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FOSTERING INNOVATION IN MATH AND SCIENCE EDUCATION

HEARING

BEFORE THE

SUBCOMMITTEE ON TECHNOLOGY, INNOVATION, AND COMPETITIVENESS

OF THE

COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION
UNITED STATES SENATE

ONE HUNDRED NINTH CONGRESS

SECOND SESSION

APRIL 26, 2006

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FOSTERING INNOVATION IN MATH AND SCIENCE EDUCATION

WEDNESDAY, APRIL 26, 2006

U.S. SENATE,
SUBCOMMITTEE ON TECHNOLOGY, INNOVATION, AND COMPETITIVENESS,
COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION,
Washington, DC.

The Subcommittee met, pursuant to notice, at 10:10 a.m. in room SD–562, Dirksen Senate Office Building, Hon. John Ensign, Chairman of the Subcommittee, presiding.

OPENING STATEMENT OF HON. JOHN ENSIGN, U.S. SENATOR FROM NEVADA

Senator ENSIGN. Good morning. Welcome to the hearing on fostering innovation in math and science education.

Over the past 2 years, we have seen an unprecedented amount of activity and interest in math and science education. First, the Council on Competitiveness unveiled the National Innovation Initiative. Following that, the National Academies released a report entitled, "Rising Above the Gathering Storm." Each of these reports lists specific recommendations to Congress that are designed to increase the competitiveness of the United States in the areas of math and science education.

These reports have elicited numerous legislative proposals. Senator Lieberman and I introduced the National Innovation Act. Senators Alexander, Bingaman, and others introduced three different bills that make up Protecting America's Competitive Edge, or PACE, Acts. President Bush unveiled his American Competitiveness Initiative earlier this year in his State of the Union Address.

While we might differ in our approaches, all of us agree that we need to help better prepare our Nation's students in math and science education. This country has a longstanding history of being one of the most inventive and innovative countries in the world. We have also fostered competition and attracted scientists, engineers, and mathematicians from across the world. Today, however, I feel that we are losing that competitive edge.

The purpose of today's hearing is to look at what is working in the fields of math and science education. Each of the witnesses here today is part of the solution to a vexing problem. The problem is, How do we get more students interested in math and science classes? And how do we make good math and science classes available to every student?

When drafting the National Innovation Act, I was appalled to learn that less than one-third of the U.S. fourth- and eighth-graders perform at or above proficient in math. American 15-year-olds ranked 24th out of 40 countries that participated in the program for international student assessment examination. That examination measured a student's application of mathematical concepts to real-world problems.

It is no wonder that while China graduated approximately 350,000 engineers, computer scientists, and information technologists with 4-year degrees in 2004, the United States graduated approximately 140,000 with 4-year degrees in these same fields. We need to do much better.

The National Innovation Act does three things to help improve America's competitiveness. It increases research investment, increases science and technology talent, and it develops an innovation infrastructure. Today, I would like to focus on how the National Innovation Act increases science and technology talent. Specifically, this legislation would increase the number of graduate fellowships and graduate traineeships at the National Science Foundation. This would help students pursue graduate degrees in sciences, technologies, engineering, and mathematics. The National Innovation Act also encourages the development of professional science master's degree programs as a means of increasing the number of highly skilled graduates entering the science and technology work force. My legislation also enlarges the Science, Mathematics, Engineering, and Technology Talent Expansion program, commonly called the Tech Talent program, which provides funding to universities to increase the number of graduates with degrees in math and science.

Finally, the legislation extends the Department of Defense's Science, Math, Research for Transformation, or the SMART scholarship program, which supports individuals pursuing doctoral and master's degrees in relevant fields.

I believe that the Federal Government needs a four-pronged approach to improving STEM education and fostering innovation in math and science education.

First, I believe that math- and science-related programs need to be housed and supported in agencies that have proven track records in providing effective math and science education programs, both for teachers and for students.

Second, it is vital that we take stock of all current Federally funded programs as we move forward with comprehensive legislation.

Third, it may be necessary to create some new Federal programs to support programs that have been proven effective in the field. Congress must ensure that we do not hamper these efforts, but enhance them.

Finally, it is absolutely imperative that we include metrics, measurements of effectiveness, for current and new programs.

The National Innovation Act is a great step toward meeting these goals. I am going to work with my colleagues on the Commerce and HELP Committees to come up with common sense solutions to these problems. In doing so, we hope to work with each of you here today and draw on your expertise. By working together,

the Federal Government can help graduate more students in the STEM—Science, Technology, Engineering, and Math—fields.

Today, we are pleased to have a distinguished panel of witnesses with experience from across the spectrum and who are on the front lines working with our students every day.

Before the testimony begins, I would like to state, without objection, any of the Senators' full written statements will be made part of the record. Senator Sununu is here, and if you have an opening statement, I welcome it at this time.

STATEMENT OF HON. JOHN E. SUNUNU, U.S. SENATOR FROM NEW HAMPSHIRE

Senator SUNUNU. Thank you, Mr. Chairman.

I'm interested to hear from our witnesses today, and, in particular, those that are here to offer and provide a little bit of information about the work that they're doing and about the success that they have already seen.

I have an education in science and engineering, which, miraculously enough, did not prove too great an obstacle to get elected to public office, or, conversely, maybe my failure to prove my worth in the private sector drove me to have to run for political office. But I'm here, nonetheless. And so, by way of education, background, interest, and experience, this is naturally a subject of great interest to me, and, about like any other subject, not one where I have significant opinions. But I am certainly willing to listen. My personal experience, both in my own education and in a number of siblings and close friends, classmates that have all gone on to technical educations and careers, is that you decide, as a student, that you're interested in these areas of math and science, you know, not when you're a junior in college, not even when you're applying to college, not even when you're a junior and senior in high school. You decide this is an area of interest that you find fun and interesting and engaging when you're in the fifth grade or sixth grade or seventh grade. And that interest is generated, by and large, by one thing, and that's good teachers.

Certainly, family experience matters, as well. If we've got parents who are interested in their child's education and interested, in particular, in this area, and you have good teachers, that's when kids get interested. And it happens somewhere between fifth and eighth grade. And if they have that interest, they'll pursue it in high school. And then, when it comes time to make a choice about long-range education plans, they may select a career in math and science.

There are limited things that we can do at the Federal level to really affect that process. Now, we could talk about what those might be—I think school districts setting real clear standards for curriculum and for achievement in these areas, and testing their students in these areas, the right curriculum, the right standards, and working to make sure that their teachers are accredited in these areas. That's very important. But, again, there are limited things that we can do at the Federal level to accentuate that process. We have a great vehicle for support, inspiration, and funding of scientific and technological advancement nationwide and worldwide here at the Federal level, and that's called the National

Science Foundation. And while there's—Congress being what it is, we've made every effort possible to mess that up. It still works relatively well, because it's peer reviewed, and the bulk of the money goes to investment in the physical sciences and computational mathematics. And that's what it's intended to be for.

A number of the legislative proposals out there, well intended, contemplate Balkanizing that funding stream even further. In fact, there's one legislative proposal that says, "You know, maybe this whole peer-review thing isn't a good idea. Let's set aside a percentage of the money for discretionary Congressional initiatives." Now, you know, I like to think that I'm relatively intelligent, but, in that regard, I'm intelligent enough to know that I can't make a better choice than a good panel of peer-review experts in the field of, you know, crystalline—crystal formation or ceramics or statistics or computational mathematics or cryptography. You know, I'm not going to make a better choice. So, we need to be very careful about undermining the things that work.

I will also underscore the fact that, intentions being what they are, we've already made a great effort, a noble effort, to do what we can at the Federal level to provide recognition and even financial support for these endeavors. When it comes to scholarships, which are important and justifiable in these areas, we have the National Institutes of Health Undergraduate Scholarship Program, the Graduate Assistance in Areas of National Need, the U.S. Department of Energy's Office of Fossil Technology Scholarships, Academic Competitiveness, and National Science and Mathematics Axis to Retain Talent Scholarships, the SMART Grant Program Scholarships, the National Aeronautics and Space Administration Scholarships, the National Science Scholars, the Commerce, Science, and Technology Fellowships Program, the Ernest Hollings Scholarship on Ocean Atmospheric Science, Technology Research, and about at least a half dozen others, the point being not that any one of these programs do a good job, or don't do a good job.

There's a pretty comprehensive litany of efforts to highlight the importance and the value of science and technology education. So, we should be mindful of what's already out there, identify whether it's working or not, and then begin our efforts by trying to make the best use of that which already exists.

With regard to simple recognition, such as, awards and honors, again it is very important to highlight at a national level, again, the value of science, technology, and engineering. This sounds very self-serving to say how important engineers are to America, having studied to be one, and I had worked as one, at one time. But we have a National Medal of Technology, a National Medal of Science, Malcolm Baldrige National Quality Award, the Presidential Award for Excellence in Science, Mathematics, and Engineering Mentoring, the Presidential Early Career Award for Scientists and Engineers, the Presidential Awards for Excellence in Mathematics and Science Teaching, the Green Chemistry Award, Congressional Space Medal of Honor, and about 20 others, all relating to fields of science, technology, and mathematics.

My point is not to suggest that these are good programs or bad programs, effective or not effective, but the legislation that's been written and introduced, it—I think one of the bills that's received

the most exposure creates at least 21 new programs, without really looking at any of those that I just mentioned to determine how they might be better funded, how they might be better structured, how we might do a better job of communicating the existence of these programs.

So, I appreciate the value of having this discussion, but I encourage people to sort of exercise caution, not undermine and weaken those things that we have. I am advocating to double the funding in the National Science Foundation, along the lines that we have done so for the National Institutes of Health for 5, 6, 7 years, and it seems to be an idea that's caught on. That's good. And I'm certainly not the only person that had been encouraging such funding.

But I think we want to make sure we stay focused, and we make sure we understand what the Federal Government can do, and can do best, what academic institutions, higher learning, colleges, universities can do, and do best, what great nonprofits, like the Boston Museum of Science can do, what they do best, and what superintendents and teachers and parents, at the local level, can do, and do best.

Thank you, Mr. Chairman.

Senator ENSIGN. Thank you.

Now we will hear from our panel of witnesses. But before we do, I would like to make just one comment about having an engineer in the Senate. I could make a joke about it, but it has actually been very valuable to have the diversity that we do have, and you can see this by the statement of my colleague today.

Now I want to start with Dr. Mary Ann Rankin. She is going to tell us about her experiences with the UTeach Program at the University of Texas at Austin. I have heard her testify before, and we would like to explore about UTeach today, because I think it is a very exciting program.

Dr. Rankin before you begin, if all witnesses could keep their testimony to around 5 minutes I would appreciate it. We are not going to put you on the clock or anything, but around 5 minutes or so, so we can have some good time for discussion afterwards, that would be great. OK?

Thank you.

STATEMENT OF MARY ANN RANKIN, PH.D., DEAN, COLLEGE OF NATURAL SCIENCES, UNIVERSITY OF TEXAS AT AUSTIN

Dr. RANKIN. Thank you, Senator. I appreciate this opportunity to speak to you today about our math and science teacher preparation program.

We believe that strong teachers are a key element in improving America's competitiveness, and they are in frighteningly short supply. The prospects are frightening for the future, as well.

In 1997, we initiated a highly successful teacher preparation program at the University of Texas for math and science majors, called UTeach. Research-one universities have not traditionally assumed much responsibility for teacher training. And, in fact, before we established UTeach, UT Austin had very few science or math majors pursuing certification. We had a student body at that time of about 8300 majors. Four science majors, and 19 math majors the

year before, had achieved certification and most of those didn't actually go on to teach.

With the UTeach program, we've now doubled the number of math majors and increased, by six times, the number of science majors being certified. Enrollment in the program is at 470 this semester. This year's 74 graduates will bring the total number of grads to about 350. Approximately 88 percent of those are teaching or searching for teaching positions; 75 percent of those who graduated 5 years ago or more are still teaching.

The quality of our students is very high. Prior to initiation of the UTeach Program most of the students receiving certification pursued it as a last resort after not achieving their primary goals. Now students are choosing this career path as their first choice. As a group, they have high SAT scores, higher grades, and much better retention, compared with other students in the college. Approximately a quarter of them are traditionally under-represented minorities, which is about twice the college average. They emerge dedicated and excited at graduation, with excellent content knowledge and considerable experience in the classroom. And I'll tell you a little bit more about that.

A number of our students have assumed leadership positions in their schools, such as department chair, director of curriculum, AP teachers, even as early as their second or third year of teaching. The National Research Council in the Gathering Storm report, and prior to that, the U.S. Department of Education, have cited UTeach as a model program. A number of other institutions in Texas, Louisiana, Colorado, and now in California, have begun using UTeach as a model and initiating similar programs. In fact, the California program will be statewide and the largest of its kind in the Nation. We were even mentioned in *TIME Magazine* recently, so that was exciting.

The key elements of UTeach that we believe are most responsible for its success are, first of all, we employ outstanding experienced high-school and middle-school teachers as instructors, advisors, and field supervisors, along with regular science and education faculty. They are the equivalent of faculty in this situation. In partnership with the College of Education, we have replaced the traditional general education courses with pedagogy courses focused on how to teach math and sciences that are intermingled with the discipline courses in the program. So, we've thrown out all of the old education courses, and we now have these new, very much more exciting courses, which include field experiences at every level and follow national and state guidelines for math and science educator training.

We aggressively recruit science and math majors to the program, including paying the tuition for the first two courses, which are field-teaching experiences done under outstanding classroom teachers. These early field experiences allow students to try teaching, and are a very effective draw into the program.

The ability to complete the program with a full major in math or science with teacher certification within 4 years is also important. We've developed a streamlined version for post-baccalaureates that can be completed in 1 year.

We offer internships for students who need to work, doing jobs that are relevant to the teaching profession and that reinforce their experience and commitment to teaching. And this is also very important.

We have some scholarship support based on good performance in the program. We have induction support—and this is really key—for graduates, once they are out and teaching, including assistance with lesson plans, curriculum development, advice on classroom management and other sorts of coaching. And, finally, we now have a UTeach master's degree in science and math education that provides the possibility of an advanced degree, if they wish to pursue it.

Thank you very much for your kind attention, and I'd be very happy to answer questions at the end.

[The prepared statement of Dr. Rankin follows:]

PREPARED STATEMENT OF MARY ANN RANKIN, PH.D., DEAN, COLLEGE OF NATURAL SCIENCES, UNIVERSITY OF TEXAS AT AUSTIN

Thank you for this opportunity to speak to you today about UTeach, an innovative and very successful teacher preparation program for Math and Science majors.

In 1997 we initiated a highly successful teacher preparation program for *math and science majors* called UTeach. Research 1 universities have not traditionally assumed much responsibility for teacher training, and indeed prior to establishment of the UTeach program, UT Austin had very few *science or math majors* pursuing certification: 4 science; 19 math in 1996 from a body of about 8,300 majors. It was usually a fall back or last resort for students who did not achieve their primary goal such as admission to medical school, or graduate school, and many who were certified did not actually go on to teach.

We wanted to create a program that would attract large numbers of strong math and science majors to teaching, and prepare them for success; we believe we have achieved that goal. Since the inception of the UTeach program we have doubled the number of math majors and increased by 5–6 times the number of science majors being certified. Enrollment is at 470 students this year and this year's 74 graduates will bring the total number of grads to about 350. Approximately 89 percent are teaching, planning to teach, or actively searching for teaching positions. Seventy-five percent of those who graduated in 2001 or before are still teaching.

The quality of UTeach students is very high. As a group they have higher SAT scores, and higher grades in comparison to their College of Natural Sciences (CNS) undergraduate peer group. Approximately one-quarter of UTeach students are traditionally underrepresented minorities who we believe will be strong, inspiring role models for the minority students in their own classrooms—this is substantially more than in the overall UT undergraduate population.

These strong students are choosing this career path as a first choice; they are dedicated and excited about teaching and they emerge at graduation with excellent content knowledge and considerable experience in classroom situations. A number of our students have assumed leadership positions in their schools such as department chairman, director of curriculum, or AP teacher, even as early as their second or third year of teaching.

The National Research Council[1] and the U.S. Department of Education[2] have cited UTeach as a model program. Many other institutions in Texas, Louisiana, Colorado, and elsewhere are exploring ways to create similar programs. California has just begun an initiative based on the UTeach model that will be the largest of its kind in the Nation.

The key elements of UTeach program that we believe are responsible for its success are:

1. Adherence to national and state guidelines for math and science education.

[1] *Educating Teachers of Science, Mathematics, and Technology: New Practices for the New Millennium*, National Academy of Sciences Press, (2000); *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future*, National Academy of Sciences Press (2005).

[2] *www.ed.gov/news/speeches/2004/03/03182004.html*; *www.uteach.utexas.edu/about/recognition/Title11Report03.pdf*.

2. Employment of outstanding, experienced high school and middle school teachers as instructors, advisors and field supervisors along with regular Science and Education faculty.
3. New pedagogy classes to replace the traditional general education courses focused on how to teach math and science, intermingled in the curriculum with discipline courses.
4. Inclusion of field experiences in the pedagogy courses at every level.
5. Aggressive recruitment of science and math majors to teaching. This involves:

- Advertising the program to new and continuing math and science students.
- Providing monetary incentives to try the program.
  —UTeach pays the tuition for the first two courses. These focus on field teaching experiences. Students are carefully prepared by our master teachers to teach math/science lessons in public school classrooms in pairs 4 times a semester, first in elementary and then in middle school classrooms under outstanding classroom teachers. This allows them to try teaching and in many cases is a very effective draw into the program.
- Internships for students who need to work, doing jobs that are relevant to the teaching profession—working in museums, AISD classrooms, informal science clubs, etc. These internships help both the students and the organizations for which the students work and reinforce their experience and commitment to teaching.
- Scholarships based on good performance in the program, especially for upper-division students.

6. Ability to complete the full program with a major in math or science and teacher certification in four years. We have developed a streamlined version of the UTeach curriculum for Post-baccalaureates that can be completed in one year.
7. Induction support for graduates. Many new teachers leave the profession within the first few years of service. We believe that a substantial support system, including assistance with lesson plans, curriculum and advice on classroom management can make the difference between first years that are rewarding or intolerable and we have a program in place to supply this kind of support.

We have also developed summer coursework leading to a UTeach Masters degree in Science and Mathematics Education. This provides the possibility of an advanced degree as part of the long-term support we provide to our UTeach students.

Thank you for your kind attention. I'd be happy to answer questions.

Features of UTeach Success

- New, highly relevant pedagogy courses focused on teaching math and science
- Early, intensive and continuing field experiences
- The guidance and inspiration provided by master and mentor teachers
- The aggressive recruitment of science majors by invitation to take the two initial UTeach courses for free
- Paid internships that offer opportunities for community outreach and informal science teaching that reinforce teaching commitment
- Compact degree plans that allow most students to graduate in four years having completed both their content courses and the requirements for teacher certification
- An accelerated program for post-baccalaureate students that gets them into the classroom quickly but prepares them well
- A technology-rich curriculum that emphasizes the use of new educational tools in instruction
- A research experience that can help transfer the thrill of new discovery to the public school classroom
- Mentoring of new teachers and providing a path to an advanced degree

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UTeach: A National Model for Teacher Preparation in Math and Science

The UTeach program was developed at The University of Texas at Austin to help address the disturbing shortage of qualified math and science teachers that exists in Texas and beyond. UTeach graduates are mathematics and science majors (not education majors). They are strong students and they are becoming teachers in large numbers.

Prior to the development of UTeach the College of Natural Sciences at UT Austin was producing very few graduates certified to teach high school math or science. In establishing UTeach we hoped to create a program that would attract a large number of strong students to this career path as a first choice and that would train them to be outstanding, successful teachers.

Selected Awards for UTeach Graduates

2006

- Elizabeth Abernathy (certified, Spring 2003) is selected as the Teacher of the Year at Kealing Middle School
- Katie Arrington (graduated May 2001, currently in the UTeach Master's Program) is selected as Math Curriculum and Instructional Specialist in Round Rock ISD
- Geoff Mathews (graduated Fall 2000) is selected as Technology Specialist in Round Rock ISD.

2005

- Michael Degraff (Graduated May 2005, currently in the UTeach Master's Program), teaching at Bowie High School in Austin ISD, is selected as Mathematics Chair Honored Graduate by the UT Mathematics Department
- Dan Powderly (Graduated Spring 2003) is named Teacher of the Year at Castleberry High School in Forth Worth.

2004

- David Villalobos (graduated Spring 2001) is selected as Travis HS Teacher of the Year.

2003

- Chris Vande Sande Mihealsick (Graduated Spring 2002) is selected as Teacher of Promise for Crockett High School in Austin

Our original aims have been met. From a pilot project with 28 students in the fall of 1997 UTeach has now matured to a high-profile, well-respected program with an enrollment of over 400 students/year. Nearly 300 students have graduated and nearly 89 percent are teaching, planning to teach, or actively searching for teaching positions. Over 75 percent of the graduates who began teaching in the Fall of 2001 or before are still teaching.

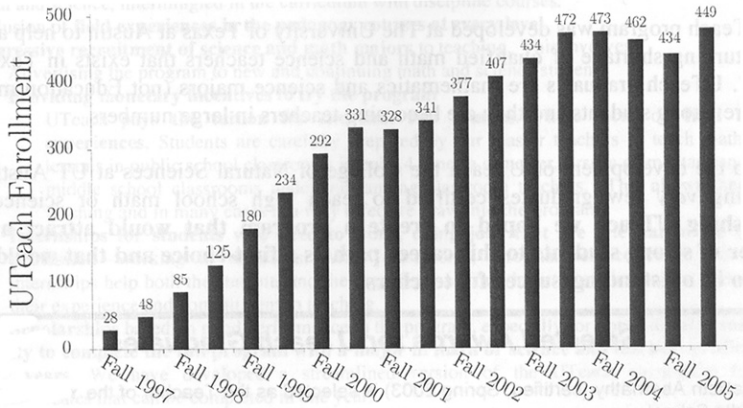

Figure 1: Growth of UTeach from 1997 to present.

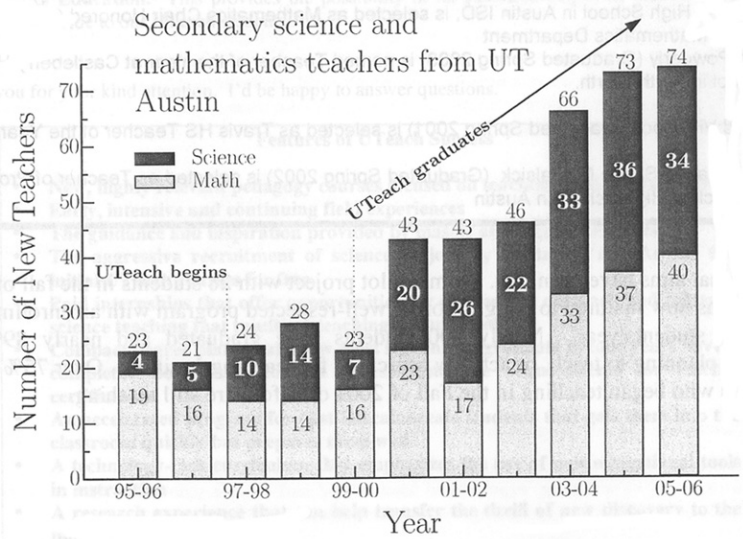

Figure 2: Numbers of majors certified to teach math and science at UT Austin from 1995 to present

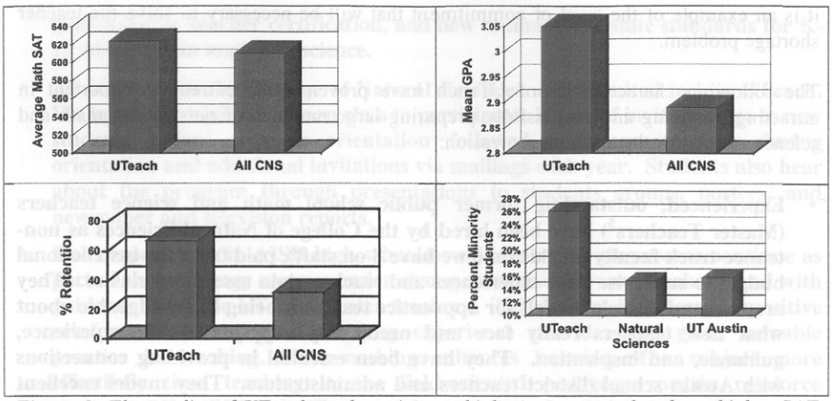

Figure 3: The quality of UTeach students is very high. As a group they have higher SAT scores, and higher grades in comparison to their College of Natural Sciences (CNS) undergraduate peer group. Approximately one-third of UTeach students are traditionally underrepresented minorities—twice as many as in the overall UT undergraduate population. Retention in the UTeach program is approximately twice as high as in the College of Natural Sciences as a whole. See http://uteach.utexas.edu for more information.

Beyond its ability to attract top students into math and science education, the success of UTeach can be measured by its increasing stature as a model program for teacher preparation in which colleges of science and colleges of education work together with public schools. On the UT Austin campus, the College of Liberal Arts has implemented its own version of UTeach. The UT System has declared UTeach to be a part of the *Every Child Every Advantage* initiative,[1] and the National Research Council[2] and the U.S. Department of Education[3] have cited it as a model program. Texas A&M has implemented a program similar to UTeach after several discussions with us. Many other institutions in Louisiana, Colorado, and elsewhere are exploring ways to create similar programs. Indeed, to bolster its long-term economic prospects, which are largely dependent on the availability of a work force with science and math skills, California has embarked upon an initiative to improve teacher preparation and increase the number of certified math and science teachers graduating from its public universities.[4] The reform is based upon the UTeach model developed at UT Austin and is statewide in scope, with the full backing of the governor. This is an effort to quadruple California's annual production of credentialed science and mathematics teachers, from 250 per year to 1,000 per year by 2010. This initiative is the largest of its kind in the Nation and although it has just begun, it is an example of the level of commitment that will be necessary to solve the teacher shortage problem.

The following characteristics of UTeach have proven to be extremely important in attracting, retaining and successfully preparing large numbers of outstanding math and science majors for the teaching profession:

- Experienced, outstanding former public school math and science teachers (Master Teachers)[5] have been hired by the College of Natural Sciences as non-tenure-track faculty (at this time we have 8 on staff), paid from the instructional budget to supervise field experiences and teach certain associated classes. They are tremendous role models for apprentice teachers; being knowledgeable about

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[1] *www.utsystem.edu/EveryChild/K16PrgDes-Initiative1.html.*

[2] *Educating Teachers of Science, Mathematics, and Technology: New Practices for the New Millennium*, National Academy of Sciences Press, (2000); *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future*, National Academy of Sciences Press (2005).

[3] *www.ed.gov/news/speeches/2004/03/03182004.html*; *www.uteach.utexas.edu/about/recognition/Title11Report03.pdf.*

[4] *http://www.universityofcalifornia.edu/academics/1000teachers/.*

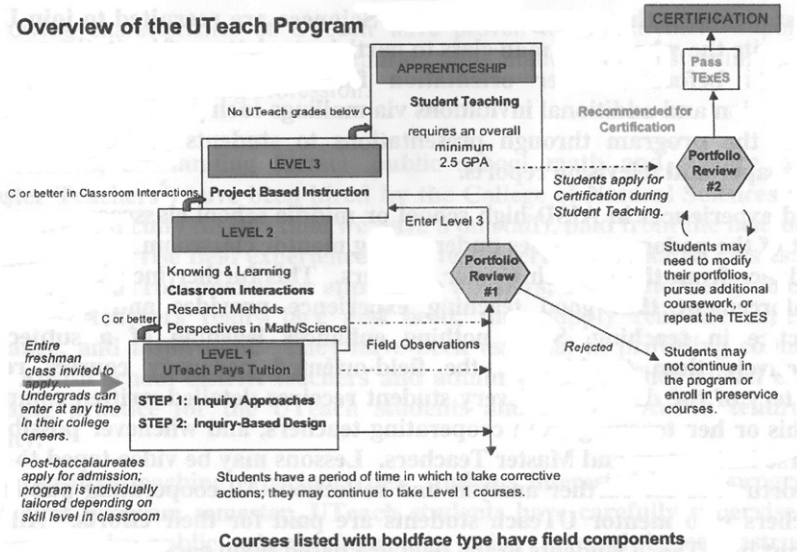
[5] A Master Teacher is an individual with at least 3 years public school teaching experience whom has put into practice the instructional strategies on which we will be evaluating UTeach students. Master Teachers are tremendous examples and guides, they are knowledgeable about what new teachers really face and need, and they are indispensable in providing connections with local school district teachers and administrators.

what new teachers really face and need, they supply real life experience, guidance, and inspiration. They have been essential in providing connections with Austin school district teachers and administrators. They model excellent teaching practice for the UTeach students and the UT Austin tenure-track faculty.

- Early positive teaching experience gets students interested in the program. In their first program semester, UTeach students have carefully supervised field experiences in public school classrooms using research-based instructional materials that give them successful but realistic teaching experiences, and let them judge whether teaching is a good personal choice. The first two UTeach courses are field experiences in Austin elementary and middle school classrooms guided by inspiring, veteran teachers. This experience typically creates satisfaction and a commitment to teaching in participating students. The introductory courses are offered at no cost to the students. Although this is not a great savings, it seems to be important in convincing students to participate.
- Innovative new professional development courses have entirely replaced the old education curriculum. The new courses focus on new theories of learning and on how to teach science or math effectively to diverse learners. They combine content material and pedagogy, are integrated with science and math courses, and emphasize the connections between the sciences and between mathematics and the sciences. Students acquire expertise with instructional technology through experiences woven throughout the pedagogy courses and learn how to use technology effectively in teaching. UTeach instruction models teaching practices expected of its graduates, emphasizing the use of inquiry and technology to engage students more deeply in learning mathematics and science. There are no generic education classes.
- UTeach was designed in consultation with a group of outstanding high school teachers and the State Board for Educator Certification, according to new state guidelines for teacher certification, and new national and state standards for K–12 education in math and science.
- All students in the College of Natural Sciences are recruited to join UTeach. We invite the whole freshman class to participate; letters of invitations go to new students before summer orientation followed by a presentation during orientation and additional invitations via mailings each year. Students also hear about the program through presentations to students groups, posters, and newspaper and television reports.
- Field experiences in AISD high school or middle school classrooms continue as part of the pedagogy courses under strong mentor classroom teachers, and with guidance from the UTeach master teachers. This further increases the positive reinforcement that good teaching experience provides and gives valuable practice in teaching. Since nothing enhances learning of a subject more effectively than teaching it, the field-oriented pedagogy courses reinforce mastery of the discipline. Every student receives detailed written commentary on his or her teaching from cooperating teachers, and whenever possible from course instructors and Master Teachers. Lessons may be video taped to provide opportunities for further analysis and reflection. All cooperating public school teachers who mentor UTeach students are paid for their efforts. All lessons taught by UTeach students in the field are based upon carefully prepared lesson plans that are available for review by course instructors, Master Teachers, and cooperating teachers prior to delivery.
- Student teaching is the final field experience and it is overseen by master teachers through the college of Natural Sciences. Mentoring and help, either online or in person, continues even after students graduate and begin teaching. All UTeach students complete a portfolio that documents their accomplishments according to the state standards and additional UTeach program requirements. Final evaluation of teaching proficiency is done by trained observers, based on the candidate's classroom performance.
- UTeach is a 4-year program. Students can finish in 4 years with certification, having completed a strong degree program in mathematics or science with student teaching. Therefore students can obtain teaching certification without expending money or time beyond a normal undergraduate degree.
- UTeach degree plans are available for all teaching certifications grades 4–12 involving science, mathematics, and computer science. They are constructed with attention to state and national standards for teacher preparation in each discipline, including both process skills and content items. All the competencies of teachers required by the state, and assessed by the portfolio and final observation are covered during the UTeach course sequence. We also allow profes-

sionals to change careers and become teachers in an accelerated program that strikes the right balance between getting them into the classroom quickly and preparing them well enough so that they stay.

- All UTeach students have a research experience to expose them to the challenges of open inquiry and technical accomplishment that characterize investigations in science and mathematics and to teach them how to facilitate such experiences for their own students.



- Internships and scholarships are available for students who need them. Internships are funded from private donations solicited by the college; they provide financial help in an educational setting, augment student training and field experiences, and maintain commitment. 60–90 students per semester work in nonprofit educational settings. Tasks range from mentoring children in math and science outreach activities or assisting in Austin public school classrooms, to working in museums or preparing educational software.
- UTeach is a partnership between Colleges of Education and Natural Sciences (although the students are all Natural Sciences majors). This may not be essential but has been an important element of success at UT Austin.
- The fact that this program developed at a Research 1 University means that very strong math and science students are involved in the program and we are able to infuse the program with an understanding of research and analysis as the foundations of science. The program could be replicated at non-R–1 universities and colleges, but a less well-prepared student body or faculty might mandate some enrichment activities in the discipline courses in order to have the level of discipline preparation that is characteristic of UTeach students.

Another critical concern is support for our UTeach graduates and other novice science and math teachers. Many new teachers leave the profession within their first two years of service. We believe that a substantial support system, including assistance with lesson plans, curriculum and advice on classroom management can make the difference between first years that are rewarding or intolerable. To address this difficult problem we have developed, with support from the Michael and Susan Dell Foundation, a scalable, sustainable support system for novice math and science teachers. It involves on-site visits by experienced mentor teachers combined with 24–7 online help and on-demand Saturday workshops. We are also developing summer coursework leading to a Master of Arts in Science and Mathematics Education. We have established a graduate-level program of professional development that will lead to a UTeach Master of Arts in Science and Mathematics Education. This provides the context of an advanced degree path for our new-teacher mentoring program and will hopefully be an added incentive for our novice teachers to continue teaching. It will also provide a rigorous, practical, high-profile path to a master's

degree for in-service teachers across Texas. We believe the mentoring-to-masters continuum will enable participating teachers to develop from novices to seasoned professionals, and will provide more established teachers with practical opportunities for real professional renewal. For Texas this will mean more and stronger teacher-leaders in mathematics and science throughout the state.

Funding for the program comes primarily through university resources. About $1.5 million/year pays the normal costs of University instruction. However, some aspects of the program such as the internships, tuition for the first two courses, and the induction support for new teachers require private funds, and many private foundations and individuals have provided support since 1997. We are working to establish an endowment to permanently support these kinds of expenses and have raised over $7 million towards a goal of $15 million. The income from this endowment as well as additional one-time funds from foundations and individuals augments The University of Texas support for the program.

Replication of UTeach

The time has come to implement the UTeach model across the U.S. At UT Austin, where UTeach was pioneered, the number of secondary science and math teachers certified per year has increased dramatically since inception of the program. Now is the time for science, math and education faculty and administrators at other research universities to develop the same level of involvement in teacher preparation that has made UTeach a success.

The improvement of teacher preparation calls for programs that are effective, and based upon experience. Effectiveness needs to be valued more highly than novelty in this situation, and cooperation between institutions valued more highly than competition. Thus we recommend an alternative to the traditional merit review process.

A program aiming to affect most of the country's large public research universities could proceed in phases. A first phase might be to identify universities that already have the capacity to prepare many secondary mathematics and science teachers, and whose programs are largely consistent with the provisions outlined above. These universities would complete the process of developing model programs, and develop the capacity to assist other universities to do the same. UT Austin would welcome the opportunity to share the strategies used to develop UTeach during this phase, and would be glad to improve UTeach through interactions with other universities. In a second phase, each of the model programs in phase I would assist universities in geographic proximity to develop their own new programs. A third phase should be sufficient to affect public universities willing to participate, and private universities willing to offer competitive opportunities. Universities not interested in participation might be persuaded by the successes in the first two phases. Principal Investigators should be Deans of Arts and Sciences and co-PI's should be Deans of Education. Deans retain enough contact with faculty and departmental issues to ensure program implementation but are high enough in the administrative hierarchy of most universities to effect permanent change.

We suggest that replication awards be for 6–8 years, focused on creation of teacher preparation programs on the UTeach model. Suggested requirements for a successful application appear in Appendix 1. Successful applicants would be reviewed annually. Continued funding for the full term would be tied to progress on specific benchmarks.

Funds should be granted on a annual basis, subject to review and successful completion of benchmarks for enrolling and graduating students, creating courses and degree plans, and employing staff. Note that an important component of the program is the adoption of teacher preparation as a well-supported, permanent part of normal university operations. Therefore the grants should be set at a size designed to enable a new program to begin, without creating dependency that threatens the program when Federal funding terminates. Appropriate uses of grant funds include hiring Master Teachers, employing support staff, summer salary for participating faculty, or funds for student recruitment such as tuition remission. In any successful program, costs will rapidly exceed the amount of the grant. Deans, Provosts, and Presidents must therefore be aware of the commitment they are making *as the process begins*. Specific, explicit commitments on the part of the central administration should be required as a condition of participation in the form of an MOU. Potential for additional state support for a program should be part of this planning process.

In endeavoring to establish UTeach-like programs at other institutions, we must take into account differences in administrative structure, mission, location, and student population. For example, one hallmark of UTeach is the excellence of the math/science knowledge that UT Austin graduates possess, as evidenced by their high scores on certification exams and their classroom performance. If students do not enjoy the same degree of preparation in their discipline as UT Austin College of

Natural Sciences majors, it may by necessary to enrich the science and mathematics curriculum at their universities. This would require additional funding. We have developed a program at UT Austin focused on at risk students admitted under Texas House Bill 588 passed in the 75th legislature that granted automatic admittance to all high school graduates in the top 10 percent of their graduating class to any Texas public college or university. This program, called the Texas Interdisciplinary Plan, is described in Appendix 2. It emphasizes enrichment activities, mentoring, small class sizes and work on applied problems. It has been very successful at UT Austin, fits well with the UTeach curriculum, and could be adapted to augment basic math and science programs at other universities. Similarly, UT Austin is located in a large metropolitan area that affords many and varied classroom experiences for our students. This has been extremely important to the success of the UTeach program. Universities located in more rural settings will face special challenges with respect to providing field experiences for pre-service students, and we would need to find ways to address this issue to achieve maximum success in these regions.

In summary, we seek to help create an initiative that will assist other universities to develop programs similar to UTeach that redefine how math and science teachers are trained. We suggest the creation of a Federal initiative with a goal of enabling institutions across the country to increase the number and quality of science and mathematics majors obtaining teacher certification with funding dependent upon incorporation of the elements of success that we have demonstrated in the UTeach program. Providing scholarships to students attending traditional programs is insufficient to produce the type of teachers needed to lead more students to careers in math and science. It is critical that any Federal initiative serious about transforming math/science education in the United States include funding for institutions to develop teacher-training programs as innovative and effective as UTeach.

Profiles of UTeach Students and Graduates

UTeach students come from many backgrounds and bring many different strengths to support their hopes of changing lives through teaching. These students and graduates will be glad to discuss their experiences at UT Austin, in UTeach, and as future and current teachers.

Current UTeach Students:

April Lisa Olivarez: April Lisa is a senior majoring in mathematics, who is student teaching this semester. She comes from south Texas and she and her brother were the first in her immediate family to attend college. While still in high school, she took courses at UT Pan American and South Texas College, along with math and computer science AP courses. She ranked 8th out of 614 students at Mission High School and came to UT Austin in the fall of 2002. She is an officer in the UTeach student organization and also works with a youth group five times each week as a mentor.

Janice Trinidad: Janice graduated summa cum laude from Fordham University with a Bachelor of Science in Physics. She was admitted to the UTeach program for post-baccalaureates in the spring semester of 2005. She is working as a teaching assistant while conducting research and taking coursework towards teacher certification in physics and math, the UTeach Master of Arts, and a Ph.D. in theoretical physics. She is a past and current recipient of the Noyce Scholarship, funded by the National Science Foundation.

Jenna Saldaña: A sophomore mathematics major, Jenna comes from Carrizo Springs, Texas, a predominately Hispanic town close to the U.S.-Mexican border. Jenna's dedication to quality education in our schools was demonstrated early in the program when she worked as a tutor/mentor in Dove Springs, an economically distressed neighborhood. Spanish is the first language for most of the students in that area. Jenna believes that her own fluency in Spanish is an asset in her work with these children. She is working towards certification in mathematics.

Tyler Ham: Tyler is a senior majoring in mathematics. For the past 3 years, he has also been a UTeach employee, working as the program's webmaster and data analyst. He graduated from Sam Houston High School in Arlington, Texas, second in his high school class of 373 students. His strong high school performance, taking AP classes in math and physics, English, chemistry, computer science, and history, has carried over into college course work. He is pursuing certification in mathematics.

Alba Esparza: Alba is a junior majoring in mathematics at The University of Texas at Austin. Originally from El Paso, she graduated from Clint High School near the top of her class, taking AP courses in mathematics. Now in her second semester with UTeach, she is working towards the goal of becoming a middle or high school math teacher.

Meagan Vickers: Meagan graduated second in a class of 99 students at Columbus High School in Columbus, Texas, a small town between Houston and San Antonio. Currently, Meagan is a senior and student teaching towards her certification in mathematics. Meagan has received University Honors every semester she has been with UT.

UTeach graduates:

Ditrell Binkley: Ditrell graduated from The University of Texas at Austin in 2004 with a degree in mathematics. Though graduating first in his high school class of 360 students, Ditrell hit a few rough patches on the road to graduation from UT. He left UTeach for a couple of semesters, but a conversation with one of our Master Teachers brought him back into the program. Ditrell began teaching for Paredes Middle School in 2004. Beginning in 2005, while still at Paredes, Ditrell began work on a UTeach Masters in Math Education. Ditrell is dedicated to educational reform and intends to become an administrator.

Eliana Prada Owens: Eliana came to the U.S. from Venezuela in 2000. After taking courses at Austin Community College, she was accepted to The University of Texas at Austin, where she majored in mathematics. A native Spanish-speaker, Eliana was a self-motivated student, determined to excel academically. She graduated with honors in the fall of 2003. Her first teaching job was with Georgetown High School, and now she is teaching mathematics at Stony Point High School in Round Rock. Eliana has been very successful in implementing the kinds of inquiry-based learning techniques emphasized by the UTeach Program. She has been a student in the UTeach Masters in Education program at UT since the summer of 2004.

Steven Sinski: After graduating from high school in San Antonio, Steven came to The University of Texas at Austin where he earned a bachelor's degree in Biology in the fall of 2005. He is working for the UTeach program and will be searching for a teaching position in the fall.

Natalie Pickering Wieland: Originally from New Mexico, Natalie graduated in December 2005 with a Bachelor of Science in Chemistry and a perfect 4.0 GPA. She received the Noyce Scholarship, funded through the National Science Foundation, and is currently teaching at Round Rock High School.

Jesse de la Huerta: Despite the difficulties of living as an English language learner while in the public schools of south Texas, Jesse graduated from Rivera High School in Brownsville ranked 7th in a class of 296 students. Jesse earned his undergraduate degree in mathematics from The University of Texas at Austin in the fall of 2004. Currently, he teaches in Austin, Texas, at the International High School, one of the magnet schools at Johnston High School, where he says he has found his calling.

Katie Weber: Katie graduated from The University of Texas at Austin in 2004 with a Bachelor of Science in Biology. She received University Honors during each of her nine semesters as a Longhorn and was a speaker at Commencement. Currently, she's teaching at Henry Middle School in Leander, TX.

David Vance Ballard: Vance came to UTeach through an unconventional route that included a stint as a deputy sheriff. He graduated from The University of Texas at Austin in 2005 with a bachelor's degree in Biology. He is now teaching for Del Valle High School in the Austin, Texas area.

APPENDIX I—CONDITIONS FOR AWARDS

To be awarded support, a university would need to develop a plan for the improvement of teacher preparation in science and mathematics with the following elements.

- Description of current certification rate of science and mathematics teachers.
- Statement of goals for improvement with timeline describing numbers of students enrolled in program and graduating.
- Description of any existing university programs that indicate university capacity to develop teacher certification on the UTeach model.
- Identification of an organizational unit within the College of Arts and Sciences or College of Science that will adopt teacher certification as its primary mission with signed agreement from the central administration.
- Identification of core faculty in departments of science and mathematics who will champion teacher preparation in their departments by teaching courses dedicated to preparing future teachers, help create new degree plans, advise prospective students within their major, and assist as needed with program administration.*

- Identification of core faculty in the College of Education who will champion teacher preparation in their departments by creating and teaching courses specific to the preparation of secondary science, mathematics, and computer science teachers and working closely with colleagues in Colleges of Arts and Sciences.*
- Description of the process to be used in locating classrooms for field experiences. Supporting letters from school officials able to coordinate relations between university and school districts required.
- Description of courses to be created over the funding period, focusing on courses involving practical experience in teaching. These must involve early field experience.
- Description of degree plans existing or to be created enabling students to graduate in 4 years with a major in science, mathematics, or computer science and secondary teaching certification. Programs must make possible graduation in 4 years with certification. Post-baccalaureate programs may also be included.
- Description of schedule for hiring Master Teachers to supervise field experiences. Programs must involve former secondary teachers employed full time at the university.
- Description of other program elements, such as teaching portfolio, student support, opportunities for community service, student organization.
- Supporting letters from the Deans of Science and Education and the President or Provost of the university are required. These letters must describe the internal university resources that will be made available as the project proceeds. These include:

  —Identification of space to house the new unit
  —Identification of administrative support as program grows, including administrative assistants and advisors
  —Identification of faculty and instructional lines to be committed
  —Commitment to make fundraising from private sources for the improvement of teacher preparation in science and mathematics a high priority at the university.

APPENDIX II—ENRICHMENT ACTIVITIES FOR STUDENTS WITH POOR PREPARATION FOR ADVANCED MATHEMATICS OR SCIENCE AT UT AUSTIN: THE EMERGING SCHOLARS PROGRAM AND THE TEXAS INTERDISCIPLINARY PLAN

When math-challenged Calculus students are accepted into the Emerging Scholars Program they feel special and proud. Other students respect, even envy them. They do extra and harder problems than the other students rather than easier and fewer, but they do them in teams with expert guidance from specially trained teaching assistants. Emerging Scholars register for an extra course in addition to the regular Calculus class. The extra class (which meets for six hours a week) is run by two teaching assistants who devise hard but practical problems for them and help the students learn how to work them. We have a great deal of data on this program because we have run it for nearly fifteen years. When they emerge from this program, ESP students are fully competitive with the other students. They move from getting D's and F's on their Calculus tests to A's and B's (see figure 1 below). An added benefit is that the numbers of minority math majors has risen steadily, because many of our ESP students have gone on to major in math! Without the Emerging Scholars Program many would not even have passed Calculus. Graduation rates are substantially higher among ESP students relative to other College of Natural Sciences students (see figure 2 below) even though this is only one course in their program. The increase in self confidence achieved with ESP has a profound impact. A similar approach works in other subjects such as Chemistry, but with modification of the enrichment material.

* Letters from each faculty member, describing their interest and commitment to teacher preparation are required.

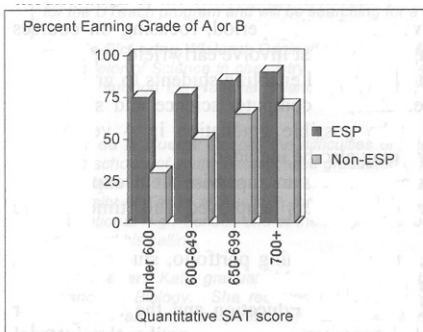


Figure 1: Academic performance of Emerging Scholars students (dark bars) at various levels of preparation as measured by entering math SAT scores, compared to non-ESP students in the same calculus courses (light bars).

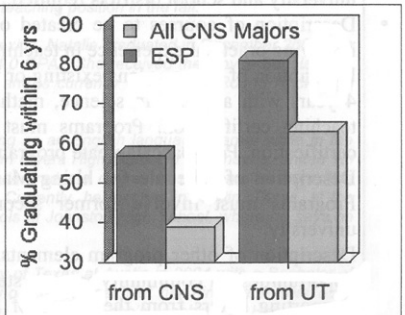


Figure 2: Graduation Rates of Emerging Scholar's Students from the College of Natural Sciences (CNS) or the University of Texas at Austin (UT) compared to the general student population in the College of Natural Sciences

The Texas Interdisciplinary Plan (TIP) is a broader enrichment program based upon the principles of success demonstrated by the Emerging Scholars Program. Like ESP, TIP has been developed to assist students who are likely to be at-risk in their transition to the University of Texas at Austin.[6] TIP uses many of the same techniques as ESP, particularly the extra enrichment in small groups and cohort study teams. The average TIP class size is 50 or less instead of the College average of 100, and classes are taught by instructors especially selected for their outstanding teaching record. Each basic science course has one to two hours of supplemental instruction each week in addition to a TIP seminar (see below) with a format that is similar in structure to the Emerging Scholars model. Students are personally assisted by upper class peer mentors.

Peer mentors are trained in time management, group dynamics, campus resources and services, and how to successfully assist students in their coursework. They offer academic and social guidance and support to TIP students. Selected for excellent academic performance, major, and leadership experience, peer mentors are upper division students who have themselves shown great capacity to overcome obstacles and succeed in our rigorous undergraduate curriculum. They work as academic tutors and assistants to TIP instructors and provide an introduction to UT social life through activities such as a bowling tournament in the Student Union, a tour of library services and resources, and a picnic lunch on one of the malls. Peer mentors are asked to reflect on their experiences and to continue their own training at weekly meetings with their supervisor. They play a critical role in the success of each of their TIP students.

In addition to their regular classes, TIP students attend a three-hour seminar/workshop each week at which students are coached in strategies for achievement in their course work, good study habits, and answers to specific questions. The TIP program coordinator in the Dean's Office also organizes special events as a part of this seminar to introduce TIP students to scientists at UT and in the broader community. This immediate link of the student experience to potential future career development is important. Researchers, physicians, medical school administrators and graduate students are among the speakers. Like the additional problems sessions that Emerging Scholars students take, the TIP seminar course is at the heart of the program. It is the innovative academic venue where core course issues of immediate concern to PENS students can be aired and addressed.

In the fall of 2004 we added a TIP signature course for freshman: a *Critical Thinking Seminar* that challenges students to examine their own thinking from the

[6] TIP was created to serve a new population of students automatically admitted to The University under the top 10 percent rule. This statute, House Bill 588 passed in the 75th legislature, grants automatic admittance to all high school graduates in the top 10 percent of their graduating class to any Texas public college or university. TIP participants are drawn from this pool of students and further selected for their persistence in overcoming the challenges of low socioeconomic background. The invitation is specifically worded to emphasize the rigor and special opportunities of TIP, such that students regarded it as an honor to be invited to join. Nearly all TIP students were in the top 10 percent of their graduating class, close to half are among the first in their families to attend college, many are female, and more than 60 percent are of an underrepresented ethnic minority.

perspective of rigorous intellectual standards. The seminars are kept small (approximately twenty students) to ensure a high level of student-to-student interaction. The curriculum includes two innovative student projects, including a Nobel Prize term-project and peer presentations on current issues and events.

The results of the 1999 pilot program were extremely good. TIP students had an average freshman GPA of 2.94, compared to 2.6 in the control group. They also had many fewer students on academic probation (6 percent compared to 23 percent). It is important to emphasize that these students took classes that were just as hard as the larger sections. In some cases, they took exactly the same exams, but they had extra attention and tutoring, extra work, and smaller classes. They scored better *despite having an SAT a full 200 points below the college average.* Success was achieved despite taking a *more rigorous curriculum* (three math and science course instead of the more common two) than the typical incoming CNS student. More recent results from academic year 2004–05 are summarized below.

TIP freshmen are academically more successful during their first semester at UT. This trend has been consistent over the past several years.

Fall Grade Point Average	TIP	Control
Life Science	3.01	2.53
Computer Science	2.81	2.43

TIP freshmen are four times less likely to be on academic probation, independent of their gender, race or first generation status.

% on Probation Spring 2005	TIP	Control
Life Science	5%	19%
Computer Science	0%	26%

TIP students are almost twice as likely to graduate from the College of Natural Sciences as non-TIP students. Twenty-nine of the original 1999 cohort (N=46) have graduated from UT Austin with an average GPA of 2.91. Of these students, 72% graduated in the College of Natural Sciences while only 42% of control students graduated in the College.

The TIP model provides some important lessons with respect to developing a successful UTeach program at universities and colleges where the student population is less well-prepared than students at UT Austin. We expect that an enrichment program with focus on mentoring, application of coursework to workplace settings (this is a natural consequence of the field experience that is a part of many of the UTeach pedagogy courses), small class size and enrichment activities will be necessary and effective in producing teachers who are extremely well-prepared in their discipline.

Senator ENSIGN. Thank you, Dr. Rankin. It is great to hear some of the things that you're doing down at the University of Texas at Austin.

Our next witness will be Mr. Paul Dugan, Superintendent of Washoe County School District. He is new in his position. I had a great meeting with Mr. Dugan in Reno, and I am very excited to hear about what you are doing in Reno, Nevada, Washoe County School District.

STATEMENT OF PAUL DUGAN, SUPERINTENDENT, WASHOE COUNTY SCHOOL DISTRICT

Mr. DUGAN. Good morning. As you mentioned, my name is Paul Dugan, and I'm the superintendent for Washoe County School District. Our school district serves the Reno/Sparks area of northern Nevada and has an enrollment of approximately 62,000 students,

with a 42-percent minority population, of which 30 percent are Hispanic/Latino. I have been fortunate to be a part of this school district for the past 23 years, serving as a teacher, counselor, school administrator, and, most recently, completing my second year as superintendent. It certainly is a pleasure and an honor to be here today.

In December of 2004, our board of trustees took what we considered a bold step and enacted a policy we call the Gateway Curriculum. This new policy requires that, effective with the entering freshman class of 2006, all students will be automatically enrolled in 4 years of math, 3 years of science, and will be scheduled for a full courseload of six subjects their senior year. Currently, students are only required to take 3 years of math, 2 years of science, and four courses their senior year.

The school board took this step for five compelling reasons:

First, research has shown, particularly the work of the Education Trust, that to have any chance of success in the world of work or in post-secondary education, high school students must regularly engage in rigorous and intellectually challenging work. We believe that high school should not be a gatekeeper sorting students into unequal paths, but, rather, it should serve to well prepare all students for wherever their chosen career paths lead. High schools should be a gateway to success for all.

Second, the achievement gap for high-poverty and minority students must close. Traditionally, and sadly, these students are too often placed in our least challenging classes; and, thus, may face economic lifetimes of minimum wage earnings. Requiring a rigorous curriculum for all students will have the potentially greatest impact on our poor and minority students.

Third, the Gateway Curriculum is not a wholesale attempt to send all students to 4-year universities; however, we firmly believe that all students must be prepared for, and have access to, some form of post-secondary education, be it vocational training, military experience, trade school, community college, or university studies. A high school education is not enough anymore if our students are to compete locally, nationally, and globally.

Fourth, too many of our graduates are required to take remedial-level college coursework because they have not been properly prepared for post-secondary studies. Our own research clearly demonstrates that completing a fourth year of math in high school, including second-year algebra, eliminates this need for remediation.

I need to emphasize that this fourth year of math need not be the traditional trigonometry or calculus. A variety of rigorous fourth-year courses, including math related to the skilled trades or the business world, are currently under development.

Finally, thanks to the American Diploma Project, it is now well documented that the demands of the workplace and the requirements for post-secondary education have converged. The paradigm has shifted. All students need both post-secondary education and a job. It is not an either/or situation. All students need first- and second-year algebra, geometry, statistics, data skills, and science. All students need strong oral and written communications skills, as well as analytical thinking and research capabilities. All students will clearly benefit from additional math and science courses.

As the Washoe County School District prepares its first group of students to take part in this new curriculum, it will be critical that both thoughtful course development and well-designed student support be adequately addressed.

Furthermore, we understand very well that this is not merely a high school policy, but, rather, a K–12 policy that demands that those teaching at the elementary and middle school levels do all that is necessary to prepare their students for these new curriculum challenges. If we adequately address these issues, along with meaningful teacher professional development and parental support, we will have come a long way in ensuring success for our students, our school district, and the community we serve.

Thank you very much.

[The prepared statement of Mr. Dugan follows:]

PREPARED STATEMENT OF PAUL DUGAN, SUPERINTENDENT, WASHOE COUNTY SCHOOL DISTRICT

Good morning—My name is Paul Dugan and I am the Superintendent of the Washoe County School District. Our school district, serving the Reno/Sparks area of Northern Nevada, has an enrollment of approximately 62,000 students with a 42 percent minority population, of which 30 percent are Hispanic. I have been fortunate to be a part of this school district for the past 23 years serving as a teacher, counselor, and school administrator, and most recently, I am completing my second year as Superintendent. It certainly is a pleasure and an honor to be here today.

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The School Board took this step for several compelling reasons:

1. Research has shown—particularly the work of the Education Trust—that to have any chance of success in the world of work or in post-secondary education, high school students must regularly engage in rigorous and intellectually challenging work. We believe that high school should not be a "gatekeeper," sorting students into unequal paths, but rather, it should serve to well prepare all students for wherever their chosen career paths lead. High school should be a Gateway to success for all.

2. Secondly, the achievement gap for high poverty and minority students must close. Traditionally—and sadly—these students are too often placed in our least challenging classes and thus may face economic lifetimes of minimum wage earnings. Requiring a rigorous curriculum for all students will have the potentially greatest impact on our poor and minority students.

3. The Gateway Curriculum is not a wholesale attempt to send all students to four-year universities. However, we firmly believe that ALL students must be prepared for and access some form of post-secondary education, be it vocational training, military experience, trade school, community college, or university studies. A high school education is not enough any more, if our students are to compete locally, nationally, and internationally.

4. Too many of our graduates are required to take remedial level college coursework because they have not been properly prepared for post-secondary studies. Our own research clearly demonstrates that completing a fourth year of math in high school, including second-year algebra, eliminates the need for this remediation. I need to emphasize that this fourth year of math need not be the traditional trigonometry or calculus. A variety of rigorous, fourth-year courses, including math related to the skilled trades or the business world, are currently under development.

5. Finally, thanks to the American Diploma Project, it is now well documented that the demands of the workplace and the requirements for post-secondary education have converged. The paradigm has shifted. All students need both post-secondary education *and* a job. It is not an either-or situation. All students need first and second year algebra, geometry, statistics, and data skills. All stu-

dents need strong oral and written communication skills, as well as analytical thinking and research capabilities. All students will clearly benefit from additional math and science courses.

As the Washoe County School District prepares its first group of students to take part in this new curriculum, it will be critical that both thoughtful course development and well-designed student support be adequately addressed. Furthermore, we understand very well that this is not merely a high school policy, but rather a K–12 policy that demands that those teaching at the elementary and middle school levels do all that is necessary to prepare the students for these new curriculum challenges. If we adequately address these issues, along with meaningful teacher professional development and parental support, we will have come a long way in ensuring success for our students, our school district, and the community we serve. Thank you.

Senator ENSIGN. Thank you.

Our next witness will be Thomas McCausland.

Mr. McCausland is the President and CEO of Siemens Medical Solutions USA. He will be discussing what Siemens has done in the private sector to help address this ever-growing problem.

STATEMENT OF THOMAS N. MCCAUSLAND, PRESIDENT/CEO, SIEMENS MEDICAL SOLUTIONS

Mr. MCCAUSLAND. Thank you, Mr. Chairman, and good morning. Thank you for inviting me today and giving Siemens the opportunity to discuss our perspectives on the role of math and science education in innovation and maintaining U.S. competitiveness.

My name is Tom McCausland, and I am the chairman of the Siemens Foundation, as well as the president and CEO of Siemens Medical Solutions, headquartered in Malvern, Pennsylvania.

As one of the world's leading engineering and technology companies, Siemens has long recognized the importance that innovation plays in staying competitive in the global economy. We invest heavily in innovation by dedicating $900 million a year to research and development here in the United States alone, where we have closer to 7,000 employees working specifically in this field. Globally, Siemens spends $6.0 billion a year, with 70,000 employees in R&D filing close to 26 patents per day. In our business, the velocity of innovation is so fast that 75 percent of our products marketed today have been developed just in the last 5 years.

Innovation and growth are not possible without highly qualified and educated scientists, mathematicians, and engineers. It is absolutely imperative that we do everything that we can to keep up with the growing global demand for these minds if the United States is to remain in the competitive edge in the global arena.

Siemens applauds the efforts of the Senate—of Senator Ensign and others in the Committee for their efforts in focusing Congressional attention on the potential harm of the U.S. innovation deficit caused by a lack of commitment to long-term research and development and math, science, and technology education excellence. By raising the bar through programs like the National Innovation Act and the American Competitiveness Institute, we feel that we can achieve the goals of enrolling more students in master's programs and graduate research fellowships, and produce the 10,000 more scientists, students, post-doctoral fellows, and technicians, in addition to the 100,000 highly qualified math and science teachers that we need by 2015.

While government is obviously the primary force moving us forward, we at Siemens, as well as our colleagues at other corporations in the private sector, are also working to challenge and motivate the next generation of engineers and scientists. In fact, 15 national business organizations led by the Business Roundtable, have joined together in a coalition to support action on this issue at all levels of government—Federal, State, and local—as well as by the private sector, including parents, educators, and community leaders. The coalition, called Tapping America's Potential, has set a goal of doubling the number of bachelor's degrees awarded annually to U.S. students in science, technology, engineering, and math.

To give you some examples of what we, at Siemens are doing, we recently created Siemens Science Days, a program designed to spark an interest in math, science, and engineering among fourth- and fifth-graders. We are doing this by using our 70,000 employees located in all 50 States to go out to the schools in their communities and to show students the exciting opportunities in these fields through real-world examples and through hands-on activities.

Since the inception of this program just over a year ago, we have reached close to 5,000 students in 13 States. However, we cannot expect students to become scientists and engineers if we do not keep encouraging them and challenging them throughout their schooling. That is why we also reward students who pursue studies and excel in these fields by awarding scholarships through our Siemens Awards for Advanced Placement and the Siemens Competition in Math, Science, and Technology.

The Siemens Awards for Advanced Placement recognize the top male and female student from each state who has scored the highest in their math and science advanced placement exams by presenting them with a $2,000 college scholarship, and, in addition to the top national male and female winner, who receives a $5,000 scholarship, we also recognize one teacher and one school from each state with a $1,000 award for their math and science programs.

The Siemens Competition in Math, Science, and Technology is the Nation's premier science and math research competition for high school students where we award $750,000 in scholarships annually to students and the top student and team each wins a college scholarship of $100,000. In this endeavor, we partner with the college board and seven premier universities, of which the University of Texas is one.

While these are truly incredible students, their achievements would not be possible without the dedication and mentoring provided by their teachers and schools. So, to ensure that we continue to have excellent teachers, we not only award grants to teachers and schools through the Siemens Awards for Advanced Placement, but also through the Siemens Competition, where we recognize schools with a $2,000 award for each project from the school that makes it to the regional finalist level.

We are proud of the teachers we have now. However, we also want to make sure that we continue to have excellent teachers in the future. That is why, just in this past year, we partnered with the United Negro College Fund and the Thurgood Marshall Schol-

arship Fund to award scholarships to students studying at the Nation's historically black colleges and universities who are training to become teachers in math and science.

Since we launched all of our programs, we have awarded 512 scholarships through the Siemens Competition, 250 scholarships to students, as well as 180 awards to teachers and 129 to schools, through the Siemens Awards for Advanced Placement, and 40 scholarships through the Siemens Teacher Scholarships.

But we are not the only ones to place a high priority on education initiatives. As a founding member of the Business Education Network, which is an affiliate of the U.S. Chamber of Commerce, we are working closely with colleagues at other leading companies from across the Nation to make sure that we, as businesses, are doing our part to foster and challenge tomorrow's innovators.

We are encouraged that the Committee is exploring the education issues necessary to keeping America at the innovation forefront. As you consider the Committee's program and begin to address the educational problems of this country, we would like to take the opportunity to offer you the assistance of Siemens. We look forward to working with Congress and the Administration to help identify ways to work more collaboratively in helping to prepare today's students to become tomorrow's innovators.

Thank you, again, for allowing me to testify.

[The prepared statement of Mr. McCausland follows:]

PREPARED STATEMENT OF THOMAS MCCAUSLAND, PRESIDENT/CEO, SIEMENS MEDICAL SOLUTIONS

Mr. Chairman, Ranking Member and other Members of the Committee, good morning. Thank you for inviting me today and for giving Siemens the opportunity to discuss our perspectives on the role of math and science education to innovation and maintaining U.S. competitiveness. My name is Thomas McCausland, and I am the chairman of the Siemens Foundation as well as the President and CEO of Siemens Medical Solutions headquartered in Malvern, PA. Mr. Chairman, with your permission, I would like to insert my written statement in the hearing record, and I will provide a brief summary.

As one of the world's leading engineering and technology companies, Siemens has long recognized the importance that innovation plays in staying competitive in the global economy. Siemens invests heavily in innovation by dedicating $900 million dollars a year to research and development here in the United States alone, where we have close to 7,000 employees working specifically in this field. Globally, Siemens spends $5.2 billion a year with 70,000 employees in R&D, filing close to 26 patents per day.

So, as you can see, making sure that we have enough highly skilled and qualified scientists, mathematicians, and engineers is a priority for us. Because without them, we will not be able to make advancements on the technologies that we have today. Just how important is it to have enough scientists, mathematicians, and engineers? Seventy-five percent of Siemens products have been developed over the last five years.

Innovation and growth are not possible without highly qualified and educated scientists, mathematicians and engineers. And it is absolutely imperative that we do everything that we can to keep up with the growing global demand for these minds if the United States is to maintain its competitive edge on the global arena.

Siemens applauds the efforts of Senator Ensign and others on the Committee for their efforts in focusing Congressional attention on the potential harm of a U.S. innovation deficit caused by a lack of commitment to long-term research and development and math, science and technology education excellence. By raising the bar through programs like the National Innovation Act and the American Competitiveness Initiative, we feel that we can achieve the goals of enrolling more students in master's programs and graduate research fellowships, and produce the 10,000 more scientists, students, post-doctoral fellows and technicians in addition to 100,000 highly qualified math and science teachers that we need by 2015. While Govern-

ment is obviously the primary force moving us forward, we at Siemens and as well as our colleagues at other corporations in the private sector are also working to challenge and motivate the next generation of engineers and scientists. In fact, fifteen national business organizations, led by the Business Roundtable, have joined together in a coalition to support action on this issue at all levels of government: Federal, State and local, as well as by the private sector, including parents, educators and community leaders. The coalition called: Tapping Americas Potential, has set a goal of doubling the number of Bachelors degrees awarded annually to U.S. students in Science, Technology, Engineering and Math.

To give you some examples of what we at Siemens are doing, we recently created Siemens Science Days—a program designed to spark an interest in math, science and engineering among 4th and 5th graders. We are doing this by using our 70,000 employees located in all 50 states, to go out to the schools in their communities to show students the exciting opportunities in these fields through real world examples and through hands-on activities. Since the inception of this program just over a year ago, we have reached close to 5000 students in 13 states.

However, we cannot expect students to become scientists and engineers if we do not keep encouraging them and challenging them throughout their schooling. That is why we also reward students who pursue studies and excel in these fields by awarding scholarships through our Siemens Awards for Advanced Placement and the Siemens Competition in Math, Science and Technology.

The Siemens Awards for Advanced Placement recognize the top male and female student from each state who has scored the highest in their math and science Advanced Placement exams, by presenting them with a $2,000 college scholarship, in addition to a top national male and female winner, who receives a $5,000 scholarship. We also recognize one teacher and one school from each state with a $1,000 award for their math and science programs.

The Siemens Competition in Math, Science, and Technology is the Nation's premier science and math research competition for high school students, where we award approximately $750,000 in scholarships annually to students and the top student and team each wins a college scholarship of $100,000. To give you an idea of just what it takes to win the Siemens Competition, the most recent winner, Michael Viscardi, solved the 19th century Dirichlet problem, which can be used to calculate the amount of heat at any point across the surface of an object. The previous year's winner, Aaron Goldin, invented a gyroscopic generator that uses the movement of ocean currents to generate electricity.

While these are truly incredible students, their achievements would not be possible without the dedication and mentoring provided by their teachers and schools. So to ensure that we continue to have excellent teachers, we not only award grants to teachers and schools through the Siemens Awards for Advanced Placement, but also through the Siemens Competition, where we recognize schools with a $2,000 award for each project from their school that makes it to the regional finalist level.

We are proud of the teachers we have now; however, we also want to make sure that we continue to have excellent teachers in the future. That is why just this past year, we partnered with the United Negro College Fund and the Thurgood Marshal Scholarship Fund to award scholarships to students studying at the Nation's historically black colleges and universities who are training to become teachers in math and science.

Since we launched our programs, we have awarded 512 scholarships through the Siemens Competition; 250 scholarships to students, as well as 180 awards to teachers and 129 to schools through the Siemens Awards for Advanced Placement; and 40 scholarships through the Siemens Teacher Scholarships.

But we are not the only ones who place a high priority on education initiatives. As a founding member of the Business Education Network, which is an affiliate of the U.S. Chamber of Commerce, we are working closely with colleagues at other leading companies from across the Nation to make sure that we as businesses are doing our part to foster and challenge tomorrow's innovators. Additionally, we are also on the board at the Business Roundtable, which is committed to advocating public policies that ensure vigorous economic growth, a dynamic global economy, and the well-trained and productive U.S. workforce essential for future competitiveness.

So why are we so focused on making sure that we have enough highly skilled and qualified scientists and engineers in the coming generations? The innovations that these brilliant young people create are the lifeblood of Siemens and the millions of Americans we serve.

For instance at the moment, Siemens radiation therapy systems treat 30,000 cancer patients every day; our lighting and control systems operate at 65 of the nations 100 busiest airports, to ensure that air travel continues safely and efficiently; our

power generation equipment produces one third of the Nation's electricity; our water filtration plants filter enough clean drinking water to fill 750,000 bottles; and our building automation, fire safety and security solutions in over 35,000 North American facilities help ensure that we live and work in safe and energy efficient buildings.

If we do not have the next generation of scientists, mathematicians or engineers, then who is going to develop the next life saving cancer therapy equipment? Or ensure that we can meet the growing demand for energy in this country with the most efficient and environmentally friendly technology? Or provide enough clean drinking water for our families? Or develop more advanced building technologies to give us the peace of mind that we are living and working in the safest buildings?

As Benjamin Franklin pointed out, "investment in knowledge pays the best interest", and we need to make sure that we are investing heavily in our students. They are the future of our Nation, and the better we prepare them today, the more our Nation will advance tomorrow.

We are encouraged that the Committee is exploring the education issues necessary to keeping America at the innovation forefront. As you consider the Committee's program and begin to address the educational problems of this country, we would like to take the opportunity to offer you the assistance of Siemens. We look forward to working with Congress and the Administration to help identify ways to work more collaboratively in helping to prepare today's students to become tomorrow's inventors.

Thank you again for allowing me to testify. I look forward to answering any questions that you might have.

Senator ENSIGN. Thank you.

Finally, we will hear from Dr.—and this is a challenging name, but we're going to give it a shot——

Dr. MIAOULIS. Miaoulis.

Senator ENSIGN.—Ioannis Miaoulis? Is that it?

Dr. MIAOULIS. That's right.

Senator ENSIGN. Very good. Dr. Miaoulis is the President and Director of the Museum of Science in Boston. He will discuss what museums and other public nonprofits are doing in the fields of science, technology, engineering, and math.

STATEMENT OF DR. IOANNIS MIAOULIS, PRESIDENT, MUSEUM OF SCIENCE; DIRECTOR, NATIONAL CENTER FOR TECHNOLOGICAL LITERACY

Dr. MIAOULIS. Thank you, Mr. Chairman. Thank you for the opportunity and your enthusiasm and support for education.

My involvement with the K–12 science education started in the mid-80s. I was a professor at Tufts University in Massachusetts, and later on became Dean of the School of Engineering. Actually, Senator Sununu's father was one of my colleagues at Tufts, in the Mechanical Engineering Department.

I was quite involved with schools, in K–12 schools, working on the science curriculum. In the early 1990s, I realized that what we cover in science does not cover what we intend to cover in science. In science, we try to prepare—we teach science, because we want the children to understand the world around them. However, most of the items and processes we use every day are man-made, they are not natural. Just try to imagine how this meeting would look like with nothing man-made. And if you look at the curriculum, it focuses about 98 percent on things like rocks and animals and the human body and chemical reactions, and it does not cover things like how cars work or how the phone works. We spend about a month during the kids' schooling teaching them how volcanoes

work, and no time teaching them how a car works. How often do you find yourself in a volcano, compared to a car? You know?

[Laughter.]

Dr. MIAOULIS. Why is it so important that we only teach about the natural world and not about everything else we deal with? I think we should have a balanced curriculum, teach about volcanoes and flowers, but also teach about how buildings work, how pens work, how technology works. Technology is not just computers and VCRs and PDAs.

So, fueled with this passion to introduce engineering into schools, and also armed with a couple of other good arguments: first, that engineering makes math and science relevant, because kids see how you can use math and science to solve real problems, and also opens career opportunities to children that, frankly, do not know what engineers do. Most people in the United States do not know what engineers do. They think that engineers drive trains and repair VCRs. When the Space Shuttle—when the Space Shuttle goes up, everybody calls it a science miracle. When something goes wrong, they call it an engineering error.

[Laughter.]

Dr. MIAOULIS. By the way, there isn't such a thing as a "rocket scientist." They are called "aerospace engineers."

[Laughter.]

Dr. MIAOULIS. So, fueled with all these arguments, in 1998 we started the process in Massachusetts to introduce engineering as part of the formal curriculum into schools. And in the year 2001, Massachusetts became the first state in the country to have engineering as part of the K–12 curriculum and test it. As you know, if it's not tested, unfortunately, it's not taught.

When the museum approached me to ask me if I'm interested in joining it, I saw that as a tremendous opportunity to start a national effort to introduce engineering as part of the curriculum in every school in every state. So, I joined the museum in 2003, and in 2004 we started the National Center for Technological Literacy, and we have goals that are very simple to articulate and probably challenging to achieve. We want, by year 2015, to have engineering in every single school in every single state, from K through 12, and, by 2015, to have at least one cultural institution in every state that champions technological literacy for all citizens.

Now, what do we do to accomplish that? In the National Center we do three things. First, we provide advocacy and support. Part of what I'm doing today is the advocacy part. I have visited more than two-thirds of the states to talk with key education folks in trying to convince them to introduce engineering as part of their regular curriculum. Once a state agrees that this is an important thing, then we have a team of experts that go into that state and help them develop standards. We're currently working with 25 states, and we would love to work with Nevada. That's not one of the 25 states. I hope you can help us do that.

The second thing we do is curriculum. We have identified and purchased and put online information about all the curricula we could find worldwide in engineering and technology education, and we have correlated them with International Technology Education Association (ITEA) standards. So, a teacher can go online for free

and find out what's available for engineering and technology for a particular grade level. We get about 2,000 teachers using our website every week.

Also, we identified gaps in the curriculum. In the elementary school level, there is very little in engineering education. And their teachers spend most of the time teaching kids how to read. Instead of fighting that, we work with the teachers. We have a series of books that are now used by thousands of children, and they are storybooks. Each book features a child from a different part of the world that talks about her community and a challenge the community faced, and how an engineer solved the problem. And kids get to do engineering activities as they learn how to read, and they learn about world culture.

Also, we have a high school curriculum that's now being taught in about a quarter of the schools in Massachusetts and in several other states. In our text book there is the story of 32 engineers that do things that high-schoolers found very cool and very interesting. Although it sounds like a storybook, the material covers 100 percent of the technology and engineering standards and 80 percent of the physics standards of Massachusetts.

The third thing we do is professional development through workshops with teachers and administrators to help them integrate engineering into the curriculum. Typically we form partnerships with institutions throughout the United States, because we cannot physically be present in every single state, running workshops.

So, these are the three things we do in regard to technological literacy. And now, I want to read to you some policy recommendations. Please consider the following as you craft innovation legislation:

Include engineering and technology teachers alongside math and science teachers in any and all incentive programs enacted to recruit, train, mentor, retain, and further educate teachers. These teachers should teach the engineering and innovation process. Many people remember technology education as "shop class." Well, I'm afraid it will remain "shop class" if these teachers are not provided with continuing educational opportunities to bring their skills up to 21st-century expectations.

Be sure to define "engineering and technology education" to include the engineering design process. Senator Kennedy's new National Defense Education Act has a fine definition and has included technology teachers, as well as math and science teachers, in the various teacher programs.

As you define "rigorous curricula," consider requiring that each student take at least one engineering or technology course for graduation. The problem-solving skills taught in engineering will benefit all students, even if they do not pursue a technical career.

Also, remember that museums are excellent providers of teacher professional development, a resource that is likely underutilized in many communities. Be sure they are eligible participants in these initiatives.

Science assessments will soon be required by No Child Left Behind. First, work to ensure that they mirror the newly adopted NAEP Science 2009 Framework, which includes technological design as a required skill set. Second, require some measure of

progress, as with the adequate yearly progress for reading and math. If there is no—if there are no repercussions, States will not likely invest much in their success.

And, finally, if we're truly concerned about innovation and global competition, it is time for a major commitment and investment in technological literacy. The National Center for Technological Literacy at the Museum of Science is perfectly positioned to serve the Nation in this capacity. We work with other science and technology centers and State departments of education to upgrade their engineering and technology standards, assessments, curricula, teacher preparation and certification programs. If we can be of any service in any State—in your State, Mr. Chairman—please let us know.

I'll be happy to answer any questions.

[The prepared statement of Dr. Miaoulis follows:]

PREPARED STATEMENT OF DR. IOANNIS MIAOULIS, PRESIDENT, MUSEUM OF SCIENCE; DIRECTOR, NATIONAL CENTER FOR TECHNOLOGICAL LITERACY

Good morning and thank you, Mr. Chairman, and Members of the Subcommittee. I will not take your time reiterating the well-documented educational problems facing this country. Mr. Chairman, and Members of the Subcommittee, it is clear you recognize the challenges with the introduction of your National Innovation Act. I am most grateful for the opportunity to share with you an exciting education innovation spreading across the Nation. I will offer some policy suggestions at the conclusion of my time.

History

Massachusetts was the first in the Nation to incorporate engineering into its state K–12 frameworks or standards. I am proud to have been a part of that process while serving as Dean of Engineering at Tufts University. These state standards were modeled after the International Technology Education Association standards. The state then rightly moved to include engineering in the state assessments—because we know if it isn't tested, sadly, it isn't taught.

Rationale

I understand the concern for math and science education but I am worried that K–12 technology and engineering education is overlooked. The reason may be that the existing curriculum was adopted over 100 years ago when technology was not as pervasive. Our science curriculum focuses on the natural world but rarely the human-made world—the things students interact with everyday.

The beauty of engineering is that it is the connector. It is the application of math and science that provides relevance to students. This answers the perennial question, "Why do I have to learn algebra?"

Definitions

Many people are unclear about the definitions of science, engineering and technology education. Science is the study of and inquiry into the natural world. Engineering is designing under constraints, which impacts both the natural and the human-made world. New technologies are the result of the engineering process.

Many people confuse educational technologies (or IT gadgets) in the classroom with technology education, the study of innovation and design. That is why I prefer to stick with the term, "engineering education;" there is no room for confusion.

National Center for Technological Literacy

To promote engineering in K–12 classrooms across the nation, the Museum formed the National Center for Technological Literacy.

Educator Resource Center

Our first mission was to find resources for teachers to use. We created an online Educator Resource Center, like Amazon, that contains only engineering and technology curricula (the way we define and understand it). Frankly, we found very little at the elementary level, some fair middle school curricula, and some very expensive high school programs.

Engineering is Elementary

To fill the void, we are developing the "*Engineering is Elementary*" curriculum that meets the national and state standards. With some corporate seed money and a generous grant from the National Science Foundation, we are developing a series of 20 engineering units for children in grades K–5. These units are aligned with popular science topics and are heavily weighted in literacy and social studies so it is very easy for teachers to integrate them into their lessons.

After publishing just 7 units, we have been overwhelmed with the interest we have received from across the nation. We partner with other science centers, universities, school districts, and others around the country to provide the teacher professional development and help disseminate this exciting curriculum. In fact, these units, which are thoroughly pilot and field-tested, are currently being reviewed by NASA for their Explorer Schools program.

Results

Not only are the kids having fun while learning, and the teachers are raving about the units, we have the data to show that we are busting some unfortunate myths children (and teachers) have about engineers and technology. Most children and teachers think that technology is an electrical device of some sort. They think engineers mostly work in construction or with electricity. These are fields that typically do not attract women or minorities. They don't understand that this pen, these windows and water bottles, are forms of technology, designed by engineers. They have no idea of the vast array of careers that are available to them in the wide range of fields of engineering that our innovation economy needs.

Engineering the Future

We are also field-testing a full-year high school course, "*Engineering the Future,*" for students in grade 9 or 10 in which students apply math and physics to solve real-world problems. Similar to the elementary curricular results, initial findings show an increase from 45% to 79% in understanding that examples of technology include not only electronic devices but also devices that satisfy human needs.

Outreach

We have been invited to help, in one way or another, in 25 states. Whether it is serving as a keynote speaker, providing advice on standards revision, offering teacher professional development workshops, or providing curricula, the interest in K–12 engineering education is growing.

Why Us?

We are not your typical curriculum developers. We are not text book publishers. The Museum is a nonprofit science and technology center. Our Board of Directors, representatives of national and multi-national companies, believe this is a national imperative. They support the mission of the National Center for Technological Literacy to enhance technological know-how by introducing engineering as a new discipline in K–12 schools and to present technology as equal to science in the informal education setting.

We hope you agree.

Policy Recommendations

Please consider the following as you craft innovation legislation:

- Include engineering/technology teachers alongside math and science teachers in any and all incentive programs enacted to recruit, train, mentor, retain and further educate teachers. These teachers should teach the engineering and innovation process. Many people remember technology education as "shop class." Well, I am afraid it will remain shop class, if these teachers are not provided with continuing educational opportunities to bring their skills up to 21st century expectations.
- Be sure to define "engineering/technology education" to include the engineering design process. Senator Kennedy's New National Defense Education Act has a fine definition and has included technology teachers as well as math and science teachers in the various teacher programs.
- As you define "rigorous curricula," consider requiring that each student take at least one engineering/technology course for graduation. The problem-solving skills taught in engineering will benefit all students, even if they do not pursue a technical career.
- Remember, museums are excellent providers of teacher professional development, a resource that is likely under-utilized in many communities. Be sure they are eligible participants.

- Science assessments will soon be required by No Child Left Behind. First, work to ensure that they mirror the newly adopted NAEP Science 2009 Framework which includes "Technological Design" as a required skill set. Second, require some measure of progress as with the aolequate yearly progress for reading and math. If there are no repercussions, states will not likely invest much in their success.
- Finally, if we are truly concerned about innovation and global competition, it is time for a major commitment and investment in technological literacy. The National Center for Technological Literacy is perfectly positioned to serve the Nation in this capacity. We work with other science and technology centers and state departments of education to upgrade their engineering/technology standards, assessments, curricula, teacher preparation and certification programs. If we can be of service in your state, please let me know.

I am happy to answer any questions you may have.

Senator ENSIGN. Thank you.

I want to thank the entire panel. You know, obviously we have a full range of people involved in the education of our children, and that is one of the reasons we set the panel up this way, so that we could hear about some great things that are happening out there in America. And a lot of these things need to be replicated across the country. I mean, it is great to learn about little pockets of progress, but, Dr. Miaoulis, as you talked about, it needs to happen in every school. And, Mr. Dugan, as you were talking about in Reno, all children need to be exposed to these things. And I am glad you are here to hear what Dr. Miaoulis was talking about, about the importance of teaching engineering in the younger grades. Some of this stuff is common sense, but it is not traditional. And that is why I think that we need to look at what we are doing in America to educate the next generation in science and math. When you're living in an information age, and you have been teaching in your schools based on curricula developed in a different type of industrial age, you have to remake your schools to reflect what we need to be competitive in the world. The rest of the world is reforming how they teach these subjects in their schools, and we need to adapt here in the United States.

I liked what Senator Sununu talked about, about a teacher inspiring students. In an earlier hearing we had Craig Barrett, Chairman of Intel, talk about some of the awards that Intel distributes. They are similar to what the Siemens Corporation is doing. I think it is wonderful, and I want to applaud corporations like Siemens and Intel for what they are trying to do: inspiring young people. In addition, one of the things Craig asks every one of the winners of the Intel awards he talks to is, "What inspired you to go into science?"—and every single one of them have responded that, "it was a teacher."

And I thought, Dr. Rankin, what you talked about was fascinating to me in the last hearing that we had. If you are an education major who happens to take a couple of science classes, your passion is not science. Whereas, if you are a science or a math major, or an engineering major, that's where your passion is, and you happen to teach—or you then take classes on how to teach, that makes a lot more sense to me. If I'm going to have somebody inspire students, I want somebody that actually is inspired by science themselves. And that's where I think that a lot of this needs to go.

We have huge challenges, because we have a lot of teachers out there that are already teaching. We do have a shortage of science and math teachers across the country—definitely in my state at least. But I love a lot of the ideas that we are hearing today.

I want to start with you, Dr. Rankin. Retention rates among all teachers is a huge problem today. How do your retention rates compare with those for the average teacher? Do you have any statistics on that?

Dr. RANKIN. Well, we know that about—as I said a few minutes ago, three-quarters of the students that we produced that are out teaching for 5 years are still teaching. So, that's huge. I mean, we've actually looked in the Austin Independent School District at retention in schools of math and science teachers, and the turnover in 5 years in Austin is 100 percent. That doesn't mean they've all left teaching——

Senator ENSIGN. Right.

Dr. RANKIN.—but they've all——

Senator ENSIGN. Statistics.

Dr. RANKIN.—left that school. And many of them have left teaching.

Senator ENSIGN. Mr. Dugan, what kind of turnover—or what kind of retention rates do you see after 5 years, normally, with teachers?

Mr. DUGAN. Senator, for Washoe County School District, I think ours is above average, but our concern is being able to attract—as we add these math and science classes, we are very concerned that we won't have the math and science teachers to fill the additional classes that we need to fill, and, when the teachers that we have leave, that we won't be able to fill them with new math and science teachers.

Senator ENSIGN. Let's take this to our responsibility up here. As Senator Sununu said, we are limited in what we can do. But one of the purposes for having a hearing like this is to highlight some of the good things that are happening out there, to bring attention to them, to get *TIME Magazine* or other magazines to pay attention and to write articles about this, to get the press to report, so that other people pay attention, so a buzz is created, "There's excitement going on, these things are happening. It's happening over here." We can shine a light on it and highlight those things, but we can also do other things up here—fund pilot projects and things like that. When you look at what you're doing with UTeach—and we want to see that replicated, and that's starting to happen in the other States—do you have any recommendations for us, up here? What would you do, or tell us to do, to have UTeach-style programs go to more places around the country?

Dr. RANKIN. I think we need an initiative that funds very faithful replications of proven programs. I mean, you know—and a lot of times—NSF has had a number of initiatives—the Department of Education—for coming up with new programs. And, in fact, we've had funding for that. But I think, at this point in time, really what we should be doing is trying to fund faithful replication, and maybe at some key sites across the country. I think we need to get Research-One universities involved in this, because, frankly, that's where the really strong students are that can go out and be the

real leaders in schools. For years, the dogma was that those students would not be interested in teaching, wouldn't consider it. Well, that is not true. They really will. But it needs to be a kind of program that inspires them.

So, I think what you need to do is identify really effective programs, we're not the only one.

Senator ENSIGN. Right.

Dr. RANKIN. There are a number of them. But you need to find those and specify, in legislation, as precisely, as possible I don't know anything about writing legislation. I'm sure that's a challenge. But if you can—if you can manage to fund faithful replication, rather than new pilot projects, I think, in that—that's where we ought to be going right now.

Senator ENSIGN. Let me turn to Mr. Dugan, and what you're doing in Washoe County. Some people are saying, "Gosh, my child can't handle the math that they're taking now." We do hear that. And now you are going to increase the justification. Can you walk through why you think that it's important to increase the amount of math and science that is included in a more challenging curriculum?

Mr. DUGAN. Senator, I think, to answer that question, not only do we need to increase it, but we need to make it relevant. And that is going to be a real challenge. And that was one of the major concerns, because it was not easy for Washoe County to pass this, in December of 2004, because of some of the things that you just said. People were saying, "Well, you know, math already—my son or daughter's having trouble with it, and you're just going to add another math. They're going to want to drop out." And we are very sensitive to that. So, unless we—while it is important that we make it rigorous, it is equally important that we make it relevant. And so, what we are doing is working very closely with the university, the community college, and the business community in developing these fourth-year classes and looking at our second-year algebra classes and see how we can teach them differently. Because, you're right, if we do just the same that we've done, we'll have serious problems. And while I am very proud of what Washoe County is doing, I also could become very ashamed if we don't step up to the plate and provide the support to the students and make these courses relevant to them.

Senator ENSIGN. I would make a suggestion, because I was very impressed with Dr. Miaoulis and some of the things that he's doing to inspire students in math, science and engineering fields. Dr. Miaoulis, I would love to get you out to Nevada. And one of the reasons I think it is good to have Mr. Dugan here is, some of the science that you're talking about is, I think, exactly what Dr. Miaoulis is talking about. And it would be great to hook the two of you up in some of the other school districts as well as our university systems in the state. We would love to help bring you out to Nevada and get you involved in our school systems and help us improve in the State of Nevada.

I want to come back to some more questions, but I want to be cognizant of my colleague from Virginia, who has really been one of the leaders in technology. Senator Sununu, myself, and Senator Allen, we seem to be the three that are pretty consistent at show-

ing up at hearings like this and participating. I think this is because all three of us have a real passion for this subject.

So, I'll turn it over to you, Senator Allen, to spend a little time. Take whatever time that you need, and then I'll come back and we'll continue the discussion.

Thanks.

STATEMENT OF HON. GEORGE ALLEN, U.S. SENATOR FROM VIRGINIA

Senator ALLEN. Thank you, Mr. Chairman. Thank you for letting me drop in.

We're having a Foreign Relations hearing right now on the nuclear pact with India, which is very important. We have energy needs. So do they. And our relationship with India is very important.

It also does work into this very same subject. And India is the world's largest democracy. They're also competitors. And having been in India and just seeing where they're going in innovation, I want to make sure the U.S. is the world capital of innovation. India is clearly moving that way, as well. And this hearing is very important. And I commend your leadership. And I just really enjoy working with you, because I think this is—there are certain things that are going to be key for the future of this country. We do need to get our—better energy security. We need to have the right tax and regulatory policies for investment. And education, knowledge—knowledge is power in the future.

When one does look in—at engineers, scientists, technologists that we're graduating here in this country, compared to India, compared to China, those countries, right off the bat, have three times to five times the population. And the exponential difference, though—you take engineers, for example, who are important, since they're going to design and develop the new innovations, the intellectual property, the inventions of the future—you get all these different statistics, but every one of them, were one-quarter, let's say, of India, and one-eighth of China. When you then look even further, though, at those who are in our engineering schools, approximately a third or so are from another country, which is fine. I want America to be the magnet for the best minds in the world—in fact, you can attach a visa to their diploma if they graduate in some of these very important professions and disciplines for our future. But if, then, you look at the U.S. citizens—and some of you have mentioned and alluded to this—generally speaking, you get these sorts of figures, that about 15 percent of the engineers are women, African-Americans are about 6 percent, and Latinos are about 6 percent. Well, from my perspective, if we're going to compete with countries that have three, four, eight times as many people, we need to get all Americans interested.

I've worked, in the past—and I want to commend Siemens for what you're doing in the scholarships with the United Negro College Fund and the Thurgood Marshall Scholarship at Historically Black Colleges and Universities. If one looks at—not the University of Texas, necessarily, but if you look at minority-serving institutions, whether they're historically black colleges and universities or Hispanic-serving institutions or, the couple of dozen tribal colleges,

you find that their technology infrastructure is simply not there, in most cases. And, indeed, since they don't have that technology infrastructure and—which is so important, they also don't have the faculty, which means, for those students at these minority-serving institutions, they're not getting the training and education for—to be able to even compete to get the 60 percent of the jobs out there in the real world increasingly that require technological proficiency. That's why Senator Sununu and others have supported this measure I've gotten through the Senate twice which would provide grants to minority-serving institutions to upgrade their technology infrastructure.

There are a variety of things that I think we need to do to incent, encourage young people—and, from listening to teachers, you have to do it by middle school; high school's too late; college is way too late—to make math cool, as you're doing there in Washoe County, or making it relevant—use the term "math is cool." Altrai's trying to do that, in Richmond. Just make it relevant. Maybe nanotechnology advancements. Those lithium ion batteries that they're working on in Nevada, I think, are exciting, or trimetaspheres that'll be able to cure cancers and get right at the cancerous cells. Maybe those sorts of things will interest them. But I'd like to hear from each of you all. And since Siemens is actually doing it—you're asking, "What can the Government do?"—the scholarships that are part of the measure that we've introduced, I think, is very important. It says to parents and young people that, "If you're good in biology or physics or sciences, math, engineering, you'll get a scholarship."

I saw a little girl, a middle school kid—I was giving a speech on the courthouse steps in Southside, Virginia, in Pittsylvania County, and she said she wanted to be a forensic scientist. I said, "Oh, that's great." I said, "What college do you want to go?" She wasn't sure if she could afford college. And I thought, you know, if a child's good in this, income should not be a barrier. So, I think scholarships matter. Obviously, you all, at Siemens, believe that. But if you could share with us what specific idea do you all think would be beneficial to encourage or incent more women, African-Americans, and Latinos, who are disproportionately underrepresented in these areas, which are great-paying jobs, which are important for the competitiveness of our country, and, ultimately, our security and standard of living.

I'm going to start with you, Dr. Rankin, since you're in charge of UT.

Dr. RANKIN. Well, honestly, I think, again, teachers are the key. One of the things that prompted me to initiate the UTeach program was that I had been involved in a lot of very successful outreach programs to minority populations in Texas, and I thought they were very valuable for the individuals involved. I still do. And we have a lot of them. But it seemed like we were not really helping many people. Teachers have a multiplier effect that the individually focused outreach programs can't have. A teacher will affect hundreds, sometimes thousands of students, if they stay teaching a long time, and can be so inspirational. One of the things that I missed was really good role models in the classroom. One of the things that I like so much about UTeach is that we seem to be at-

tracting a large number of minorities to this profession, who will then go out and be strong role models for their students.

I think the other thing—I mean, we talk about focusing on substantial curriculum and the expectations for minority students. I think that is really key. If you expect these kids not to be able to do something, they won't do it. Low teacher and parent expectations are self-fulfilling, and the students themselves come to share those beliefs. The teacher, again, is really important in reversing this cycle. Having strong enrichment programs that expect them to succeed and put them into a rigorous curriculum, I think, is incredibly important. So, programs like Mr. Dugan has are very effective. We have a program at UT for top 10 percent kids that come in now, by law, to University of Texas with somewhat lower SAT scores and poorer preparation than other students. Everyone was afraid that these kids from the valley and rural areas and so on wouldn't succeed at UT. But we put them in, not a remedial curriculum, but an enriched curriculum that really actually challenges them in very positive ways and gives them applied problems. These kids succeed better than the average. They're doing beautifully. I mean, I think, actually, in the testimony that I submitted, there's a little summary of this program. But I think having expectations for success, and then giving kids the support and inspiration to get there is really key.

Senator ALLEN. Thank you.

Mr. Dugan, as opposed to "Duggin," right?

Mr. DUGAN. Correct.

Senator ALLEN. Alright.

Mr. DUGAN. Thank you, Senator.

Currently, 69 percent of our students in Washoe County—and we have 62,000 students—end up taking three credits of science, and 45 percent end up taking four credits of math. But those that aren't doing that are—predominantly, are minority students. And so, when you ask, "What is it that the Federal Government can do to support what we're trying to do?" I would say I think you hit on it. Once we get these students, these minority students, into these programs, they have to be able to have the ability to go on to—whether it be a 4-year college or whether it be on to some vocational training. So, I would be looking at the support coming in ways of scholarships, dollars available to these students to make sure that they have the same access to post-secondary education that others do.

Senator ALLEN. Thank you.

Mr. McCausland?

Mr. MCCAUSLAND. Thank you, Senator.

One of the things that I try to do is also talk to our competitors and winners of the advanced placement awards and just ask them how they—you know, what is it that is motivating them? And I always tell them—start out by saying, you know, "What do you call a geek—29-year-old scientist engineering geek?" They say, "I don't know." And I say, "You usually call them 'boss.'"

[Laughter.]

Mr. MCCAUSLAND. So, they want to know——

Senator ENSIGN. I thought you were going to say "billionaire."

[Laughter.]

Dr. RANKIN. Yes, me, too.

Mr. MCCAUSLAND. Not at 29.

[Laughter.]

Mr. MCCAUSLAND. It's usually 35.

[Laughter.]

Mr. MCCAUSLAND. And so, they want to know that what they're doing is relevant, that they have some future for themselves. And I say—what I find is, it's the parents, it's the teachers, and it's some end goal or career that they're looking for, so that they know there's something out there for them to do at the end of their training, whether it be at the end of high school, or whether it be beyond, into college.

So, it's got to be "cool" to be a scientist. And what we're trying to do is to create heroes. There are lots of sports heroes in high school. We want to have heroes of the kids who are in science and math, so that other kids can look up to them to say, "Hey, I can do this, too."

And so, creating heroes, making sure that there's a future for them—that's really what they want to have. And then the inspiration, what we can do to make sure the parents and other teachers are there to stimulate them and make sure that they know that they've got somebody behind them to keep pushing them.

Senator ALLEN. Thank you.

Dr. MIAOULIS. Senator Allen, in my testimony I talked about our National Center for Technological Literacy has as a goal to introduce engineering as a new discipline from K through 12. And I'm happy to tell you that Virginia, your State, is one of our partner States, and we worked recently at the Children's Engineering Conference in Richmond.

If we're successful in introducing engineering from kindergarten through 12th grade, you'll eliminate the problem of having too few women and minority folks in engineering. And I'll explain to you why. First, we start at a very early age, through materials that show engineers and heroes looking like all the kids that engineering does not attract right now. So, they see folks from the African-American community, and from the Latino community being the heroes in their town because they solved a real problem. Then, if you look at who becomes engineers—I'm an engineer, too—about 68 percent of us have had a parent or a relative that's an engineer. If you take a group like African Americans, who are folks that go to college but do not go into engineering traditionally, they go into medicine, into law, into education, the parents and the relatives are not in the community to mentor the kids. And the reason engineering needs that parental or relative to push the kids is because it's not part of the regular curriculum right now. You have math, so kids know about math, know about reading, about social studies, but they don't know about engineering. If you have it as a discipline, the more kids will go into engineering, because they know what it is, and, frankly, because they see the relevance of engineering and how engineering can improve the world.

We're talking about innovation in math and science, but if you think what's connecting math and science with innovation, it's through engineering, which is not part of the curriculum.

And, by the way, Mr. Chairman, the reason that engineering is not part of the curriculum is, the topics that now are part of the curriculum were decided in 1893 by the Committee of Ten, chaired by President Elliot, at Harvard, and they didn't put engineering there, because all engineering, at that point, was focused on agricultural technologies, which was part of their home education, because 80 percent of folks were farmers. So, they didn't think to put engineering then, because it wasn't essential. But as technology took off, the topics didn't change, and now we have kids that know all the parts of a flower and have no idea how the world around them works.

Senator ALLEN. Thank you all. I was taking notes through—and they're all outstanding ideas that I think that we can buildupon. In fact, when you're talking about all of you, one way or the other were talking about role models and heroes and sports heroes and all the rest, so one thing that struck me when I was in India around last Thanksgiving I was meeting with the leaders of the India Institutes of Technology, and in that country there are plenty of women who are engineers. And so, it's a question of attitude, rather than aptitude. You're right, engineering is the application of it—building bridges, computer-aided designs. I like some of the computer games where my son or daughter can build an amusement park. Well, that's making it relevant. What do you want? Slides. What are the rollercoasters going to look like? Where are you going to have water, and all the rest? But the one thing that struck me is that they said that the children there—their ticket out of poverty in India and the poverty is heart-wrenching in India, notwithstanding its great economic growth—but the kids in middle school, they said they were focused on passing these exams at the end of high school so that they'd get into one of the India Institutes of Technology, where the tuition is obviously much, much, much less than tuition in our country.

And in our country a lot of young people, if they're from a low-income background, their way out of poverty, they think, is football or basketball or baseball or some sports. One of you all—Mr. McCausland mentioned sports heroes. Well, it's going to be one out of 100,000 that are going to make it to the pros. And there's nothing wrong with team sports. In fact, I think they're great. You learn a lot from team sports. But as far as a career, a long-term career, and at—lead a fulfilling life, being an engineer, being a scientist, being a researcher, being even a technician of some sort, all of that is going to be a much more rewarding career for them, fulfilling, as well as more likely. So, we do need to make sure that young people know of these opportunities, help them meet those opportunities. Obviously, education's the key to it, but also make sure that every American, no matter their gender or race or ethnicity, recognizes that they should have this opportunity to compete and succeed and lead a fulfilling life.

And I thank you, Mr. Chairman, and all of you all, for your testimony, your insight. This reinvigorates me, and I think we've gotten some really good insight from you. And we're going to keep fighting, recognizing we need more talent, we need more investment. And I know that the Chairman and I are going to provide the leadership to get this done for the future of America.

Thank you.

Senator ENSIGN. Thanks, Senator Allen. Thanks for being here and offering your valuable input to this hearing.

I want to explore a couple of other questions before we conclude. And I want to go to Mr. McCausland and talk about the public-private partnerships that we're trying to explore up here in some of the innovation and competitiveness legislation. How important are such partnerships, and what would those public-private partnerships look like as we're going forward with competitiveness/innovation initiatives that we are considering up here on Capitol Hill?

Mr. MCCAUSLAND. Yes. I think, first of all, that most of us believe that we have to do something. That's why we're here. The world is a competitive world, and some of our competition is, you know, outside of the U.S. And so, making sure that the atmosphere, that private institutions like Siemens, have the ability to invest in, and get credit for investing in, programs that develop in—I want to be sure that we emphasize the fact that it's not just the students in engineering, but the teachers, as well, because we know that we can't graduate 10- or 20,000, or 200- or 300,000 engineers without the teachers in the background to be, making sure that we're getting them through the pipeline. So, making it relevant for industry to be able to invest in this, being able to encourage local partnerships, not only with the Federal Government, but with the cities and the communities that we live in, because clearly schooling all is local in our world. So, making sure that there are funds available and, I would say, also tax incentives for us to be able to do things that are targeted toward these very, very important feeder schools in the communities.

Senator ENSIGN. Mr. Dugan, could you comment on the P–16 Council? Kind of elaborating on this public-private partnership idea and what you're doing in the schools in Washoe County.

Mr. DUGAN. Gladly, Senator.

Several years ago, Washoe County developed what we first called Partners in Education Program that consisted of educators at the community college/university level and high school, elementary, and middle school level. That grew into what we now call the Education Collaborative, which includes the business community and the communities of higher education. And working together, I think we have developed a much better relationship with all of those entities that you have to have in order for your educational program to be successful. It was the university system that worked with us to really develop the research that kind of woke us up with regard to the challenges we were having with students leaving our educational system and not being able to succeed at the college and community college level. That occurred about 5 years ago. So, that P–16 Council is truly a collaborative effort with all working toward the same goal of making sure that our students are not only prepared for college, but, equally important, prepared for the world of work. And so, we're very proud of it. And the State of Nevada is using the Washoe County's Education Collaborative model to develop their own P–16 statewide council, of which I am a member. And I think that will go a long ways to deal with the statewide challenges that we have.

Senator ENSIGN. Dr. Miaoulis, we have a lot of after-school programs funded at the Federal level. Could you comment on even the use of museums? You know, Senator Allen was focusing on minorities, and a lot of the after-school programs are targeted toward lower income students, which are maybe overrepresented by minorities. Could you comment on that aspect of using museums as part of the after-school-type programs?

Dr. MIAOULIS. Museums are wonderful environments to be active participants in the after-school program. Not only do they offer education, but it has to be fun for the kids, because kids don't necessarily choose to go to school, but they choose to go to museums, so we have to make sure that it's a very appealing atmosphere. Also, teachers and parents feel comfortable going to a museum, because, again, it's a fun atmosphere. And museums participate, and can participate in two different ways, first by directly offering programs at their sites—and quite a few museums and science centers do that; and, second, by partnering with other organizations, like 4–H or Boys and Girl Scouts that offer after-school programs, to provide them with materials, like the ones we create at the National Center, or workshops for "train the trainer" kind of thing, so that they can offer after-school activities that are meaningful and are infused with science content. It's a challenge, because a lot of the after-school providers do not have a science background, so the resources should go into developing materials and also do professional development for after-school providers in the area of science and mathematics and engineering education.

Senator ENSIGN. I'm glad you said that. It is interesting. We take our kids, and I've been on a few of the field trips. We have some of those very interactive science-type museums in Las Vegas, and we've taken our kids down there. And, like you said, it's really key that these museums are fun for the kids. Some of the highly interactive parts that they have really do make the science interesting and relevant to young students. And I think that is what we've all been talking about here, about making these subjects relevant. You have to make it relevant for a first-grader, and relevant for a senior in high school. And especially in today's world because some of the simple things that museums used to do are not nearly as relevant even to a first-grader today, because the technology has become so advanced. My youngest child is in first grade, and, you know, when they can play with a Game Boy or they can play with some of the other things, the museums are going to have to work on keeping all of the engineering relevant.

When I was a kid, we used to hang out in museums all the time. It was just something we did, because I didn't have a lot of parental supervision when I was young, and that was one of the places we went and just hung out. And I think that that is a great atmosphere if the museum has the right things and can teach a lot of kids. So, I would encourage you to continue the work that you are doing.

Another question—I want to go back to Dr. Rankin, because I think it is so important. When we are talking about what Mr. Dugan is doing in the high schools, and talking about getting those teachers trained, it isn't just about warm bodies. You know, we can't just have the teachers coming in and they happen to be like

we've talked about before, the traditional, education major, who is not going to inspire that next generation of engineers, the next generation of people to go on and to become that 29-year-old geek that Mr. McCausland talked about, that happens to someday become that next billionaire. But part of this is about making math and science "cool." This is part of what the teachers do. I mean, teachers make it exciting for students. They bring in the ideas that you've talked about, Mr. Miaoulis.

I guess I want to explore just a little more on where you are coming up with these ideas, and how you are actually implementing to teach, maybe some of the specifics of your pedagogy?

Dr. RANKIN. Pedagogy, yes.

I had to learn that word when we started this program.

Senator ENSIGN. Yes. I guess that's a common word. When I say it around teachers, they all—they all understand, and they think it's——

Dr. RANKIN. Yes.

Senator ENSIGN.—funny that I can't pronounce it properly, but——

[Laughter.]

Senator ENSIGN.—but in veterinary medicine, we never had that word, so it wasn't——

[Laughter.]

Senator ENSIGN.—something I learned. But I think that pedagogy is really an important concept you know, these science majors learning how to teach. What exactly are you teaching on the science aspect of that, that you discovered that was different? What are the actual techniques for teaching science or math, versus, you know, normal teaching in other subjects?

Dr. RANKIN. Part of it is teaching our students how to use discovery methods, how to really teach through inquiry and discovery. This is really important in science. Instead of standing up and giving a lecture, which is, of course, what most of us know how to do, it's very much harder, but much more—it's much more inspirational, and kids actually retain the information much longer if they can discover part of it themselves, or if they can have hands-on experience. So, we try to teach our students, even in their college courses in science, using those kinds of methods, and then also inform them as to how to use them, and how to use technology. I mean, talking about using Game Boys and things like that, these kids want fast feedback, they want excitement. And you can do some of that with technology, if you know how to use it properly. So, that's a big focus.

Another thing, though, that we do—I mentioned briefly that we had these internships. And, frankly, it's a very good opportunity for public-private partnerships. But the internships fund students to do educationally relevant jobs instead of flipping hamburgers, they go out and work in after-school programs or at museums or something where they can really use what they've learned in their science or math classes, use what they're learning in their pedagogy courses, but in a practical field situation, you know, not just a classroom. It reinforces their own learning, and it gives them these different kinds of exercises and sophistication, you know, in different kinds of situations.

So, we try to use both applications in the field—that's one of the other reasons why we have field experiences in almost all the pedagogy courses. They go out and work in Austin classrooms to implement what they're being told how to do.

Senator ENSIGN. On what Dr. Miaoulis is talking about—and I remember when I learned science and math as a student, I mostly learned about the earth around us and our surroundings—When you're teaching are you implementing some of these practical discovery techniques?

Dr. RANKIN. Yes.

Senator ENSIGN. Using the man-made objects, as well as the——

Dr. RANKIN. Yes.

Senator ENSIGN.—natural objects?

Dr. RANKIN. We use kits and robotics and all sorts of things to teach principles. For example, if you're trying to teach them something about friction there are all kinds of tricks you can use that are fun for them, and yet get the principle across, and help them remember it. So, this is a big focus.

And we also have, in fact, a special course for our students that's part of the pedagogy series, in research methods. So, they have a research experience, but they also learn how to set that up for a class. So, the class can actually discover new knowledge, not just do an exercise.

We've tried to infuse that through all of the pedagogy, and also through the extra things that we do. But, frankly, a lot of this, the internships and all of this field experience under mentor teachers in the classroom requires extra money that is hard to find in a state schools' budget, you know. So, we fundraise all the time, from foundations and companies and so on, in order to pay for these extras. Again, I think that's a very good place for a public-private partnership, too, in replicating some of these programs. I'm sure we're not alone in that.

Senator ENSIGN. Well, I want to thank all of you. It's been a great discussion. I've said this before: one of the reasons I really like subcommittee hearings, is because they can be more of a discussion, and you don't have to just have 5 minutes with 15 Senators up here. You can have more of a discussion, back and forth. And I have personally found them to be very, very valuable. And they have influenced a lot of my thinking.

I just want to emphasize to you that your time here is very valuable and very much appreciated. I think that your experiences and testimony is going to influence a lot of what the Senate is going to do, and hopefully the final product of what we do on innovation and competitiveness legislation that we are working on. We all recognize the challenges. You know, the devil's in the details, as we put all this stuff together. But your time here has been valuable for this Senator, and you also see behind me the staffs of all the other Senators, and they are the experts anyway. The Senators only know a little bit about a lot of this stuff. So, it's important that they heard a lot of the discussion that was going on today, and I think it's going to inspire us as we go forward with legislation.

So, again, I want to thank all of you for being here today. This hearing is adjourned.

[Whereupon, at 11:30 a.m., the hearing was adjourned.]

APPENDIX

PREPARED STATEMENT OF HON. CONRAD BURNS, U.S. SENATOR FROM MONTANA

In the Senate we are charged with spending the dollars entrusted to us by the taxpayers with the greatest possible efficiency and to create the greatest possible impact. We have a responsibility to show results for each dollar that we spend. Investment in research and development in mathematics, science, and engineering has always had a strong return on investment. These funds produce jobs, bolster economic growth and improve the quality of life for Americans.

The country that wins the battle of technology will dominate the world economy in the decades to come. In the Senate, we must implement policies to ensure that the United States remains on the cutting edge. That means we have to train tomorrow's innovators today.

The challenges facing today's educators are more complex then ever before. As policymakers, we must find ways to leverage Federal resources for the best interests of America's students not only in urban inner cities but in rural areas like Montana, where recruiting faculty poses a significant challenge.

Today's students are tested in the same core subjects that have been a part of formal education for a century: mathematics, reading and writing, history, and science. In addition, students must learn to navigate new technologies to make them competitive in the job markets of tomorrow.

I want to thank the witnesses for being with us today to talk about where STEM education fits into the puzzle of the modern curriculum.

Interestingly, the solutions to these challenges require policymakers to think like engineers. We must take stock of our resources and develop plans to direct those resources where they will achieve the most success. We need to put in place broadband Internet access for our schools in order to lay the foundation for innovative distance-learning opportunities. Technology has the potential to eliminate the impact of distance and isolation and to provide a meaningful classroom experience from across the state, across the country, or even across the world. We need to partner educators with the small businesses and entrepreneurs in the local communities to teach life and work skills.

I look forward to hearing the testimony of this panel. I am particularly interested in how STEM education can fit into the existing educational frameworks, and how proposed changes would affect the schools in Montana that face unique challenges that are fundamentally different from schools in America's urban centers.

PREPARED STATEMENT OF HON. JOHN D. ROCKEFELLER IV,
U.S. SENATOR FROM WEST VIRGINIA

Mr. Chairman, I commend you for holding this hearing and I am disappointed that I could not personally attend the hearing due to my recent back surgery and recovery.

I share and support your keen enthusiasm for innovation and competitiveness. This is an issue that I have tried to work on since coming to the U.S. Senate. Working with the Council on Competitive and the Majority Leader, Senator Frist, we created a bipartisan Forum on Technology and Innovation to help encourage thoughtful dialogue on technology from 1999 to 2002. Now, many strong voices are contributing to this essential debate which is very encouraging.

There are many ways to promote innovation, and basic investment in math and science, but the fundamental component to build the foundation is quality teachers. While I welcome new ideas and new incentives, we should also review and support the investments in ongoing programs that support innovation and education. One example is the National Science Foundation's Math and Science Partnership program. These partnerships are reporting real, measurable gains in math and science education at all levels. A report released earlier this year, indicated that the Math and Science Partnerships reported a 7 percent increase in proficiency in partici-

pating elementary schools. Even more promising, the partnerships reported a 14 percent increase in some of the participating high schools. This is stunning and it deserves to be continued and expanded.

Another small, but effective program is the National Science Foundation's Experimental Program to Stimulate Competitive Research (EPSCoR) which helps the 25 smaller, under-served states become more competitive. Investing in these states is vital. While the EPSCoR states currently only receive about 10 percent of all National Science Foundation funding, these states have about 20 percent of our population, 25 percent of all doctoral and research universities, and 18 percent of the employed academic scientists and engineers. EPSCoR is a solid long-term investment in our future scientists and engineers who will lead on competitiveness and innovation, and be the role models in their communities and schools.

This Subcommittee hearing provides a good review of some selected programs with promise. In addition to the testimony of Dr. Mary Ann Rankin of the University of Texas at Austin, I am delighted to share information with my colleagues about the West Virginia University's Benedum Collaborative. This partnership was created in 1989, and it provides a 5-year program for students to begin clinical work at a local school after their sophomore year in college. Under the program, students have over 1,000 hours of clinical experience and graduate with a bachelor's degree in a content area, such as math or science, and a master's in education with a recommendation for state certification. Studies indicate that students in professional development schools tend to score higher on standardized assessments.

Today's hearing is an important step in our discussion of ways to promote math and science education as a way to develop competitiveness and innovation.

PREPARED STATEMENT OF PROJECT LEAD THE WAY (PLTW)

Project Lead the Way is pleased to provide this testimony on behalf of the organization as well as the schools, universities and corporate partners that participate in Project Lead the Way nationwide (see appendix), the thousands of educators who have gone through our professional development program and the 175,000 young people who have been affected by our efforts.

Background

Project Lead The Way (PLTW), a non-profit program supported by private partnerships and foundations, has developed a four-year sequence of courses which, when combined with appropriate mathematics and science courses in middle and high school, introduces students to the scope, rigor and discipline of engineering and technology prior to entering college. The program is funded locally using a variety of private and public resources and also relies on public-private partnerships.

PLTW shares the interest of this panel and countless other public officials who are attempting to address the issues surrounding the Nation's concern regarding global competitiveness. We firmly believe that a better-educated and prepared workforce is crucial to securing this Nation's place as a global economic leader and innovator. It is an issue that PLTW's founder, the Charitable Leadership Foundation of Clifton Park, New York, has been attempting to address since 1996 with the creation and proliferation of a not-for-profit pre-engineering program for our Nation's high schools and middle schools. Started with the humble goal of being in 50 high schools in upstate New York by 2005, the program is currently found in over 1,300 schools in 45 states.

Beliefs

While PLTW believes that its curriculum and program are exemplary, there are a number of fundamental assumptions that belie its formulation and success. First and foremost, PLTW believes that success in the science, technology, engineering and mathematics (STEM) disciplines begins the moment a child walks into a classroom for the first time. It is crucial that any Federal endeavor in this area address this fact. It is not enough to engage young people in middle and high school. Interest in these studies must be nurtured from day one. In particular, girls and other underrepresented groups must find STEM appealing at a young age if we can reasonably expect them to pursue them successfully in later years. So, while secondary education is where one might intuitively look to focus on postsecondary preparedness for the pursuit of STEM disciplines, PLTW believes it is important that elementary students receive similar focus.

Further, PLTW's rigorous and relevant curriculum is based on the premise that bringing engineering curriculum and concepts to students through practical application while they are still forming opinions about interests and careers is crucial. No one can deny that these interests are formed at a very early age. As a result, it

is important that young people are exposed to curricula that go beyond math, science and technology, and educators are explicitly encouraged to include engineering in elementary education.

The success of PLTW can largely be attributed to its reliance on project-based learning and the program strongly advocates for the use of project-based learning. Engineering is a field and profession based on the success of projects, and this should be reflected in any measure of an engineering curriculum's success.

Recognition and Elements of PLTW's Success

In October 2005, Project Lead The Way was cited in the report *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Educational Future* by the National Academy of Sciences, The National Academy of Engineering, and the Institute of Medicine of the National Academies. Among the report's recommendations was that K–12 curriculum materials for science, technology, engineering and mathematics (STEM) education modeled on world class standards foster "high-quality teaching with world class curricula, standards and assessments of student learning." It further went on to say that "The model for this recommendation is the Project Lead The Way pre-engineering courseware (page 4)."

In addition, the report noted, "Students participating in PLTW courses are better prepared for college engineering programs (page 5–15)."

PLTW is understandably proud of this distinction. It does beg a number of questions, however.

Why has the program grown so quickly and what has been its effectiveness?

The answers to these questions are grounded in the attributes of the program's organization, and in its curriculum and professional development.

Partnership—The mission of Project Lead The Way is simply to "create dynamic partnerships with our Nation's schools to prepare an increasing and more diverse group of students to be successful in engineering and engineering technology programs." Partnerships with state departments of education and labor, colleges and universities of engineering and engineering technology, and major industries and corporations (see attached listings) have been reached to validate and support the program throughout the country. Local, state and regional ownership of the program with the engaged collaboration and support from the national Project Lead The Way program has created a vibrant and responsive network of stakeholders that keeps the initiative vitally active and strong.

Curriculum—As has been repeated countless times on Capitol Hill, curricula needs to be rigorous and relevant to meet the interests and expectations of today's students. PLTW agrees. The attributes of the program curricula that have contributed to Project Lead The Way's success are:

- Contextual project/problem based instruction.
- Integration of recognized national learning standards including those of the National Academy of Sciences, The National Council of Teachers of Mathematics and the International Technology Education Association.
- Breadth and depth of content, updated and revised regularly.
- Supported by comprehensive professional development for teachers and school counselors.
- Prepares students for successful transition to 2- and 4-year college programs.
- Written to standards of quality and consistency so as to carry college credit that is recognized by over 30 post-secondary engineering and engineering technology schools nationwide.

Professional Development—Rigorous, relevant professional development for teachers, presented in immersed and ongoing formats, is essential to breed and assure student success. The attributes of the Project Lead The Way professional development program are:

- Pre-Training Teacher Assessment.
- Two-week Summer Training Institute required for each course a teacher might teach (80 hours seat time) at 30 university sites nationwide.
- Ongoing teacher training and reinforcement through the Project Lead The Way online Virtual Academy.
- Required school counselor professional development at university sites.

Not-For-Profit Benefits to Schools—As a not-for-profit, Project Lead The Way provides at no charge to schools:

- Contemporary, rigorous, project/problem-based curricula, updated regularly, for eight (8) full year, high school courses and six (6) middle school units.

- Access for trained instructors to the Virtual Academy.
- Teacher and counselor professional development protocols for use by university and college partners.
- Use of an optional Purchasing Manual, developed under the procedures of the New York State bidding laws, for lowest pricing on all equipment and supplies for all Project Lead The Way courses.
- Information and promotional materials for use by school counselors with parents and students.

Program Evaluation—PLTW believes that unbiased, critical examination of its curriculum and program elements is crucial to its goals and success. Initial research findings on the effectiveness of the Project Lead The Way program include:

A study by the Southern Regional Education Board (2005) which found that Project Lead The Way students:

- Achieved significantly higher in mathematics than students in comparable career/technical programs.
- Achieved significantly higher than all students in career/technical programs in mathematics, science and reading.
- Completed significantly more, higher level mathematics and science courses.

A study by True Outcomes of York, Pennsylvania (2005) showed that:

- 80 percent of seniors in Project Lead The Way planned on attending college or community college compared to 65 percent nationwide.
- 54 percent planned to enroll in engineering or engineering technology compared to 10 percent nationally.
- 19 percent planned on attending community college or Technical School.
- Overall schools offering PLTW were representative of their state's population.
- Minority student participation met or exceeded the proportion of Bachelor's Degrees awarded in Engineering in 2004 to minority students by race.
- The representation of Hispanics and African-Americans in PLTW courses was double their representation in post-secondary engineering programs nationwide.
- Female student participation in Project Lead The Way was comparable or exceeded the total proportion of females earning Bachelor Degrees in Engineering in 2004, in the fields of Mechanical, Electrical and Computer Engineering, and in Engineering Technology, but less than the percentage in biomedical and environmental fields.

Conclusion

In 1985, "A Nation at Risk" was published alerting the country to an impending crisis due to perceived significant inadequacies of the existing K–12 education system. Since then these sentiments have been echoed in many subsequent research papers, most calling for reform, but with no real innovative solutions or recommendations. With few exceptions, these reports have instead focused on increasing the quantity of more of the same traditional courses and approaches—approaches that have proven limited in their scope and overall effectiveness.

The latest proposals from Washington do the same: increasing AP course participation, expansion of the IB Program, increased foreign language instruction, more math at all levels, and more math teachers. While well intended and even valiant, the reality is that if these proposals move forward, students will continue to ask, "Why do I need to know this?" and "Where will I ever use this?" Raised in an age where interactive technology has influenced almost all of their life experiences, traditional passive learning models fall far short for the majority of today's students. Today's student thrives on curricula that are contextual and which invite their engagement in project/problem based activity. In short, they do best with school curriculum that is BOTH rigorous AND relevant; where they understand why they need to know something, and where and how they can use it.

Don't forget the majority of students in this great country whose learning styles and interests are not met in traditional settings and coursework. Contextual, project-based learning, where students can apply what they have learned in mathematics, science and English classes, supported by rigorous and relevant curricula and professional development, must be part of the solution that any Federal legislation or investment pursues.

APPENDIX

Project Lead The Way Courses

Gateway To Technology (Middle School)

- Design and Modeling
- The Magic of Electrons
- The Science of Technology
- Automation and Robotics
- Flight and Space
- Technology in Motion (in development)

Pathway To Engineering (High School)

- Principles of Engineering
- Introduction to Engineering Design
- Digital Electronics
- Computer Integrated Manufacturing
- Civil Engineering and Architecture
- Biotechnical Engineering
- Aerospace Engineering
- Engineering Design and Development

University Affiliates

Arkansas Tech University
Duke University, Pratt School of Engineering.
Eastern Michigan University
Milwaukee School of Engineering
New Hampshire Technical Institute
Old Dominion University
Oregon Institute of Technology
Penn State University
Purdue University
Rochester Institute of Technology
San Diego State University
Sinclair Community College
So. Seattle Community College
University of Colorado at Colorado Springs
University of Illinois—Urbana
University of Maryland at Baltimore County
University of Minnesota
University of Missouri—Rolla
University of New Haven
University of South Carolina
University of South Florida
University of Tennessee at Chattanooga
University of Texas at Tyler
Weber State University
Worcester Polytechnic Institute

Strategic Partners

Autodesk, Inc.
Intel Corporation
Kern Family Foundation
NASA
Rolls-Royce Corporation
Southern Regional Education Board

SCIENTIFIC AND TECHNICAL INTELLIGENCE COMMITTEE, NATIONAL INTELLIGENCE COUNCIL, DECEMBER 2005

GLOBAL TRENDS IN SCIENCE AND TECHNOLOGY EDUCATION: POLICY IMPLICATIONS FOR U.S. NATIONAL SECURITY AND COMPETITIVENESS—EXECUTIVE SUMMARY

Scope Note

The United States' competitive edge in basic science, research advancement and technology development is closely associated with the production level and quality

of graduate level degrees and advanced academic research.[1] International students have historically played an essential role in supplementing U.S. scientific and technical (S&T) talent and in funding graduate and post-graduate education and research. International students remaining in the United States after completing their studies provide a pipeline for S&T research and development expertise into the workforce. For the past few decades, the United States has led the world in attracting international students pursuing S&T graduate degrees and in keeping those who desire to remain in the United States to seek careers in S&T-related research and development. Recent data, however, indicate a downward trend in foreign applications and enrollments at U.S. colleges, universities, and research institutions, especially in the science and engineering fields.

The *Conference on Global Trends in Science and Technology Education: Policy Implications for U.S. National Security and Competitiveness* was organized to facilitate a dialogue, share diverse perspectives, and establish a baseline of knowledge regarding worldwide trends in international S&T higher education. This conference, which took place on June 3, 2005 at the Army-Navy Club in Washington, D.C., brought together government policymakers, leaders of non-profit institutions, intelligence analysts, industry leaders and professors from scientific and engineering disciplines. Their mission was to evaluate global trends in S&T graduate/post-graduate programs, and the resultant implications for U.S. national "intellectual" security and competitiveness. The views expressed are those of the non-government experts.

Key Findings

Major Trends

The conferees observed the following trends affecting Global Science and Technology Education:

- Significant growth in the number of international S&T academic institutions and research centers resulting from globalization
- Increased competition for students from foreign academic programs especially from English-speaking countries and regional hosts such as China
- Continued perception by foreign students that the United States is "inhospitable" after 9/11
- Declining proportion of state and Federal S&T investment funding since the 1970s.

Impact on National Security and Competitiveness

The conferees judged that recent trends are having the following impacts on U.S. national security and economic competitiveness:

- The majority of attendees believed that the U.S. basic research capability is at risk and will degrade U.S. security and economic competitiveness. A minority argued that global access to information—including technical information—reduces the risk to the United States resulting from a loss of leadership in basic research.
- Since new technologies and technical leaders increasingly reside overseas, the majority of attendees judged this would result in increasing U.S. dependency on overseas sources for technology and hence greater security and economic risk. An alternative minority view is that this shift is merely a reflection of cost and market forces and as long as the United States has access to this technology, the United States will receive net benefits.
- Conferees were in consensus that U.S. technical superiorities for national defense are eroding.

Candidate Courses of Action

The conference attendees identified the following candidate courses of action to reduce the risk from present trends in international S&T education:

- Acknowledge that a "national" plan and policy such as a National Defense Education Act (NDEA) 21 is needed to stimulate U.S. S&T education and to maintain a healthy S&T infrastructure.

[1] At the request of the National Intelligence Council, Oxford Analytica is conducting a research effort to evaluate the strengths and weaknesses of the national innovation systems of China and India. The "quality of scientific and technological human capital" is one of the ten components of a national innovation system that will be evaluated. The report is anticipated to be available in the late Spring of 2006.

- Renew national focus on large-scale collaborative projects in a variety of scientific areas of national importance. Provide funding, public recognition and awards.
- Provide more agile technical graduate education. Increase Federal funding for such initiatives as the creation of Master's of Science programs, particularly in emerging technologies. Develop—at all education levels—quality online science and engineering education.
- Establish partnerships with foreign education and R&D centers. Establish public-private partnerships within the United States and with multi-national corporations to improve public awareness and access to S&T education.
- Change foreign student negative perceptions of U.S. hospitality and educational opportunities through incentives and outreach. Extend Visa Mantis clearance for new scholars beyond two years and relax "intent to return" visa provisions for graduate students.
- Establish and fund a data collection system that provides more detail about the global flow of international students, academic decision-making and post-graduate career paths.

The complete report has been retained in Committee files.

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