And I think something has changed. And being by far the oldest member of this panel, when my—in my gen-

eration, I think our parents knew that the way to a better life was education, because most of them didn't have it. I was the first in my family to go to college, the second to go to high school. But my parents knew that that was where it was at.

And you had a choice. You could become a lawyer. That means 3 years of law school. You could become a medical doctor. That means, what, four or 5 years. You could become a Ph.D., six, 7 years. You could become an engineer in 4 years. And so engineering for my generation was the opening door. My children, my daughter is a lawyer, but engineering for our generation was the chance, and I think that's changed.

Dr. PRICE. That's interesting. Fascinating. Thank you so much. I yield back.

Chairman MCKEON. Thank you. Ms. McCollum.

Ms. MCCOLLUM. Thank you, Mr. Chair. I think this has been a good conversation for a lot of reasons. For one reason, those of us who were able to attend the hearing I think realize the need of us talking to each other more about the future of our country.

I'm going to give a couple of examples, because I think you've really done a good job of answering the question. I recently attended a visit to a Boys and Girls Club in Minnesota in St. Paul in a very, very poor urban neighborhood. And I met a young man who was approached by one of the site supervisors at Boys and Girls Club saying, nice to meet you, and why are you launching rockets on the back of our area? And he thought he was going to get in trouble. He thought the police were going to get called, whatever. And he said, well, you know, I don't know. I saw a book and I just was kind of curious. And they invited him in.

A couple of years later, this young man now teaches the rocket program at the Boys and Girls Club where we have children of very diverse language, social, religious backgrounds, but they all have the commonality of poverty, with a young person that they look at, even though he's Spanish and not Somali, that they can relate to. That young man is going to be going to school because of the TRIO program, because it provided an opportunity through TRIO to have someone in the high school to be there to kind of mentor him, because his parents didn't graduate necessarily from high school let alone go to college to figure out how to fill out all the paperwork to apply for college and to have someone help that family even with the financial aid paperwork.

So, we have a lot that Congress can be involved in, in creating opportunity for students, whether it's supporting after school programs, supporting college opportunity for families who might have someone who would be eligible to help that family and that student work through it.

Then I've had two science teachers, one at Hancock Elementary—and these are both in St. Paul—and I have great suburban teachers, too, but you mentioned especially the target of urban schools, and Gaultier School in St. Paul where I met science teachers who helped and reinforced and mentored one another in grade schools but the last science teacher, Mr. Childs, his wife was talking to me about how things started coming home from Home Depot, and things started happening down in her basement. She kind of held her breath. She said, I thought for a minute I was

going to get that cabinet I had been asking for. She didn't begrudge the family income going toward the students at Gaultier Elementary.

But when we start talking about public education is a black hole, always having their hand out, how teachers repeatedly have these cushy jobs where there's no accountability and all of our students are failing, why in heaven's sakes would anybody in their right mind decide, I want to be a teacher? When I decided to go into public education and get my license to teaching, teaching was a respected education. People were proud of our public school system. Do we need to improve it? Absolutely. Does it have changes that need to happen? I agree. Do we need to have high standards and accountability? You bet.

But this Committee and the way it presents the challenges facing public education, we often do a great disservice and discredit to our public school system in the way that even we discuss the challenges and the problems that are out there. We always hear about the problem teacher in public schools. We don't hear about Mr. Childs, who takes money out of his own income to create that active learning.

The testing concerns me, and I'm a social science teacher. I like to say science, but it's social science. I don't do math or solve the problems of the world like Mr. Holt can through physics. But we tried to have an interdisciplinary curriculum. In other words, when I would teach World War II, I would talk about all that was going on with science and physics. The excitement, the good things, the bad things that can come out of science, the challenges.

When teaching geography, teaching the ecology, how water, soil, land, resources can make a difference in populations settling and being successful. When we start doing all this testing, and we do need to have accountability standards and testing, I agree—do we lose not only in your field of science, I think we lose in the social sciences, in literature, to chance to do that link to bring science in. And I think the point that got made about, you know, do we need I think you said Detroit engineering, you know, 1 hour, see what he's up to this week on television, I'm understanding that forensic science is kind of going through the roof right now with interest because of all the forensic science that's on. What role does media and does message have to do, you think, in order to keep people engaged?

Chairman McKEON. Thank you.

Ms. McCOLLUM. I know. Everybody else went over their time, but we've got to go, so.

Chairman McKEON. I'm sorry. Mrs. Davis.

Mrs. DAVIS. Thank you. Thank you, Mr. Chairman. I appreciate your all being here, and I can't help but feel as I sit here and I had a chance to look at this quickly, the road map that you were so involved in, Mr. Augustine, the road map for national security and how imperative it is.

We've all talked about the Sputnik moment. You know, sometimes I wonder where's the sense of outrage that we haven't been able to make some progress in some areas that had been talked about for a long time? And I think you've certainly itemized some of those areas in which we need to work harder.

I wanted to ask you, because—and I admit this has been a personal interest of mine. But it sometimes surprises me that there hasn't been more emphasis on nationally board certified teachers. Is that a program that you're familiar with in the states? North Carolina, California have done a lot with this. And part of my question is, I appreciate the fact that in your company, Lockheed Martin, that you got involved, that you helped teachers with fellowships, you brought people into the workplace. Am I wrong in saying where is everybody else in this? I mean, I think that you can cite a number of really fine, wonderful examples, and certainly we have them in San Diego, and I applaud those companies.

But in many ways, I don't see that this is something that really has taken hold in the country, that people feel a real investment in. When I mention nationally board certified teachers, we've created a lot of hoops for people to get into that program. And it seems to me that if companies would invest even in one teacher, what kind of a statement that would make to do that. I may be talking about something that you're not familiar with, but I'm wondering, you know, where is more of that coming from the private sector? Because they're the ones that are suffering. I have trouble even when I interview for positions finding well qualified people. I know what it's like for the private sector, and certainly in math and science.

Mr. AUGUSTINE. Well, I'm probably not as well qualified to comment on that as my colleagues, so I'll be brief. But if I understand the program you're describing, it's a program whereby people who are subject matter experts can teach. Is that correct?

Mrs. DAVIS. Well, the nationally board certified program is one in which teachers can demonstrate their excellence in a particular area, all the way elementary through high school. And it's—when we talk about people demonstrating performance and being paid differently, some states have given some additional dollars to people. They have compensated them in some way. They've encouraged them to go into low performing schools. And it's a tool that could be more widely used.

And if in fact you're not familiar with it, that tells me something. I'm not concerned that you're not familiar on a personal level, but that tells me something. And, Mr. Chairman, I think, you know, generally it's just something that we can use as a tool. It's not a silver bullet. I don't think there's a silver bullet out there. I think it's a combination of factors.

Mr. AUGUSTINE. I like the concept that you describe. And you say why doesn't it work better than it does, and I suspect it comes back to the point of unfortunately, teaching doesn't command the respect that it once commanded. And it's a cultural issue, and I don't know how you legislate respect.

I do think one thing we could do much better is to put up examples of successful teachers, particularly to attract young women in to science and technology and minorities. If they could see people who have succeed, who were excited about what they did and that made good contributions, I think that may be the best way to change this cultural problem we face.

Mrs. DAVIS. Perhaps I can just focus on Dr. Magnanti for a second then, because I think one of the problems as I understand it

is how many women, how many minorities are serving in top faculty positions at your university.

Dr. MAGNANTI. This is a significant issue, though I'm glad to say we see some progress at the University of Michigan, Princeton University, RPI, MIT have women presidents now. We see I think more women in academic leadership positions in our country.

I can't help but think, as a bit of an aside, given our last two Committee Members to speak, and I looked to my left, we ask what has changed in terms of the educational system, and I think Mr. Augustine pinpointed it well in terms of education as a road to upper mobility. But if we go back thirty years ago, forty years ago, maybe even longer, when I was in K-12, we'd go back a long time ago, what opportunities did women have at that point in terms of career opportunities, and what were their opportunities? It was teaching and nursing, by and large. And being secretaries, right?

Now it's great for the nation. We've got this enormous set of other opportunities that women have in our society, and it's a wonderful thing for us. But it means that we I think have extracted some of that wonderful talented women from the education, K-12 education, are now doing other things. And I think to think of that systemically, and what's the systemic effect of that. And I think things like salary and other things I think are a measure of this in terms of how we think about it. But we didn't need maybe as high salaries then because women didn't have other opportunities.

So I think thinking this as a system, and I think it's another rather significant change in terms of the overall landscape of the K-12 system.

Mrs. DAVIS. Thank you. I appreciate that. And if you can continue to help us out with the kind of investment that's really required to get the doctoral students in to make the connections between K-12 and the universities and then into the private sector, public sector, I think that's important.

And it is a national security issue. And I think that we really don't get that yet.

Dr. MAGNANTI. If I could also offer, I think the situation with women in terms of engineering and science is improving some. We're up to about half of our incoming class now are women at MIT, which startles people when they hear it, and the Nation is about 17 to 20 percent. But the issue of minorities is much more drastic, and I think it's a much, much more serious concern. Both are of concern, but we're just not attracting enough minorities to engineering and science.

Mrs. DAVIS. Thank you, Mr. Chairman.

Chairman McKEON. We've been called to vote. We have just a couple of minutes to get over there now. But, you know, I think it's not just teachers that have lost respect. I think it's attorneys, it's bankers, it's policemen, it's across the board I think our sixties didn't help a lot. And I think it's going to take some work to get that respect back, and it has to start at a young age with children, and then we develop—we're going to have to work hard to develop that.

Thank you very much. I think this has been an outstanding panel, an outstanding hearing. I hope that you'll stay in touch with

us as we go through the higher ed reauthorization and as we work more in this area. We have a lot to do.

Thank you very much. This panel stands adjourned.

[Whereupon, at 11:53 a.m., the Subcommittee was adjourned.]

[Additional material submitted for the record follows:]

Statement of Hon. Jon C. Porter, a Representative in Congress from the State of Nevada

Good Morning, Mr. Chairman. I am pleased that the subcommittee is holding today's hearing on the challenges our educational system faces, particularly in the fields of math and science. I appreciate our panel of witnesses for joining us today and the diverse perspectives that they can provide us on this important issue.

One of the building blocks of our nation's success throughout our history has been the ingenuity and invention which allow us to continually overcome the challenges we face and fill the needs that we have. This ability has traditionally been the product of a free-thinking and open society, in concert with the excellence of the education available to us. As our dynamic economy continues to grow, we must continue to rely on this ingenuity and vitality of thought. Excellence in the fields of math and science must be a priority for this to occur, as our increasingly technological society requires increased research and scientific engagement.

The basis for these abilities lies firmly in the ability of our elementary and secondary schools to provide the highest quality math and science education available. To ensure that this education is of the finest quality, Congress, in concert with States, local education agencies, and institutions of higher education, must strive to provide the necessary incentives to bring our best and brightest math and science teachers into the classroom.

In my own school district, we hire approximately 2000 new teachers per year. A significant portion of these slots are teachers of math and science. Our tremendous growth has brought significant challenges in recruiting the finest teachers. We can all work together to engender greater interest in these fields, so that we can continue our strong tradition of technological advancement.

Again, Mr. Chairman, thank you for calling this hearing today on this most important issue. I look forward to the testimony of our witnesses and am hopeful that we can work together to provide excellence in math and science education to all of our students.

