REFORM IN K–12 STEM EDUCATION

HEARING

BEFORE THE

COMMITTEE ON SCIENCE AND TECHNOLOGY
HOUSE OF REPRESENTATIVES

ONE HUNDRED ELEVENTH CONGRESS

SECOND SESSION

MARCH 4, 2010

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March 4, 2010

REFORM IN K–12 STEM EDUCATION

THURSDAY, MARCH 4, 2010

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND TECHNOLOGY,
Washington, DC.

The Committee met, pursuant to call, at 10:00 a.m., in Room 2318 of the Rayburn House Office Building, Hon. Bart Gordon [Chairman of the Committee] presiding.

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Hearing on

Reform in K-12 STEM Education

Thursday, March 4, 2010
10:00 a.m. – 12:00 p.m.
2318 Rayburn House Office Building

Witness List

Dr. Jim Simons
Founder and Chairman, Math for America
Chair of the Board, Renaissance Technologies LLC

Ms. Ellen Futter
President
American Museum of Natural History

Dr. Gordon Gee
President
Ohio State University

Dr. Jeffrey Wadsworth
President and CEO
Battelle Memorial Institute

HEARING CHARTER

U.S. HOUSE OF REPRESENTATIVES
COMMITTEE ON SCIENCE AND TECHNOLOGY

Reform in K–12 STEM Education

THURSDAY, MARCH 4, 2010
10:00 A.M.–12:00 P.M.
2318 RAYBURN HOUSE OFFICE BUILDING

1. Purpose

On Thursday, March 4, 2010, the House Committee on Science and Technology will hold a hearing to receive testimony on innovative efforts to reform K–12 science, technology, engineering, and mathematics (STEM) education, and the critical importance of K–12 STEM education to our nation's prosperity and economic competitiveness. In particular, in preparation for reauthorization of the America COMPETES Act, we will be examining the role of the Federal agencies in supporting improvements in K–12 STEM education and promoting STEM literacy.

2. Witnesses

- **Dr. Jim Simons**, Founder and Chairman, Math for America
- **Ms. Ellen Futter**, President, American Museum of Natural History
- **Dr. Gordon Gee**, President, Ohio State University
- **Dr. Jeffrey Wadsworth**, President and CEO, Battelle

3. Overarching Questions

- What are the major barriers to increasing student interest and performance in STEM? What are some model programs and approaches that have had the most success in improving interest and performance in the STEM fields in elementary, middle, and high school? What are the common characteristics of effective programs? What data are available to support the effectiveness of such programs? How can programs with evidence of success serve as models of best practices and be brought to scale?
- How can the Federal Government, including the science agencies, best support and catalyze innovative reform efforts in K–12 STEM education? How can the agencies help to improve STEM literacy among the general population?
- What role can public-private partnerships play in strengthening K–12 STEM education? How can foundations, private companies, universities, informal STEM educators, the Federal Government, and other stakeholders work with States and local education agencies to improve K–12 STEM education in the classroom? What kinds of partnerships are most effective at leveraging resources, both financial and intellectual?

4. Background

A consensus now exists that improving STEM education throughout the Nation is a necessary, if not sufficient, condition for preserving our capacity for innovation and discovery and for ensuring U.S. economic strength and competitiveness in the international marketplace of the 21st century. The National Academies *Rising Above the Gathering Storm* report emphasized the need to improve STEM education and made its top priority increasing the number of highly qualified STEM teachers. The 2007 *America COMPETES Act* implemented this recommendation by expanding and strengthening two key National Science Foundation (NSF) teacher training programs.

Two more recent STEM education reports that have generated a lot of attention have emphasized, as part of their priority recommendations, the need for greater coordination between the many public and private stakeholders in the nation's K–12 STEM education system. The reports are: *A National Action Plan for Addressing the Critical Needs of the U.S. STEM Education System*, from the National Science

Board,[1] and *The Opportunity Equation*, from the Carnegie Corporation's Institute for Advanced Study.[2] The stakeholders cited in these reports include the Federal and State governments, colleges and universities, businesses, a variety of nonprofit organizations, philanthropic organizations, and of course, school districts themselves.

K–12 STEM Education across the Federal agencies

President Obama's FY 2011 budget request invests $3.7 billion in STEM education programs across the Federal Government, including $1 billion to improve STEM education among K–12 students, an increase of over 40 percent. Of that $1 billion, nearly half would be at the Department of Education: $300 million for the proposed Effective Teaching and Learning in STEM program, and $150 million through the Investing in Innovation (i3) program. The rest of the funding is spread across the Federal science agencies.

All of the Federal science agencies fund a variety of programs and activities designed to improve K–12 STEM education. K–12 STEM education at NASA, the Department of Energy, NOAA, and the other mission agencies vary widely by type of program and target audience, with activities ranging from curriculum development and professional development opportunities for teachers, to age-appropriate field trips, online resources, research opportunities, and internships for elementary and secondary school students.

In a 2007 inventory of Federal STEM education programs, the Academic Competitiveness Council (ACC) identified 105 programs and approximately $3.12 billion in Fiscal Year 2006 appropriated funds across the Federal agencies for STEM education at all levels, including 24 programs designed for K–12 students funded at approximately $574 million. However, the ACC set parameters on its inventory, limiting the programs for inclusion to those "primarily intended to provide support for, or to strengthen, science, technology, engineering, or mathematics education." As a result, the ACC inventory excluded many educational activities supported by the Federal R&D mission agencies that are managed through larger research programs and offices, including major research facilities, and that do not show up as separate line items in the budget. In a Committee on Science and Technology analysis of K–12 STEM education programs across the agencies within the Committee jurisdiction, staff has found evidence of tens of millions of dollars worth of programs that were not identified in the ACC report. For example, Committee staff have identified more than 50 programs designed to improve K–12 STEM education at NASA alone, with funding ranging from a few thousand dollars to more than $35 million in FY 2008.

K–12 STEM Education at NSF

Historically, NSF's mission has included supporting and strengthening science and math education programs at all levels. In the area of K–12, NSF carries out its mission by funding a variety of science and math education activities, including teacher training (both in-service and pre-service), curriculum development, education research, and informal education at museums and science centers. The majority of K–12 STEM education activities at the Foundation are supported by the Education and Human Resources Directorate (EHR).

Within EHR in the Division of Undergraduate Education, examples of NSF programs designed to improve K–12 teacher performance include the Math and Science Partnership (MSP) program and the Robert Noyce Scholarship (Noyce) program, both strengthened and expanded in 2007 as part of *The America COMPETES Act*.

Within EHR's Division on Research on Learning in Formal and Informal Settings, programs targeted to K–12 education include the Discovery Research K–12 program, which funds everything from basic research on learning and teaching to the development and implementation of tools, resources, curricula, models and technologies based on the research findings; the Informal Science Education program, which funds projects that advance informal STEM education; and the Research and Evaluation on Education in Science and Engineering program, which seeks to improve the methodology of education research and evaluation of education tools and models to ensure high-quality research results and effective program development.

In the President's FY 2011 Budget Request, the Education and Human Resources Directorate would be funded at $892 million, an increase of only $19.2 million or 2.2 percent over FY 2010 funding. In the FY 2011 budget, the Noyce program would be funded at $55 million, the same level since FY 2009, and MSP would be funded

[1] *http://www.nsf.gov/nsb/documents/2007/stem_action.pdf*
[2] *http://www.opportunityequation.org/*

at $58.2 million, the same level as in FY 2010 and a small decrease from FY 2009 funding.

Race to the Top

The U.S. Department of Education's $4 billion dollar Race to the Top competitive-grant program included a competitive preference for States with a demonstrated emphasis in STEM. The competitive preference, worth 3 percent of a State's total application score, has prompted many States to make STEM education a priority in their reform efforts. Additionally, the Race to the Top application guidelines encourage systemic reform, pressing States to implement interconnected reforms that include partnerships between the many STEM education stakeholders groups, including those represented in the witness panel here today. President Obama's FY 2011 budget request includes $1.35 billion to continue the Race to the Top program.

Educate to Innovate

President Obama also launched the "Educate to Innovate" campaign to improve the participation and performance of America's students in STEM. As part of the campaign, the President announced a series of public-private partnerships involving private companies, nonprofits, universities and other key stakeholder groups, focused on inspiring and educating K–12 students in STEM.

5. Questions for Witnesses

Witnesses today represent a university, a large company, a non-profit informal science provider, and a non-profit organization that invests in teacher training. All of these witnesses and their organizations are deeply committed to improving K–12 STEM education and will discuss how each of their organizations can uniquely contribute to this effort.

Jim Simons

1. Please describe the mission and programs of Math for America. What are the most important and effective components of the Math for America model? How have you evaluated the effectiveness of Math for America's programming? Are there any lessons learned from the Math for America experience regarding scaling and replication of proven-effective programs? In your experience, what unique role can non-profit organizations and the private sector play in supporting the teaching and learning of K–12 STEM, both locally and nationally?
2. What partnerships have you built in support of your programming—in terms of both financial support and intellectual resources? What have been the key factors to the success of such partnerships? How best can non-profit organizations partner with other public and private sector stakeholders, including local schools, businesses, colleges and universities, to take on systemic reform of K–12 STEM education in a community or region?
3. What has been your experience with K–12 STEM education programs supported by the National Science Foundation or the other Federal agencies? What specific steps would you recommend the Federal Government take to improve the state of K–12 STEM education in the country?

Gordon Gee

1. Please describe Ohio State University's K–12 science, technology, engineering and mathematics (STEM) education programs and initiatives, in particular programs for K–12 students and pre-service and in-service teachers, as well as education research with a STEM focus. In your experience, what unique role can institutions of higher education, such as your own, play in supporting the teaching and learning of K–12 STEM both locally and nationally?
2. What partnerships has your university built, with both local schools and the private sector, to address STEM education? What have been the key factors to the success of such partnerships? How best can universities and colleges work with public and private sector stakeholders, including state and local governments, K–12 schools, business, and non-profits, to take on systemic reform of K–12 STEM education in a community or region?
3. What involvement has Ohio State had with K–12 STEM education programs at the National Science Foundation and other Federal agencies? What spe-

cific steps would you recommend the Federal Government take to improve the state of K–12 STEM education in the country?

Ellen Futter

1. Please describe briefly the American Museum of Natural History's science, technology, engineering, and math (STEM) education programs and initiatives. In your experience, what unique role can museums and other informal education institutions play in educating students and the public about STEM? What role can museums play in supporting the teaching and learning of K–12 STEM both locally and nationally?
2. What partnerships has your museum built, with both local schools and other stakeholders, to address K–12 STEM education? How has your museum adapted its programming to meet the needs of schools and States? What have been the key factors to the success of such partnerships? How can museums best work with public and private sector stakeholders, including local schools, businesses, colleges, universities, and non-profits, to take on systemic reform of K–12 STEM education in a community or region?
3. What has been your experience with K–12 STEM education programs supported by the National Science Foundation or the other Federal agencies? What specific steps would you recommend the Federal Government take to improve the state of K–12 STEM education in the country?

Jeffrey Wadsworth

1. Please describe briefly Battelle's science, technology, engineering, and math (STEM) education programs and initiatives. In your experience, what unique role can businesses and corporations play in supporting the improvement of teaching and learning of K–12 STEM both locally and nationally?
2. What partnerships has Battelle been involved in, with both elementary and secondary schools and other stakeholders, to address K–12 STEM education? What have been the key factors to the success of such partnerships? How can business interested in promoting and improving STEM education best work with public and other private sector stakeholders, including local schools, businesses, colleges, universities, and non-profits, to take on systemic reform of K–12 STEM education in a community or region?
3. What has been your experience with K–12 STEM education programs supported by the National Science Foundation, the Department of Energy, or the other Federal agencies? What specific steps would you recommend the Federal Government take to improve the state of K–12 STEM education in the country?

Chairman GORDON. This hearing will come to order.

Good morning. I would like to welcome my fellow Committee Members and our distinguished panel of witnesses as well as all our guests here for what I know will be a valuable discussion on reform of K–12 science, technology, engineering and math, or STEM, education.

Our Committee has repeatedly heard that we need more STEM-educated graduates and teachers if we want to continue to be leaders in the global economy and maintain a high standard of living for all Americans.

As many of you know, in 2007 Congress passed and the President signed into law the Committee's landmark legislation, the *America COMPETES Act*. The COMPETES Act sought to ensure not only that our Nation will produce the world's leading scientists and engineers, but also that all students will have a strong grounding in math and science. Through the COMPETES Act, we expanded and strengthened the key teacher training programs, including the Robert Noyce Teacher Scholarship program at the National Science Foundation. As I am sure you all know, we used the Math for America model in establishing a new component of the Noyce program in COMPETES. We are fortunate to have Math for America's Founder, Dr. Jim Simons, with us here today.

COMPETES focused on improving teacher training, but there is still more work to do. This year our Committee is reauthorizing the *America COMPETES Act*. This reauthorization will give us the opportunity to strengthen existing programs and focus on ways to make more efficient and effective use of the limited resources we have to support real reform in STEM education. STEM education in this country is a problem that no one entity can solve alone. There is a role for all the key stakeholders, including Federal, state, local school districts, higher education and industry, and we must coordinate our efforts to leverage our resources.

The witnesses today represent a wide range of stakeholders in STEM education who have all been actively involved in efforts to improve K–12 STEM education, both locally and nationally. I look forward to hearing from them about how universities, private companies, nonprofits and other public and private stakeholders can work in partnership to bring about systematic reform in STEM education.

I want to thank all of the witnesses for your ongoing work and dedication to improving the quality of STEM education in this country, and for taking the time to appear before the Committee this morning. I look forward to hearing your testimony. And I think it is interesting that we have two expatriate Tennesseans here, the first Noyce scholar, who not only took that education into the academic area but also in the private sector, and I suspect has paid a lot of taxes that has reimbursed that Noyce scholarship since, and also the president of my nine-year-old daughter's favorite type of museum. So we have an excellent panel.

[The prepared statement of Chairman Gordon follows:]

PREPARED STATEMENT OF CHAIRMAN BART GORDON

Good morning. I'd like to welcome my fellow Committee Members and our distinguished panel of witnesses for what I know will be a valuable discussion on reform in K–12 science, technology, engineering, and math (or STEM) education.

Our Committee has repeatedly heard that we need more STEM educated graduates and teachers if we want to continue to be leaders in the global economy and maintain a high standard of living for all Americans.

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The witnesses today represent a range of key stakeholder groups in STEM education who have all been actively involved in efforts to improve K–12 STEM education, both locally and nationally. I look forward to hearing from them about how universities, private companies, non-profits, and other public and private stakeholders can work in partnership to bring about systemic reform in STEM education.

I want to thank all of the witnesses for your ongoing work and dedication to improving the quality of STEM education in this country, and for taking the time to appear before the Committee this morning. I look forward to your testimony.

Chairman GORDON. The Chair now recognizes Mr. Hall for an opening statement.

Mr. HALL. Mr. Chairman, thank you, and I see those Tennesseans. You know what I always tell you, I am graping up to you when I do that, how much Tennesseans meant to Texas, and I told the Chairman one time there wouldn't be a Texas if it hadn't been for Tennessee, and he said there wouldn't have been one anyway if the Alamo had had a back door to it. I never get ahead of the Chairman.

Well, I thank you, Mr. Chairman, for this hearing, and of course it is good for us to hear from such a distinguished group, particularly as we move forward on reauthorizing the Act. We have a difficult task in front of us with this forthcoming legislation. On the one hand, we know that making the appropriate investments in research, development, technology and math and science education including, of course, educating, motivating and inspiring our children about STEM, science, technology, engineering and math, subjects at a very early age are essential to our future economic prosperity. This country has long been the leader in innovation. I have no doubt that we are going to continue to be so. At the same time, we are faced with the stark reality that we have to strike a delicate balance between adequately funding our Nation's priorities while at the same time exhibiting fiscal restraint to reduce our ever-increasing deficit.

In the last COMPETES Act, we made great strides to improve K–12 STEM education in this country. As such, I believe we need to give these programs time to succeed before creating new ones. I am pleased to see that the President is trying to get the Department of Education to focus more on STEM programs but I am concerned that the National Science Foundation's unique and critical

role in K–12 has been somewhat diminished in the fiscal year 2011 budget request. It is not so much the case that we need to reform K–12 STEM education by continuing to seek new and innovative ways to capture our students' attention, as this Nation is full of good, solid examples of teachers, schools and communities that are getting it right. I refer to the Martha and Josh Morris Mathematics and Engineering Elementary School in Texarkana, Texas. It is just one of these schools. I know, Mr. Chairman, that I mention it often but you have been to that school with me and you know how innovative and successful it is, a true collaboration between the school district, the local university, industry, and the willingness of the community to embrace it.

Rather, we need to be able to figure out a way to share these successful programs, the tools they use and the various entities that came together to create them so that they can be replicated across the country without being heavy-handed on the Federal end. I know one size does not fit all but there are many good programs out there already in existence. I bet we are getting ready to hear about a few more, so with that, I would like to thank our witnesses for being here today and I look forward to your testimony.

Before I yield back the balance of my time, I would like to yield to somebody that is not here. I yield back to you, Mr. Chairman. Thank you.

[The prepared statement of Mr. Hall follows:]

PREPARED STATEMENT OF REPRESENTATIVE RALPH M. HALL

Thank you, Mr. Chairman, for calling this hearing today. It is good for us to be able to hear from such a distinguished group on what role each of their organizations play in improving K–12 STEM education, particularly as we move forward on reauthorizing the *America COMPETES Act*.

We have a difficult task in front of us with this forthcoming legislation. On the one hand, we know that making the appropriate investments in research, development, technology, and math and science education—including educating, motivating, and inspiring our children about STEM (science, technology, engineering and math) subjects at an early age—are essential to our future economic prosperity. This country has long been the leader in innovation, and I have no doubt that we will continue to be so. At the same time, we are faced with the blunt reality that we must strike a delicate balance between adequately funding our nation's priorities while at the same time exhibiting fiscal restraint to reduce our ever increasing deficit.

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I bet we are getting ready to hear about a few more, so with that, I would like to thank our witnesses for being here today, and I look forward to your testimony. I yield back the balance of my time.

Chairman GORDON. Thank you, Mr. Hall.

At this time I would like to introduce our witnesses. First, Dr. Jim Simons is the Founder and Chairman of Math for America and the Chairman of the Board of Renaissance Technology. Dr. Simons really is a good example of the evolution here of STEM education in that he started off, as I said, as the first Noyce scholar, then was successful in the academic area, then successful in the private sector, and now in a philanthropic way he is trying to give back through Math for America. So it really shows the evolution and how this is a good investment. Dr. Ellen Futter is the President of the American Museum of Natural History in New York City, and I would recommend to everyone that if you may go to New York for a play, for this or that, but if you are there, you should go to the Museum of Natural History. It is a great resource, and it is more than just a place to look, in that you have a lot of good programs there.

Now I would like to yield to my distinguished colleague from Ohio, Mr. Wilson, to make an introduction.

Mr. WILSON. Thank you, Mr. Chairman.

Today, ladies and gentlemen, I have the great privilege of introducing to the Committee Dr. Gordon Gee, a good friend of mine and the President of the Ohio State University. In addition to a previous tenure as the President of Ohio State, Dr. Gee has also served as the President of Vanderbilt, Brown, the University of Colorado and West Virginia University. I was proud to have two sons graduate from OSU during his first tour of duty there and hope to see a few of my grandchildren graduate during this tour of duty for you. For a guy who doesn't like to stay in the same place a long time, we are so glad that you are back at OSU. Welcome back, and thank you for being there.

Dr. Gee, I want to also thank you for your commitment to improving STEM education in the State of Ohio. Your innovative approaches have set an example for other universities and are why you have been asked to come here today and to speak to our Committee. And while I know testifying before this committee can't be half the fun that we had the last time when you and I journeyed to California for the Rose Bowl and saw the very successful Ohio State University perform, we are looking forward to hearing from you today and thank you so much for being here.

Thank you, Mr. Chairman.

Chairman GORDON. Thank you, Mr. Wilson.

I yield now to my distinguished colleague, Ms. Fudge, to introduce our fourth and final witness.

Ms. FUDGE. Thank you, Mr. Chairman.

Mr. Chairman, before I do that, since I am a proud alumnus of the Ohio State University, I too would like to welcome my president, President Gee.

It is my pleasure indeed today and I am very excited to introduce Dr. Jeffrey Wadsworth, CEO of Battelle Memorial Institute. Battelle has been the leader in Ohio STEM initiatives, and I have witnessed the results of these efforts firsthand when I attended the opening of the revolutionary MC Squared STEM High School in my district, Cleveland, Ohio. Battelle also manages the Ohio STEM Learning Network [OSLN], which is an unprecedented collabo-

rative aimed at building and connecting STEM teaching and learning capacity in regions across the State of Ohio. Cleveland serves as one of OSLN's five regional hubs, and I am truly astounded at the strength of the partnerships that are present in my district. I just want to say personally, having lived in Columbus for some time when I was a student at Ohio State, for a long time I never knew what Battelle was but I knew that it was important because it had the biggest buildings, the most beautiful campus, and people talked about Battelle all the time. So I want you to know, it is a pleasure for me to finally work with Battelle because I have been so impressed by what you have done for so very many years.

Dr. Wadsworth, thank you for your leadership in these efforts and I look forward to your testimony. Welcome.

Thank you, Mr. Chairman.

Chairman GORDON. Thank you, Ms. Fudge. I have just unfortunately been informed that it looks like we are going to have votes maybe a little bit before 11, so I want to try to move us forward and we can all get our questions in. Most importantly, we want to hear from the witnesses. So without any further discussion, Dr. Simons, please begin with your testimony.

STATEMENTS OF DR. JIM SIMONS, FOUNDER AND CHAIRMAN, MATH FOR AMERICA, CHAIR OF THE BOARD, RENAISSANCE TECHNOLOGIES LLC

Dr. SIMONS. OK. Well, thanks again, and I am over the mic, and Ranking Member Hall. You have heard who I am so I don't need to tell you again. I certainly appreciate the work that your Committee is doing and in particular we focus on the *America COMPETES Act* and the Noyce program, which we were fortunate enough to have us give some help to its shape, and we will get back to that soon.

I have submitted some written testimony but I will try to make my remarks even briefer since these votes are——

Chairman GORDON. We would rather hear from you than us, so you go right ahead.

Dr. SIMONS. Well, that is OK. Well, you know, it is clear that these economic wars are heating up between us and our competitors. We have a lot of advantages. You know, we have some important assets. We have big companies. We have a lot of money and we have great research universities. But what we lack, and what could do us in, is a lack of technically trained young people, because too few of our high school graduates go on to study math and science and engineering, just too few. And why is this? Well, I am going to argue here, but it is due to a lack of knowledgeable and inspiring high school teachers. So it comes down a little thing, relatively speaking: teachers who know their subject, and particularly in high school. And we just don't have enough of them. So I think the most cost-effective investment our government can make in the future of America is to ensure that secondary school teachers of math and science are knowledgeable in their fields, and simply due to the law of supply and demand, that is not the case today.

As a result, the quality of STEM education in our upper grades is far below that of our most formidable competitors. And if this situation is not soon remedied, our Nation will be fatally hobbled, and

I really mean that, as it strives to excel in a technology-based economy of this next century.

So what do we do today? How do we manage? Well, a combination of two things: we import people, and a lot of them, through various visa programs who can fill these gaps, and we export jobs to companies abroad by farming out the work that we do. There are just not enough trained Americans to fill these slots. Now, importing people is not a long-term solution. India and China, who supply a lot of these folks, are doing just dandy themselves and there will be more and more excellent opportunities for those people to stay at home, and you can already see that. And as far as exporting the jobs, exporting work, well, we will just end up having fewer and fewer high-margin companies in the United States. That is not a satisfactory outcome.

So what does it mean to be a technically trained person? Well, you have to get a bachelor's degree in math or science or engineering. But who chooses to major in those subjects? Well, someone who is prepared and inspired, that is who chooses it. Those subjects are hard, and there are a lot of less-strenuous things you can do in college besides become an engineer or a physicist or a biologist. Those are hard things. So why do people do it? They do it because they come out of high school enthused with a good background and excited about going into those fields. But if they are not so trained and excited in high school, they are just not going to make those majors.

Now, I want to look at you all on the Committee, and for that matter, whoever else is listening. So if you as an adult—I am assuming I am talking to adults—were to take a course, whether it was Italian, psychology or cooking, at the top of your list of expectations would be a teacher who knew the subject. No matter whatever marvelous qualities that instructor might have, if he or she didn't know the subject, you would feel cheated. Now, I have to tell you that in math and science, millions of American high school kids are cheated this way every day, and regrettably, due to their parents typically being unfamiliar with these subjects, most students and their parents never know the difference. You would know if your cooking teacher didn't know how to cook but you wouldn't necessarily know that your teacher who is supposed to be teaching you quadratic equations doesn't quite understand what factorization is all about or whatever.

Now, the most recent studies, and I am focusing on math here because that is what we pay attention to, it is pretty fundamental but it goes for science as well, these reports show that by 4th grade we do pretty well compared to other countries. We are better than average. By 8th grade, the end of 8th grade, we are about average. But by 12th grade, we are right at the bottom. We have gone right to the bottom. What happened? What happens between 9th and 12th grade that makes these students who were doing excellently or well in 4th grade, decently in 8th grade, why do they all of a sudden do terribly when they get to 12th grade?

Now, it is not a case of the underprivileged kids or whatever bringing the average down. In fact, our top 10 percent does worse than everybody else's top 10 percent, in fact, even worse than you

might expect by the differences in the average. So simply put, our kids do worse than our competitors' kids in every ability range.

So why is this? What happens to us? Why do we stand so low in these international rankings? Well, there may be more than one reason. But one reason really stands out. Other teachers' standards of content knowledge for teachers, countries' standards for content knowledge for teachers of math and science are far more stringent than they are in the United States, and this is particularly the case when it comes to the Asian countries where first-class STEM education is a high national priority.

Now, you can try to work around this. Various approaches have been proposed. You could have better technology in the classroom, lectures over the Internet, new curricula, kids lugging around even bigger books, and believe me, they are pretty big now. These initiatives might help some but there is no substitute for a teacher who actually knows what she is talking about and whose enthusiasm is inspiring, and I will bet everyone sitting up there today has had one or more teachers who has really made a difference in his or her life, whether it was in law school or wherever it may have been, someone who inspired you, and I am certain that no teacher would ever have inspired you if he or she didn't know the subject that they were teaching.

So what happens? Why don't we have enough teachers who know the subject in math and science in high school? And the answer is that teaching math or science in an American high school is simply not a very good job, measured both by compensation and level of respect. A person with the background and ability to do that job well can find many more attractive opportunities, and as the economy continues to increase its dependence on technology, this gap will only widen, and this is sort of the amazing thing. The very economy which is dependent on these people is stripping the classroom of those who can best train these people.

So I just want to digress for a second and bring you back to 1941. Now, I was three in 1941 and most of you were not around in 1941, but it was an interesting year because that is when we got into the Second World War and we needed to train a lot of pilots and we needed to do it fast because we didn't have anywhere near enough pilots in the Air Force. So when each class had completed its training, ready to go out to action, a few class members were kept behind to teach, and these were the best pilots on the class because the Air Force reckoned there was more value in their teaching than in their fighting, at least right away. After a while they went to war and showed their stuff, but even though if a guy became an ace, you know, shot down five planes, whatever, what do you think they did? They brought him back to teach. They brought him back to inspire the new guys coming along. So the Air Force understood that by and large, obviously there were exceptions, the best pilots made the best and most inspiring teachers.

And in this economic contest that we are getting ourselves into here big time, we do the exact opposite. The best go forth and the worst stay back to teach. Now, obviously there are exceptions. This is not every teacher in STEM education high school has no content knowledge. That is certainly not true. But too few do, and that is the problem. So there is really only one way to attract and retain

a higher quality math and science secondary school teacher: pay them more money and provide them with more respect. Now, anyone who runs a business understands that if you can't get enough welders or whatever it is or good ones, you are going to pay more and you get more good welders. But we don't seem to really understand that in the school situation. We just have to increase the compensation and the respect that these people get. Otherwise they ain't coming.

So we founded MFA [Math for America] six years ago as a pilot to address this, and I will just briefly say what we do, because I don't want to take away from Ellen, in particular, sitting next to me. We bring these kids in, typically young people but not all, into a fellowship program. We advertise. They come in, they take a test of knowledge. Do you know math? We give them a test. It is a good test. Then we interview them to see, gee, you know, would you do OK in a classroom, and if they pass those two things, we take them into the program. These are people who have typically majored in math or physics of engineering in college so they know the subject, they passed the test. We plunge them into a one-year immersion in education courses so they get a master's degree in education. They have the ticket and they can go and teach. We pay the tuition. We do this at Columbia or NYU in New York and other schools in California and so on. We pay the tuition. We give them a fellowship, $30,000, which is what you get as a teaching assistant somewhere if you were a graduate student, and then they go into the classroom, they teach four years as part of this program and we give them a stipend which escalates and ends at about $20,000 at the end of the fourth year and that is on top of their teacher's pay, and we give them lots of support in the meantime. We have seminars and lunches and all kinds of great things, and they get mentored by the people who come in on the other prong of the program, master teachers, and at the end of their four years of teaching they can apply to the next prong to become a master teacher, and a master teacher is a teacher who is already there who is an expert, considered very good by his peers and his principal, who passes the test. He or she knows his subject. And we pay them for two reasons. We pay them $15,000 a year on top of their salary and they have two responsibilities: one, keep teaching, and two, mentor the young people in the program who are coming along. And the spirit and the effect of this program is really dynamic, and I think Bart Gordon can testify to that. He came to our annual dinner of all the fellows and master teachers a few months ago and you could see, it was electric. It was really electric. These people were enthused about what they were doing. They were proud of what they were doing and accomplishing a great deal. So this is a model of a program. It is not the only way to do it, but nothing is going to work unless it includes more comp[ensation] and more respect.

So that is my message to you guys. Keep it up. The Noyce program is great. Let us make it bigger and let us find ways to really do this on a very big scale, whether it through Noyce or something else. This is a critical issue, a critical issue. OK.

[The prepared statement of Dr. Simons follows:]

PREPARED STATEMENT OF JAMES H. SIMONS

Good Morning Chairman Gordon, Ranking Member Hall and Members of the Committee. My name is Jim Simons and I am here today as the Chairman and Founder of Math for America (M*f*A) which was created to offset the alarming shortage of knowledgeable mathematics teachers in our public schools.

We appreciate your continued focus to improve mathematics and science education in our secondary schools and for recognizing the importance of a high quality science and math teaching workforce. The Congressional Innovation Agenda championed by this committee over the past two years, including the passage of the *America COMPETES Act*, has reinvigorated the essential role of math and science education in our country.

While I was especially pleased that Chairman Gordon, using the M*f*A model of stipends, scholarships and support, included an amendment to the COMPETES bill to substantially bolster the existing Robert Noyce Scholarship program, I strongly believe we need to continue to strengthen that effort during this reauthorization process.

Before talking about Math for America I wanted to give you a brief glimpse of my personal background and how mathematics has been the driving force in my life.

I am Chairman and Founder of Renaissance Technologies. The company's investment approach, fueled by my background in mathematics, has been enormously successful. Before I entered the business world, I was a mathematician. I have a Ph.D. from Berkeley, won the 1975 Veblen Prize of the American Mathematical Society and taught mathematics at Massachusetts Institute of Technology and Harvard University before becoming chairman of the mathematics department at the State University of New York at Stony Brook.

Along the way, I spent four years as a code breaker for the National Security Agency.

I serve as a Trustee of The Institute for Advanced Study, The Rockefeller University, MIT, the Mathematical Sciences Research Institute in Berkeley and Brookhaven National Laboratory. With my wife Marilyn, I am actively engaged with my charitable foundation, the Simons Foundation. Recently, we created The Simons Center for Geometry and Physics at Stony Brook which looks at the crucial interdependence between theoretical physics and the geometric side of mathematics. More recently, we initiated a Postdoctoral Fellows Program to support 68 postdoctoral positions at 46 universities. These will be three-year positions in mathematics, mathematical physics and theoretical computer science.

With Marilyn's leadership, the Simons Foundation seeks to advance math and science research through grant making that particularly encourages collaborations between the physical and life sciences. We fund studies aimed to heighten interchanges between institutions, across fields, and among scientists to facilitate the exchange of new ideas. I am especially proud of the significant work of the Simons Foundation Autism Research Initiative, which supports research to better understand the causes of autism. This initiative is the world's largest private investment in the field of autism research.

It's an honor for me to be here today to discuss strategies to improve student achievement by creating an environment that encourages people with high content knowledge in math and science to establish successful careers as public schools teachers.

Drawing a straight line from the problem to the solution, the simple answer for improving STEM education is to have the best, most knowledgeable teachers in the classroom. My thesis is that unless we meaningfully and immediately increase the level of respectability and compensation earned by secondary school mathematics teachers with strong knowledge in their subject, our nation will continue to lose its competitive edge in the technology based global economy of the 21st century.

Our economy is increasingly dependent upon technology that uses math as the starting point, and there are many private sector career opportunities for a young person with math skills and knowledge in finance, technology and research. Given that, flat salaries for teachers are thwarting the supply and demand. If we want knowledgeable mathematics and science teachers in the classroom, we must dramatically increase their compensation and give them the respect they deserve.

This is a supply and demand issue. It's clear that the widening salary gap, between quantitative skills based private sector jobs and teaching jobs in our secondary schools, has discouraged many capable people from launching a career in teaching. Taking that into account, as well as the unlikelihood that those private sector jobs will decrease their compensation in the years ahead, we instead need to increase teaching salaries to make teaching a legitimate career option. By doing so,

we are providing our students with the edge they need to keep the Nation competitive and progressive.

The relative weak ranking of US students in international assessment tests clearly demonstrates the urgency. The most recent TIMSS (Trends in International Math and Science Study) report shows that by the eighth grade, our students are rated average in mathematics, and by the twelve grade, they drop to near the bottom. Moreover, even our top 10 percent does worse when compared to the top 10 percent of most other countries. Research indicates that the best performing nations employ rigorous entry requirements and high standards for teachers, and that high performing students in math and science more likely had teachers with content-specific training. We are facing an economic onslaught of a highly competitive global workforce, causing us to fall behind to some measure because of the more rigorous teacher preparation policies of other countries—and it is these students who are outperforming our math and science students.

How do we solve this problem? The idealistic nature of many has sparked volunteerism and short-term programs to make an immediate, although temporary, impact. We need a long-term, sustainable solution to ensure that math and science teaching jobs are attractive so that teachers stay in the classroom and remain involved with education. Currently, about one-half of new mathematics teachers leave by the end of five years. Obviously, paying more is necessary, but giving teachers more recognition and respect are equally important components. Moreover, American schools and policymakers must do better. There is a preponderance of top down solutions and slogans, mostly related to testing data, standards and curriculum that does not get to the heart of the problem. We need to go directly to the center of the issue-ensuring that we have inspiring and knowledgeable teachers in the classroom.

Math can be difficult to understand and explain. Excellent teachers know and love their subjects. Outstanding teachers will not merely follow the material in a lesson plan or teach to the test, but instead will sufficiently and intelligently answer questions that enthusiastically encourage and engage students to seek further inquiry. This is not a question of the number of teachers. This is about knowledgeable teachers who are impacting the lives of countless students every day. Students today need the necessary mathematical and scientific tools to learn and think critically and analytically in order to be adequately equipped for the jobs of the future.

Having briefly touched on the roots and barriers of our national STEM educational crisis, I would like to focus on our approach to the solution and tell you about Math for America. We sponsor three Fellowship programs make teaching jobs more attractive through financial rewards, recognition and respect.

Our endeavor in starting Math for America in New York City in 2004 was to create a pilot program for a national model. M*f*A is a private nonprofit organization with a mission to improve math education in US public secondary schools by recruiting, training and retaining outstanding mathematics teachers.

Along with New York City, we have sites in Boston, Los Angeles, Berkeley, San Diego and Washington, DC. We are currently negotiating with several other cities and states interested in joining our network. We are ready to grow and provide substantial matching funds for those efforts while looking at existing state and Federal programs to best leverage our impact. For example, M*f*A sites in Boston, Washington, DC, Los Angeles and San Diego were recently awarded National Science Foundation Robert Noyce Teaching Fellowships and Master Teaching Fellowships grants. That NSF support, leveraged by the M*f*A commitment, is expected to have a significant impact on their work.

M*f*A offers Fellowships for both new and experienced teachers, including the M*f*A Fellowship which aims to increase the number of mathematically talented individuals entering the teaching profession, as well as the M*f*A Early Career Fellowship and M*f*A Master Teacher Fellowship, which support outstanding mathematics teachers already in the classroom. To date, we have more than 300 teachers in the program with about 100 additional Fellows and Master Teachers poised to enter the program this spring.

The M*f*A Fellowship is a five-year program where recent college graduates and mid-career professionals make a commitment to teach math in public secondary schools. M*f*A Fellows are mathematically sophisticated individuals who are new to teaching and use their talents to make a difference in students' lives. The program includes one year earning a master's degree in education and four years of teaching math in public secondary schools. The M*f*A Fellowship provides a full tuition scholarship, annual stipends of up to $100,000 over five years, in addition to a full time teacher's salary, and mentoring and professional development services. During the fifth year, Fellows may apply to become Master Teachers.

The M*f*A Early Career Fellowship, a pilot program, provides professional support and growth opportunities to current new teachers of secondary mathematics in a public school or recent graduates of education training programs who are certified to teach and have secured an eligible job. The four-year program includes annual stipends of up to $70,000 over four years, camaraderie with a cohort of outstanding secondary math teachers, mentoring and professional development support.

The M*f*A Master Teacher Fellowship rewards exceptional public secondary school math teachers with a four-year Fellowship in New York City. The Master Teacher Fellowship includes annual stipends of up to $60,000 over four years, professional development and leadership opportunities and support for mathematical and educational interests.

M*f*A staff, along with part-time New Teacher Advisors and Master Teachers, provide Fellows with regular professional and instructional support and guidance. M*f*A also hosts a variety of workshops and seminars to keep Fellows connected to one another and learn new math and education skills and strategies. Selected meetings are open to the public and Fellows are encouraged to bring colleagues and other department members. In addition, M*f*A urges Fellows and Master Teachers to create professional development sessions and attend and present at local and national conferences.

The M*f*A Fellowships and M*f*A Master Teacher Fellowship are based on three key principles:

- To teach math effectively, one needs a strong knowledge of mathematics, solid pedagogical skills and a desire and ability to interact with young people.
- Generous incentives make it possible to recruit highly qualified individuals into teaching and to retain outstanding mathematics teachers.
- By providing strong support services, including continuing education, mentoring and professional development, it is possible to inspire a commitment to a long-term career as a mathematics teacher.

We have established extensive partnerships with universities and school districts at each program site to provide our Fellows with the best resources and education and continuously improve overall secondary mathematics education in these public schools. In addition, working with other math education stakeholders, we created a Professional Development and Outreach (PDO) group with the Park City Math Institute to support mathematics teachers in the five boroughs through workshops and outreach activities. M*f*A Los Angeles has also worked with Harvey Mudd College and the Park City Math Institute to establish the Harvey Mudd Professional Development and Outreach Group for mathematics teachers in the Los Angeles area. It's this kind of collective effort that builds a sense of purpose, self respect and recognition that their work, as teachers, is meaningful and important.

We have found that this injection of teachers—who are highly knowledgeable and passionate about math—into public schools directly helps students, while also encouraging and inspiring other teachers, schools, districts and parents. And, by creating a community of like-minded mathematicians in the classroom, we have watched the important role of esprit de corps in fostering our mission and impact.

When Sputnik went up fifty years ago it shook our country because we were underprepared in Defense. Quick and effective congressional action, including the National Defense Act, which helped me get my Ph.D. in 1961, remedied that by creating an outstanding pool of scientists and mathematicians. Today, we are facing a vastly different and more difficult challenge with both our economic and national security threatened and our role as a leader of innovation and ingenuity considerably lessened. We must find a way to meet that challenge, and the ideas that underlay Math for America suggest a way to do this.

M*f*A attributes much of its success to its commitment to providing professional enrichment opportunities, developing leaders and creating a strong community of mathematics teachers. I believe this can be done on a national level through the creation of a Math Science Teaching Corps (MSTC). In 2006, this notion was introduced by my friend, Congressman Jim Saxton and perhaps it's time to revisit that effort. The Robert Noyce Teacher Fellows and Master Teaching Fellows Programs, which encourage talented science, technology, engineering, and mathematics majors and professionals to become K–12 mathematics and science teachers, could become a pilot program for such a national corps.

Thank you again for the opportunity to testify before the Committee and for your work over the past two years under the leadership of Chairman Gordon. I intend to continue my modest contribution to make M*f*A successful in New York City and around the country by working with the NSF and other entities. We greatly appreciate your efforts as you go through the reauthorization process of the America

COMPETES Act. I believe private sector support combined with a robust Federal Government commitment will achieve results.

BIOGRAPHY FOR JAMES H. SIMONS

Dr. James H. Simons is President of Euclidean Capital, a family office, and Board Chair of Renaissance Technologies LLC, a highly quantitative investment firm, from which he retired in 2009 after many years as CEO. Previously he was chairman of the Mathematics Department at the State University of New York at Stony Brook. Earlier in his career he was a cryptanalyst at the Institute of Defense Analyses in Princeton, and taught mathematics at the Massachusetts Institute of Technology and Harvard University.

Dr. Simons holds a B.S. in mathematics from the Massachusetts Institute of Technology and a Ph.D. in mathematics from the University of California at Berkeley. His scientific research was in the area of geometry and topology. He received the American Mathematical Society Veblen Prize in Geometry in 1975 for work that involved a recasting of the subject of area minimizing multidimensional surfaces. A consequence was the settling of two classical questions, the Bernstein Conjecture and the Plateau Problem. Dr. Simons' most influential research involved the discovery and application of certain geometric measurements, now called the Chern-Simons Invariants, which have wide use, particularly in theoretical physics.

Dr. Simons is the founder and Chairman of Math for America, a nonprofit organization with a mission to significantly improve math education in our nation's public schools. He serves as Trustee of Brookhaven National Laboratory, the Institute for Advanced Study, Rockefeller University, and the Mathematical Sciences Research Institute in Berkeley. He is also a member of the Board of the MIT Corporation and Chair Emeritus of the Stony Brook Foundation. Together with his wife, Marilyn, Dr. Simons manages the Simons Foundation, a charitable organization primarily devoted to scientific research.

The Foundation's philanthropic activities include, in addition to Math for America, a major research initiative on the causes of autism, and the recent establishment of an institute for research in mathematics and theoretical physics. The Foundation is particularly interested in the growing interface between the physical and life sciences and has established and endowed several such research programs at universities and institutions both in the U.S. and abroad. Dr. and Mrs. Simons have also privately launched and funded a country wide health care and training program in Nepal.

Chairman GORDON. Thank you, Dr. Simons. Mr. Hall leaned over to me and said, "That guy makes a lot of sense."

Ms. Futter, you are recognized.

STATEMENTS OF MS. ELLEN FUTTER, PRESIDENT, AMERICAN MUSEUM OF NATURAL HISTORY

Ms. FUTTER. Thank you very much. Chairman Gordon, Ranking Member Hall and distinguished Members of the Committee, it is an honor to have the opportunity to testify before you today.

I would like today to offer a way to support schools in improving science education, and that is the unique and powerful role that informal science education institutions like the American Museum of Natural History, that we are delighted your daughter has enjoyed, as well as other science centers, zoos, botanical gardens, aquaria and other science-based cultural institutions can play and increasingly are playing in improving the teaching and learning of science and enhancing science literacy more broadly among the general public including particularly tomorrow's workforce.

Schools will of course remain at the center of efforts to reform science education but they cannot and need not shoulder this responsibility alone. Institutions like the American Museum of Natural History, which are grounded in authentic science and have collections of real specimens and artifacts as well as working scientists and educational expertise, and are today building innova-

tive partnerships with schools that seek to empower teachers and improve student achievement. These efforts are transforming the definition of the schoolhouse by providing access to educational resources beyond the school walls, and in the process are redefining science education itself.

Museums and similar institutions have always been places of inspiration, and inspiration and awakening curiosity have long been recognized as the gateway to learning. Building on that awakening, however, is absolutely essential to achieving enduring improvement in science education, and institutions like ours have a strong role to play in this respect. We are pleased to join others, including the Carnegie-IAS Commission and Race to the Top, in pointing to museums and like institutions as catalysts for both STEM education reform and cross-sector partnerships.

One such partnership is Urban Advantage. Based on the idea that urban settings have a wealth of educational resources embedded in the assets of community science-based institutions, the American Museum of Natural History developed and now leads a pioneering eight-institution collaboration with the New York Hall of Science, New York Botanical Garden, Brooklyn Botanic Garden, the Queens Botanical Garden, the Bronx Zoo, the Staten Island Zoo, the New York Aquarium together with Joel Klein and the Department of Education, with support from Council Speaker Christine Quinn. Urban Advantage was designed to assist 8th graders in completing their Exit Project, which is a city-mandated science investigation. The program provides the following vital components: professional development for teachers, classroom resources and equipment for schools, access to partner institutions' expertise and resources, family engagement through educational outreach, capacity building with lead teachers, leadership and demonstration schools, national and local science standards built into the program design, ongoing formal assessment of formal program goals, student learning and systems of delivery, and, to serve New York City's diverse student population, the program combines rigor with equity and access. In its sixth year, Urban Advantage currently supports over 300 teachers in more than 150 middle schools. That is over one-third of New York City middle schools and it serves more than 37,000 students.

Two other programs are priorities of the Museum's STEM education strategy. First, to echo Mr. Simons' emphasis appropriately on teachers, professional development of teachers through partnerships with institutions of higher learning. Today the Museum educates more than 3,300 pre- and in-service teachers and those seeking certification on site and online annually. Second, what we call the science generation pipeline, a continuum of out-of-school science learning opportunities that serve audiences ranging from children as young as two and their parents to high school students who are matched with science mentors and conduct research. And our mission in this regard is not unique to us. There are many other exemplary programs across the country: Washington State's LASER program led by the Pacific Science Center, the Arkansas Discovery Network, the Daily Planet program of the North Carolina Museum of Natural Sciences.

With the Federal Government's vital assistance, these programs can be multiplied to achieve broad-scale change through the following actions. First, grant competition should be designed to foster cross-cultural partnerships including with informal education institutions. Second, the *America COMPETES Act* should explicitly refer to the role of informal institutions, including by providing access to funding, and of course, Congress should fully fund the Act. Third, we support the development of common standards. Fourth, these standards should be matched with state and local assessments and also should be internationally benchmarked.

In sum, communities across our country have access to an array of science-based institutions, great institutions, some large, some small, some local, some regional, but nearly all housing phenomenal resources and expertise to help schools improve science education while also promoting and advancing instincts for inquiry and discovery that are precisely what drive innovation and will fuel our country's global competitiveness. We as a field stand ready to play a larger, more formal, structural and leadership role.

I thank you for the opportunity and look forward to your questions.

[The prepared statement of Ms. Futter follows:]

PREPARED STATEMENT OF ELLEN V. FUTTER

Chairman Gordon, Ranking Member Hall, and distinguished members of the Committee, my name is Ellen Futter and, as President of the American Museum of Natural History, it is an honor and a pleasure to have the opportunity to testify before you on the topic of "Reform in K–12 STEM Education."

As you are well aware, the United States has a history of unparalleled innovation in science, technology, engineering, and mathematics that we are in danger of squandering. In these remarks, I will offer a way to support schools in improving science education, and to expand their access to vital resources for doing so. Specifically, I would like to describe the unique and powerful role that so-called informal science education (ISE) institutions like the American Museum of Natural History—other natural history museums, science centers, zoos, botanical gardens, aquaria, and other science-based cultural institutions—can play and increasingly are playing in improving the teaching and learning of science and science literacy more broadly among the general public, including tomorrow's workforce. These institutions have a wealth of resources and, as a field and sector, we stand ready to bring those resources to bear on the science education crisis in new ways, joining forces with formal education institutions and other key players to reform STEM education.

The need for systemic, long-term change in K–12 education is well recognized and has been underscored by several major national commissions in the past few years, including: the National Academies' "Rising above the Gathering Storm"; the National Science Board's "A National Action Plan"; the National Governors' Association report "Innovation America"; and the Carnegie–IAS Commission on Mathematics and Science Education's "Opportunity Equation."

American Museum of Natural History

Founded in 1869 as an institution of scientific research and education, and chartered as an educational institution by the New York State Board of Regents, the American Museum of Natural History, located in New York City, is today one of the world's foremost centers of research and education in the natural sciences, the physical sciences, and anthropology. The Museum's mission is: "to discover, interpret, and disseminate—through scientific research and education—knowledge about human cultures, the natural world, and the universe." The Museum welcomes approximately four million visitors annually onsite and was voted the third most popular family destination in the nation, and the first non-commercial enterprise on the list, in the Zagat Family Travel Guide.

The Museum is home to one of the world's most important natural history collections, including traditional collections of more than 32 million specimens and artifacts and new forms of collecting such as frozen tissue and scientific data. Together they constitute an invaluable and irreplaceable record of life on Earth. The Museum

has a scientific staff of more than 200, led by over 40 curators (tenure or tenure-track positions). In 2006, the Museum was authorized by the New York State Department of Education as the first American museum authorized to grant the Ph.D. degree. With this, the Museum launched the Richard Gilder Graduate School, which embraces both a new doctoral program in comparative biology and maintains the Museum's longstanding graduate training partnerships with such universities as Columbia, Cornell, New York University, and City University of New York. The Ph.D. program in comparative biology has now admitted two classes of students and is fully accredited.

The Museum's robust scientific enterprise, with a century-plus record of leadership in field science, theoretical science, and the professional training of scientists, provides the foundation for a wide range of public outreach and educational initiatives including professional development for teachers, permanent halls, temporary exhibitions and space shows (which travel both nationally and internationally), public programs, major conferences, and special seminars and symposia.

The scientific enterprise provides the foundation for the Museum's extensive educational program that serves learners of all ages, backgrounds, and levels of preparedness—both onsite and online. Pre-school children and their parents and caregivers are introduced to scientific investigations through collaborations with community-based organizations and through programs onsite in the Museum's Discovery Room. The Museum has extensive partnerships with the New York City school system and schools nationwide. It is the most-visited field trip destination for New York City public schoolchildren, who visit the Museum free of charge. Each year, approximately 400,000 children visit in organized class or camp groups. Visiting groups and their teachers are supported with a wide range of pre- and post-visit materials. Middle and high school students participate in an array of programs after school, on weekends, and during the summer, including an intensive program of independent research for high school students working under the supervision of Museum scientists.

The Museum is also a leader in professional development of primary and secondary school teachers, having made the strategic decision to focus on teachers as a way to ameliorate the crisis in preparing, supporting, and retaining science teachers nationwide. The Museum provides institutes, courses, and programs—both onsite and online—to more than 3,300 teachers a year. All programs are developed by scientist-educator teams and many offer graduate credit. I will describe several of these initiatives shortly.

At the American Museum of Natural History, science education is distinguished by a focus on authentic science experiences that expose teachers and students to the scientific process, including inquiry, investigation, evidence and data collection, and analysis, while also elucidating key scientific concepts. The overarching aim is to enhance science literacy for all people, especially children, to inspire full citizenship and informed participation in life; for families, who are key to children's college and career choices; and for those children who will become tomorrow's scientists or work in the STEM fields.

Informal Science Education Institutions

Schools will of course remain at the center of all efforts to reform K–12 STEM education, but they cannot and need not shoulder this responsibility alone. Indeed, in the face of this seemingly intractable STEM education problem, we must think more broadly about what constitutes an educational setting and how best to enhance the scientific resources currently available to schools. Each science-based institution has a unique and valuable combination of assets and resources to offer. Institutions like the American Museum of Natural History are grounded in authentic science, and provide access to collections of real specimens and artifacts—"the power of reality," ranging from the 65-million-year-old *T. rex* to a 34-ton meteorite to a towering totem pole—along with working scientists, laboratories and equipment, and extensive educational expertise, including many decades of experience interpreting and presenting complex topics in science for a broad public in ways that inspire, engage, and educate.

Science-based cultural institutions of all kinds are building innovative partnerships with schools, governments, corporations, foundations, and other entities that seek not only to educate teachers and improve educational outcomes for students, but, equally important, to create sustained learning opportunities that span not only a child's week and year, but his or her entire life. These efforts are transforming our definition of the schoolhouse by providing access to educational resources beyond the school walls—from museums and similar institutions—and are also, in the process, redefining science education itself.

Museums and similar institutions have always been places of inspiration that enjoy a special connection with the public, one that is marked by trust, familiarity, and enjoyment. Inspiration and awakening curiosity have long been recognized as the first, essential stop, or gateway, to learning. Building on that awakening, however, is equally critical to enduring improvement in science education, and institutions like the American Museum of Natural History have a strong role to play in that regard as well. We join the chorus of voices, including the Carnegie–IAS Commission on Mathematics and Science Education, on which I was privileged to serve, and the Race to the Top initiative, in pointing to museums and other science-based institutions not only as powerful catalysts of STEM education reform but as uniquely qualified to forge and sustain cross-sector partnerships.

There is a growing understanding of the key role informal science education institutions can play in addressing the crisis in STEM education. "Opportunity Equation," the 2009 report of the Carnegie–IAS Commission on Mathematics and Science Education explicitly points to ISE institutions: "Programs [at a growing universe of museums] are giving hundreds of thousands of students and teachers access to museum collections and staff expertise—along with powerful insights into what people find most fascinating about science." [1] The National Research Council's 2009 "Learning Science in Informal Environments: People, Places, and Pursuits" recognizes the important learning that occurs in out-of-school settings and articulates approaches to the complexities involved in assessing outcomes.[2]

Importantly, the Federal Race to the Top initiative, funded as a $4.3 billion initiative in the ARRA (American Recovery and Reinvestment Act), explicitly recognizes the valuable role museums and similar institutions can play in reforming STEM education: the program provides for a single competitive preference priority for STEM education, and it specifically includes museums, calling on States not only to "offer a rigorous course of study in mathematics, sciences, technology, and engineering" but also to "cooperate with industry experts, museums, universities, research centers, or other STEM-capable community partners to prepare and assist teachers in integrating STEM content across grades and disciplines, in promoting effective and relevant instruction, and in offering applied learning opportunities for students . . . ." [3] It cannot be overstated how significant and historic this inclusion is.

Exemplar STEM Programs

The community of science museums and other ISE institutions is deeply engaged in the national call to accelerate solutions to the crisis in STEM education. Many of the directions undertaken by the Museum and similar institutions across the Nation are built on a partnership model—among science-based institutions and school systems, local governments, institutions of higher education, and other entities. These institutions, with their unique resources, collections, working scientists, labs and equipment, and educational and interpretive expertise are increasingly taking the lead in building and managing these partnerships, and municipalities are increasingly looking to these institutions for educational leadership as are families and local communities.

Exemplar Programs at AMNH

Following are a few examples of American Museum of Natural History-led partnerships that are working to improve the teaching and learning of science, both locally in New York City and on a wider scale. All these partnerships are characterized by the collaboration of scientists and educators; the utilization of Museum resources including exhibitions, collections, public programs, and digital resources; and access to online educational resources. In addition, and importantly, national and local science standards, assessments, scope and sequence, and other forms of demonstration are built into the design so that these offerings directly support the work of teachers. Because New York City's population and student population are so diverse there is great emphasis on combining rigor with equity and access in these partnerships and programs.

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[1] Carnegie–IAS Commission on Mathematics and Science Education. *The Opportunity Equation: Transforming Mathematics and Science Education for Citizenship and the Global Economy*. New York, NY: The Carnegie Corporation of New York, 2009.

[2] Bell, Philip, Bruce Lewenstein, Andrew W. Shouse, and Michael A. Feder (eds). *Learning Science in Informal Environments: People, Places, and Pursuits*. Washington, D.C.: The National Academies Press, 2009.

[3] "Race to the Top Funds: Notice of Proposed Priorities." *Federal Register* 74:144 (29 July 2009) p. 37806.

Urban Advantage

Over six years ago, the Museum began to analyze the status of science education in New York City's public middle schools. The middle school years are considered a "sweet spot"[4] when children either develop a sustained interest in science or, too often, turn away from science altogether. Findings[5] pointed to a severe shortage of qualified science teachers, which coincided with a new City mandate requiring all eighth-graders to complete a long-term scientific investigation known as the "exit project" before progressing to ninth grade.

These findings led to the development of Urban Advantage (UA), a keystone program of the Museum's Gottesman Center for Science Teaching and Learning. Based on the notion that urban settings often have a wealth of educational resources in the assets of the local science-based cultural institutions that schools could more effectively draw upon, UA is a pioneering, eight-institution collaboration with the American Museum of Natural History as lead institution and including the New York Hall of Science, the New York Botanical Garden, the Brooklyn Botanic Garden, the Queen Botanical Garden, the Bronx Zoo, the Staten Island Zoo, and the New York Aquarium, together with the New York City Department of Education under the leadership of Chancellor Joel Klein, and launched with support from the New York City Council and Speaker Christine Quinn, along with private funders.

UA incorporates professional development for teachers; classroom resources; laboratories and equipment for schools; access to the assets of the partner institutions for teachers, students, and families; educational outreach that specifically engages families; capacity building with lead teachers, school leadership and demonstration schools; and, importantly, ongoing assessment of program goals, student learning and systems of delivery.

UA has increased in scope and reach each year since it was piloted in 2004. It began with 60 teachers and 35 schools and now, in its sixth year, supports over 300 teachers in more than 150 middle schools—fully one-third of all New York City public middle schools—and serves more than 37,000 New York City students.

Museums and other similar institutions are increasingly incorporating assessment of the effectiveness of STEM education programs into the program design, and Urban Advantage places high priority on outcomes assessment. Preliminary evaluations support the initiative's primary goal of improving student understanding of scientific inquiry as defined in the New York State Core Curriculum. Sample findings include the following: 83% of UA teachers have observed evidence of improvement in the quality of UA students' science content knowledge; and 80% of UA teachers have reported increased understanding of the process of scientific investigations. The program is also fueling new levels of partnership among the collaborators and the New York City Department of Education in creating effective professional development for science teachers, and has led to increased visitation rates to the institutions by science classes and families.

Professional Development of Teachers

Since the quality of a student's experience with science is largely determined by his or her science teacher, the professional development of both pre- and in-service teachers is a key priority in the Museum's STEM education strategy. The National Academies' "Rising above the Gathering Storm" states that "few factors are more important than [high quality K–12 mathematics and science instruction] if the United States is to compete successfully in the 21st century."[6] Science-based institutions not only can bridge teachers to science content, but, more importantly, they can bridge teachers to the actual practice of science and to working scientists. Teachers who have practiced inquiry-based investigations themselves—and who understand the scientific method—are far more capable of and likely to foster such learning behavior in their students.

Partnerships at the K–12 and the university levels are essential in the Museum's professional development programs. The Museum currently serves up to 200 teachers each year through higher education partnerships with degree-granting programs, and more than 3,300 a year through various other professional development

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[4] Carnegie Council on Adolescent Development, Task Force on the Education of Young Adolescents. *Turning points: Preparing American Youth for the 21st century*. Washington, D.C.: Carnegie Council on Adolescent Development, 1989.

[5] Poitier, Johanna Duncan. *Progress Report on Teacher Supply and Demand*. Report to the Higher Education Committee of the State Education Department. Albany, NY: University of the State of NY, 2008.

[6] National Academy of Sciences, The National Academy of Engineering, and The Institute of Medicine. *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future*. Washington, D.C.: The National Academy of Sciences, 2007.

programs at the Museum and online. The Museum collaborates with a number of local colleges and universities, including Bank Street College of Education, Teachers College Columbia, Barnard College, and three City University of New York (CUNY) schools (Lehman, Brooklyn, and Hunter Colleges). These partnerships take various forms, including customized courses; supervised internships in science and museum education; thesis and dissertation advisement; Summer Institutes in Earth, space, and biological sciences; and online science courses in the biological, physical, and Earth sciences. These courses are co-developed with faculty from each institution to determine which Museum components add value and resources that enhance the experiences of participants.

With support from an NSF Teacher Enhancement grant in 2004, the Museum developed the Teacher Renewal for Urban Science Teaching program (TRUST), a partnership with Lehman and Brooklyn Colleges (of CUNY), to establish a Museum-based component of their Master's programs in Earth science. NSF's initial support was critical to the full development and implementation of the Museum's partnerships with institutions of higher education; not only did it enable the program to prepare 120 new Earth science teachers, it also provided the necessary resources and support for the Museum to develop successful and sustainable program models. It also enabled the Museum to leverage this support to obtain foundation funding for a similar program for biology teachers in partnership with three of the CUNY colleges. This model and these partnerships have since become institutionalized and self-sustaining, supporting state certification in Earth and biological sciences. They also have spurred the creation of additional collaborations and partnerships with other area colleges and universities, including Teachers College Columbia, Bank Street College of Education, and New York University.

The Museum also reaches out to teachers across the country and increasingly around the world through Seminars on Science, an online teacher education initiative. Serving more than 1,300 teachers in 2009, the program currently offers eleven online science courses, co-taught by Museum scientists and science educators, covering areas in the biological, Earth, and physical sciences. Several institutions across the country award graduate credit for these six-week courses, and four universities specifically include them as part of the teacher preparation and certification programs: Bank Street College of Education, CUNY School of Professional Studies, Brooklyn College, and Western Governors University.

The Science Generation Pipeline

One key dimension that museums and similar institutions offer is the ability to provide a sustained exposure to the actual practice and excitement of science and discovery—revealing for children, as well as their teachers and families, the thrilling quest that science really is. To that end, the Museum has developed and launched the Science Generation Pipeline, a complete pre-K through graduate school continuum of exceptional out-of-school science-learning opportunities. The Pipeline offers educational programs ranging from the Science and Nature Program, where parents and children as young as two are exposed to and engage in science together, to the Science Research Mentoring Program, where a highly diverse cohort of high school students are paired with scientist mentors to conduct authentic research in museum laboratories and collections.

Exemplar Programs at Other ISE Institutions

There are many other examples of effective and innovative model partnership programs at institutions and communities across the country.

In Washington state, for example, the Pacific Science Center is the lead institution for the Washington LASER (Leadership and Assistance for Science Education Reform) program. The program, which aims to improve science teaching and learning through teacher professional development, curricular and material support, and leadership training, was created in 1999 as an NSF-funded dissemination and implementation project.

The Arkansas Discovery Network was created in 2003 to make hands-on, interactive museum experiences more accessible to schoolchildren and their families throughout Arkansas. The Discovery Network provides geographic coverage across the state, is composed mostly of ISE institutions, and supports the state's STEM agenda.

As of January 2009, the North Carolina Museum of Natural Sciences provided all of the state's schools with access to high definition programming of breaking news in science and the environment through a program called the Daily Planet.

The Role of the Federal Government

With all these "islands of innovation"[7] throughout communities across the country, how can these model programs be transformed into catalysts for broad-scale change? And what role can the Federal Government play in supporting the role of ISE institutions and fostering effective partnerships that integrate formal and informal educational institutions?

I should first stress that the American Museum of Natural History and the informal science education community have enjoyed significant and important support from NSF, NASA, NOAA, and NIH for educational initiatives, and we are most grateful for it.

Beyond that, however, grant competitions should be designed to foster K–12 STEM partnerships such as those described here among formal, informal, and private entities. Moreover, the value of learning in out-of-school settings—and the institutions that provide those opportunities—must be recognized and should be represented in discussion and policy development regarding STEM education, as you have done here today, and ISE institutions also must be made eligible for funding in programs that relate to these discussions.

The fact that the Race to the Top Program specifically encourages states to look to museums and other community partners in their STEM reform efforts is an important milestone, as is the STEM education work of this Committee. However, there have been several very alarming efforts to exclude museums and other informal institutions from participating at all. While museums can participate in American Recovery and Reinvestment Act programs, zoos and aquaria have been excluded; and there have been efforts to impose similar restrictions in other legislation.

Concerning reauthorization of America Competes Act that this hearing is focused on, the Act currently makes no reference to informal education. For the reasons stated, it is imperative that the Act recognize the role of informal institutions and refer to them explicitly, including by providing access to funding. And it is essential that Congress fully fund the Act.

In addition, as recommended by the Carnegie–IAS Commission, common math and science standards that are "fewer clearer and higher" and susceptible to assessment should be developed. Such standards should be matched with state and local assessments that tie to authentic science teaching and learning. And such state accountability assessments should be internationally benchmarked to assessments such as TIMSS (Trends in International Mathematics and Science Study) and PISA (Programme for International Student Assessment), and to the Nation's Report Card, the National Assessment of Educational Progress.

As an overarching point, efforts to reform STEM education suffer from lack of coordination among the Federal agencies. In this regard we support efforts to provide for government-wide coordination, as embodied in the bill H.R. 1709, STEM Education Co-ordination Act of 2009.

Experience with NSF and other Federal Agencies

The National Science Foundation's role is unique among the Federal agencies—in science education, its scope is comprehensive, embracing K–12 through graduate and lifelong learning, in both formal and informal settings. NASA, NOAA, and other science agencies, in turn, each contribute their own area of science and are critical to the Federal Government's overall STEM education capacity.

The Museum has been tremendously grateful for the support of NSF, NASA, NOAA, and NIH, which has been essential to some of our key partnership programs, as mentioned above.

Also with NSF support, we are currently able to carry out, with our Urban Advantage partners and Michigan State University, education research that will advance knowledge and practice of middle school science education, including building a greater understanding of the role of ISE institutions, and the role of inquiry-based education in supporting student learning and science literacy for teachers, administrators, and families.

Similarly, with support from the NSF ITEST Program and NASA's Competitive Program for Science Museums and Planetariums, we have been able to launch and assess the innovative Student Research Mentoring Program, described above. NASA has also generously supported our digital space shows which engage millions of viewers worldwide, while NOAA's support has enabled us to improve public understanding of climate change.

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[7] Carnegie–IAS Commission. *Opportunity Equation*. 2009.

I referred earlier to the importance of ISE institutions' interpretive and educational expertise and I return to this point here to stress that these institutions can play a powerful role in translating and interpreting current science and research for the public. NSF (and other Federal agencies) should fully tap this enormous and sophisticated outreach capacity.

In conclusion, I am gratified by the increasing recognition of the unique and powerful role that museums and similar institutions can play in reforming K–12 science education. Communities throughout the country have an array of science-based institutions—some large, some small, but nearly all housing resources and expertise that can enable schools to improve K–12 science education. As a field, institutions like ours are prepared and eager to take a larger, more formal, structural, and leadership role.

What institutions like the American Museum of Natural History have long done so well, and which is in many ways the hardest part to get right, is awaken wonder and curiosity. Today, and this is essential, this is amplified and extended by our demonstrated ability to create opportunities for sustained exposure to exploration and inquiry. We do so by sharing the power of discovery and real science with teachers, students, and families, providing a platform for sustained inquiry and learning that, in turn, enables schools to be vastly more effective. By increasingly working in cross-sector partnerships, the full value and promise of this approach can be realized and brought to scale. And, importantly, the instinct for inquiry and discovery that this approach nurtures is also precisely what drives innovation and will fuel our country's global competitiveness.

Thank you, Chairman Gordon, Ranking Member Hall, and all the Committee members for your time and for the opportunity to speak before you today. I look forward to answering your questions.

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BIOGRAPHY FOR ELLEN V. FUTTER

Ellen V. Futter has been President of the American Museum of Natural History since 1993. Before joining the Museum she served as President of Barnard College for thirteen years, where, at the time of her inauguration, she was the youngest person to assume the presidency of a major American college. Committed to public service, Ms. Futter serves on the boards of several non-profit and for-profit organizations. She is a fellow of the American Academy of Arts and Sciences and a member

of the Council on Foreign Relations and the American Philosophical Society. She has received numerous honorary degrees and awards. Ms. Futter graduated Phi Beta Kappa, magna cum laude, from Barnard in 1971 and earned her J.D. degree from Columbia Law School in 1974. Her career began at Milbank, Tweed, Hadley & McCloy where she practiced corporate law.

Chairman GORDON. Thank you.

President Gee, you are recognized.

STATEMENTS OF DR. GORDON GEE, PRESIDENT, OHIO STATE UNIVERSITY

Dr. GEE. Thank you very much, Mr. Chairman. Thanks for the great work you did for and in Tennessee and have done for the Nation. I just want it to be on the record of acknowledging your leadership. It really has been extraordinary and we appreciate it, all of us who have been part of this science community for a long time, and I want you to know how much I personally appreciate your leadership.

Ranking Member Hall, we don't know each other but I appreciate your comments also, and of course, it is great to have Representative Wilson on this panel and a graduate of the Ohio State University, Representative Fudge, we are honored for that.

I am going to be very, very quick because we are doing a tag team here, and with my good friend, my colleague, my neighbor at Battelle, Dr. Wadsworth. I must say that—and you have my written comments. I must say that I know that there are a number of conversations going on in the halls of Congress today. None are more important than this. I will go on the record saying that, and the reason is, is this is about our children but it is also about the competitive nature of our Nation. It is also about the reinvention of America. It is fundamental in terms of what we are talking about as we move forward in this Nation, that we finally acknowledge the fact that we are moving from a hardware to a thoughtware economy, that if we are going to compete in the world as a Nation, we are going to have to compete based upon your ability to outthink and outperform, not simply to outmuscle. And in order to do that, that means we are now going to have to turn to the fundamental nature of our educational system and we are going to have to become much more competitive in that regard. You have heard from my colleagues the challenges we face and the opportunities, but we now need to turn those opportunities into realities, and I think that that is what all of us are committed to.

I am speaking today on behalf of 3,600 colleges and universities in this country. We have the premier system of higher education in the world. We are also challenged in that higher education system because we need to rethink about how we do our business, and in so doing, we need to work more closely and in collaboration with a number of our friends around the larger community. It used to be that it was publish or perish. Now I believe it is partner or perish. And I want to underscore that again. We as a higher education community will not succeed, we will not be able to compete in the world unless we now partner with our nonprofits, with our businesses, with industry, with government, state, local, certainly with Federal Government. So this notion of a new rounded approach to the world is extremely important and it is now our time.

And so as we move from this knowledge economy built on innovation and ingenuity, that is the challenge, and in order to do that, we have to start with the building blocks and that is with our educational system, that is with our K–12 and pre-K–12 system and that is obviously with our university system. So we are as a university community very dedicated to STEM efforts.

In that regard, Ohio State has taken a leadership role and we are very grateful for that. As many of you know, and it has been noted by Representative Wilson, I have the most unstable employment pattern in America. I do, but nonetheless, my involvement in universities has taught me as I moved around the country that universities must take a much stronger leadership role in terms of the kinds of issues we are talking about today and we must do it in partnership with a number of people. And we are doing so. The Association of Public and Land-grant Universities has just made a commitment. They are going to prepare 7,500 teachers in STEM education every year and we are going to meet or exceed that goal, and we promise that that will not be a high water mark, that will be at the low end of what we are going to try to do.

In addition to that, what we have done at Ohio State is, we have been very privileged to have the most comprehensive effort, I think in the country, in terms of a partnership between ourselves and the leading private science organizations in this country in its research effort, and that is Battelle Memorial Institute, and we have created the Metro Early College High School, which has been designated by a number of people as the finest STEM high school in this Nation and it stands on our campus and next door to our colleagues at Battelle. And what it is, it is a partnership between the university, Battelle, the educational council, all of our community schools, and its purpose is a very simple one and that is to develop these millennial minds to lead a new era. We will have our first graduating class in June, and of those graduates, 100 percent have been accepted to college, nearly, of course, half of them to Ohio State. I am grateful for that. These are average students. And by the way, I want to say this. This is what is important. It is not about geeks—I can use that word because I look like one—but it is about individuals and students who have average ability but who will be able to achieve great things, and so these average students come from 16 school districts in the 9th and 10th grades. They focus on a core curriculum in school. In the 11th and 12th grades, they go outside the school walls for internships. They spend time on the Ohio State campus. And by the way, at the end of the fall quarter those who have been taking classes at Ohio State have about a 3.4 grade point average. Now, either our other students are not doing very well or these are really—this is an incredible teaching mechanism, but surely that shows the nature of what we are doing, and of course, what it is about is teaching teachers how to teach others and then go into the public schools. Dr. Wadsworth will discuss Metro's lessons learned.

I will just make a couple quick points, Mr. Chairman. I am over my time. First of all, STEM education cannot be truncated. All too often in this country—and as we all know, we thought about the world in quarters. We thought about it as pre-K and then we thought about K–12 and then higher education and then go out

and get a real job. It is now K through life and particularly, it is very important we understand it is P through 20 in this STEM education business, and with my partners here we have to make certain it is preschool and we start this issue and we make it a compelling and innovative issue all through this period of time, this 20-year approach we have.

Secondly, we have to support early STEM schools. This is what America COMPETES is about. We have to support early STEM schools who have proven records and who can set high standards. And finally, we have to make this. This is a three-year investment that has been made in America COMPETES. I urge this Congress to make a long-term strategic investment in the future of America through this effort.

So I urge you to be bold and to seek first-order change, Mr. Chairman. That is my report.

[The prepared statement of Dr. Gee follows:]

PREPARED STATEMENT OF E. GORDON GEE

Chairman Gordon, Ranking Member Hall, Ohio Delegation Members Wilson and Fudge, and other distinguished Members of the Committee: Thank you for the opportunity to testify today on innovative efforts to reform K–12 science, technology, engineering, and mathematics (STEM) education. I appear before you not as a scientist or as an elementary or secondary school teacher, but as the president of one of the most comprehensive research universities in the world. Established in 1870, The Ohio State University is the flagship, land-grant institution of Ohio. The university is home to more than 63,000 students and 40,000 faculty and staff. We have 175 undergraduate majors, 133 masters programs, 99 doctoral programs, and seven professional schools, which offer roughly 12,000 courses each year.

When Thomas Jefferson was designing the University of Virginia, he established several "design principles" to guide the construction of one of the first public universities in the United States. Two of these principles are particularly relevant for STEM education in the 21st century. The first principle deals with the economic value of a well-trained mind. It states that a proper education must "give to every citizen the information he needs for the transaction of his own business." The second highlights the fundamental role science and math play in educational, economic and civic development. It states that students must be enlightened "with mathematical and physical sciences, which advance the arts and administer to the health, the subsistence and the comforts of human life." As a land-grant institution, Ohio State embraces those ideals and combines them with a founding purpose to expand public education more broadly and to assure that education directly improves lives and enriches communities. Such is the basis for our approach to STEM education and economic development. STEM-driven knowledge, innovation and talent are integral to how we confront the grand challenges faced in energy, environment, health, food, water, poverty and security.

This committee is well aware of the challenges facing STEM education in the United States. Countless reports have identified the problems and many have offered solutions. I am here today to report that institutions of higher education understand that we must play a vital role in solving the grand challenge of improving the STEM pipeline. Ohio State, like many educational institutions, is reinventing itself, and a comprehensive P–20 STEM education approach is a vital part of our strategy. We must seize this time of disquiet as an opportunity to create a new American educational ecosystem that connects and develops talented minds in new and more powerful ways with increased efficiencies and shared responsibilities. Significant change in the quality and reach of STEM education requires our unrelenting pursuit of deeper partnerships across the educational spectrum, with business and industry, government, parents and extended families, and our communities. We must work together to foster stronger early-learning skills for preschoolers and to encourage all high school students to be STEM literate, with greater numbers of them ready to pursue advanced STEM studies in college. To do so, we must re-think our priorities and re-order our time. We must challenge traditional assumptions, and embrace not only innovation and creativity, but also risk. STEM education is essential if we are to fully prepare our students for leadership in a global context.

The work ahead requires new platforms for collaboration. By its sheer size, The Ohio State University is the most massive intellectual platform in America. From fostering the world-renowned and globally relevant research on the loss of polar ice at the Byrd Polar Research Center to co-founding one of the nation's finest early college STEM high schools, Ohio State brings talent, knowledge and resources together to tackle some of the toughest global problems. As we look to amplify and accelerate the quality of STEM teaching and learning from preschool through graduate school, we recognize that collaboration platforms are necessary to help dismantle barriers and to speed the cross-fertilization of innovative ideas, programs and solutions. Ohio State's STEM education strategy centers on three platforms for collaboration.

THREE PLATFORMS FOR STEM EDUCATION AT OHIO STATE

First, we enhance the power, reach and relevance of STEM education by ensuring that our internal academic structures support collaborative research, teaching and service on problems that cut across disciplinary borders.

We are investing in trans-institutional Centers for Innovation and Innovation Groups to encourage interdisciplinary scholarship across our campus. We are removing structural and budgetary boundaries and facilitating faculty collaboration to address issues and problems of global dimension that affect the quality of the human condition. The centers and groups are tackling challenges such as international poverty, food safety, computational modeling of global disease, and complex human, natural and engineered systems. With specific respect to STEM education, our recently merged College of Education and Human Ecology provides a collaborative platform to spur connections in human health, nutrition, family conditions, brain development and academic performance. Another major collaboration—both physically and intellectually—is occurring with our academic Medical Center. There, partnerships of all kinds are flourishing, translational medicine is taking hold, and plans for greatly expanded facilities are proceeding apace. State-of-the-art facilities are meaningless if top-notch medical care and talent are not available. With that in mind, we have partnered with Columbus State Community College to advance a much needed STEM workforce pipeline for health care workers.

Second, we are strengthening and extending collaborations with our early childhood and K–12 partners on the three most critical factors in making sure every child succeeds—the equitable distribution of high-quality teachers and school leaders, turning around persistently low-achieving schools and aligning the entire educational system around college- and career-ready standards.

Three examples demonstrate our commitment to increasing the number of high-quality teachers in STEM fields and enhancing an educational system around college standards: Metro Early College High School, Project ASPIRE, and Wonders of the World.

Metro Early College High School is a joint project of Ohio State, Battelle, and sixteen central Ohio school districts that began in 2006. This nationally recognized and Gates-funded STEM secondary school takes a project-based and integrated curriculum approach to preparing a very diverse student body (many first generation college students) to be college- and career-ready. Students at Metro participate in self-directed and hands-on learning experiences with teachers and mentors at Ohio State and in the community, and they participate in independent research projects and community internships. In June 2010, Metro will graduate its first class, all of whom have achieved college admission. Most Metro students have taken college coursework, with an average Ohio State GPA of 3.4.

Metro also serves as a research and development platform for Columbus City Schools. Metro helped launch Linden McKinley STEM Academy in a high poverty area of Columbus, and is the inspiration/prototype for the design and launch of state supported STEM schools in Dayton, Cleveland, Cincinnati, Akron and Columbus and other schools around the country. Dr. Jeffrey Wadsworth, Battelle CEO, will elaborate on this in his testimony.

Our overall STEM education strategy has been developed around Metro Early College High school. Ohio State benefits from its Metro partnerships in the following areas:

- **STEM R&D Innovation**: Advances the science of STEM teaching and learning and applies research-based knowledge to the improvement of practice, particularly in high schools and higher education.
- **Teacher Quality**: Helps Ohio State to be a national leader in an enterprise-wide approach to a teacher residency program model for STEM educators.

- **College Readiness and Access**: As perhaps the only early college high school situated on the campus of a research intensive university, Metro helps Ohio State to most effectively connect high-impact STEM-oriented early college efforts, particularly for underrepresented and first-generation student populations.
- **Economic Development**: Focus on STEM-oriented talent pipelines in key driver industries such as advanced energy/environmental technologies and health and life sciences.
- **Outreach and Engagement**: Leverage Metro's capacity to serve as an outreach and engagement portal for externally funded research projects in STEM disciplines.

The second example combines two major initiatives, Project ASPIRE and Wilson Fellows, to increase high-quality teachers in underserved schools in Columbus, Ohio. There is one simple truth that guides our support of schools—the quality of an education system rests on the quality of its teachers. This philosophy resulted in a $13 million Teacher Quality Partnership grant for Ohio State's Project ASPIRE from the U.S. Department of Education's Office of Innovation and Improvement. In partnership with the state's largest school district, Columbus City Schools, Project ASPIRE is designed to deliver more than 600 teachers in high-need content areas such as science and math. In the next five years, these teachers will be equipped to help low-achieving students in low-performing schools to grow and succeed academically.

We have aligned Project ASPIRE with the Woodrow Wilson STEM Teaching Fellows. In partnership with the Woodrow Wilson Foundation, Ohio State will design, deliver, scale and sustain an academically rigorous, graduate-level, clinically based teacher residency program that: a) attracts the very best candidates from traditional and non-traditional pathways; b) places and supports strong STEM middle and secondary teachers in high-need schools; c) reduces teacher attrition and associated costs; d) transforms teacher education in Ohio; and e) strengthens the quality of STEM teaching and learning. This is an enterprise-wide commitment that will fundamentally reshape the way we prepare STEM educators and work with schools and school districts. Combined, Project ASPIRE and the Woodrow Wilson STEM Teaching Fellows deepen our shared responsibility with Columbus City Schools to co-manage a human capital system that greatly increases the chances that a student will have access to high-quality math and science educators.

One final example is the Wonders of the World science outreach program, or W.O.W., led by Dr. Susan Olesik. Since 1999, Dr. Olesik and her team have successfully paired science fellows with elementary school teachers to improve science education. Now she is working with academically talented graduate students in the sciences to collaborate with third through fifth grade teachers at Columbus City Schools to develop hands-on, inquiry based science lessons to cover all areas of the elementary science curriculum. Reported Ohio Proficiency Test scores show dramatic improvements in the passing rates in science among the elementary school children involved, and teachers participating in the program are showing great progress in their science content knowledge and their ability to teach inquiry-based science lessons.

With continued funding from the National Science Foundation, Dr. Olesik is now institutionalizing these efforts at Ohio State and with Columbus City Schools. New fellows and teachers are chosen through competitive application processes to ensure that the best graduate students are paired with teachers who are committed to improving their ability to teach science. The W.O.W. program is substantially enhancing graduate education at Ohio State, having a large impact on elementary school teachers in inner-city schools while advancing science skills of the students they teach.

Our third platform is to unleash our greatest resource—our faculty and researchers—to develop new STEM education programs and assessment tools to replicate, imitate and expand successful programs to the state and national level.

The Battelle Center for Mathematics and Science Policy is housed at Ohio State and headed by former astronaut and current vice-chair of the National Science Board, Dr. Kathryn Sullivan. This center addresses the need for strong science and mathematics education as a cornerstone of U.S. global competitiveness by developing policies and practices that will increase the number of students who pursue careers in STEM education. Presently, the Center is currently engaged in a major STEM modeling program, which includes powerful analytical tools designed to guide decision-making across the entire spectrum of STEM education, from policy to program to practice.

Using Ohio as a testbed, Dr. Sullivan and our colleagues at Battelle seek to understand how success in STEM education is linked to the economic growth and competitiveness of the state. This effort would be impossible without the partnership of Battelle, as well as also the Ohio Business Roundtable and the Business-Higher Education Forum. It will involve a broad spectrum of partners from K–12 education, higher education, government and industry.

At the national level, Ohio State is participating in the Science and Mathematics Teacher Imperative (SMTI), spearheaded by the Association of Public and Land-Grant Universities (APLU). SMTI is a commitment by 122 public research universities across 42 states that prepare more than 7,500 math and science teachers annually—the largest initiative in advancing the preparation of science and math teachers in the nation. Our pledge is to substantially increase the number and diversity of high-quality science and mathematics teachers we prepare, and to build better partnerships among universities, community colleges, school systems, state governments, business, and other stakeholders. As stated during its commendation by the Obama Administration's Educate to Innovate effort, the collective goal of SMTI is to prepare more than 10,000 teachers annually by 2015. SMTI institutions are committed to quality and are using SMTI as a national platform to identify and share exemplary practices encompassing leading efforts such as Noyce Scholarships, Wilson Fellowships, UTeach and other leading approaches to foster expansion of successful programs. We look to our participation in SMTI as a mechanism to share our efforts and understand the innovations by others for potential adaptation in Ohio.

PARTNER OR PERISH

Academics are all too familiar with the phrase "publish or perish." When it comes to successful STEM programs, I suggest that institutions of higher education must "partner or perish." We are fortunate to be geographic neighbors with the Battelle Memorial Institute, a global leader in research and development, and we are aggressively deepening our collaboration to meet pressing needs.

In addition to the specific partnerships with Battelle and Columbus City Schools for Metro and Project ASPIRE, we are members of STEMColumbus, which brings together Battelle, American Electric Power, Columbus City Schools, Educational Council, the Ohio State colleges of Engineering and Education and Human Ecology, and COSI, an award-winning science center in Columbus, in a partnership to locate, link, lift and leverage Columbus City Schools middle and high school STEM clubs, camps and competitions.

Ohio State is also a founding member of the Ohio STEM Learning Network (OSLN). This is an unprecedented collaborative aimed at building and connecting STEM teaching and learning capacity in regions across Ohio. At its core, OSLN is focused on student and teacher success, built from a slate of committed partners from P–12 education, higher education and business and industry. Designed from a systems engineering approach, the OSLN develops and connects a state-wide system of innovative STEM schools and Programs of Excellence, leveraging the ongoing work of regions across the state, along with a $12 million grant from the Bill & Melinda Gates Foundation and an initial $5 million investment from Battelle.

Our successful partnerships flourish for several reasons. Together we mobilize, engage and empower the right stakeholders to make decisions on behalf of the institutions. We also must seek agreement and commitment to specific outcomes, as part of developing a sustainable business model. We select an approach that meets explicit standards of proof, scalability and sustainability. Throughout the process, we build in oversight mechanisms. And finally, we communicate, communicate, communicate.

RECOMMENDATIONS FOR COMPETES REAUTHORIZATION

I would like to recognize the leadership in Congress and the White House, both past and present, to the issue of STEM education. Through America COMPETES, Congress has pushed the Federal Government to do a better job aligning Federal programs to meet the needs of our students, teachers and researchers that are the STEM pipeline. As with any legislation, implementation is far from perfect. It is in the spirit of gratitude and good partnership that I offer a few suggestions as you debate the COMPETES reauthorization:

- **Approach STEM education from a P–20 perspective**. Nearly every report issued over the last quarter century suggests that the STEM pipeline must be strengthened. Federal programs should strive to better link the efforts from pre-kindergarten through the post-doctoral level. The multitude of individual programs across Federal agencies ought to be re-aligned, both with one

another, and with the growing industry and university initiatives focusing on STEM education and teacher development.

- **Support early college STEM schools which have proven success with underrepresented and first-generation students**. Metro Early College High School, and its sister institutions across the country, should be afforded opportunities through the Federal agencies to share best practices and compete for innovation grants to enhance their outreach efforts to first generation students.
- **Demand, incentivize, support and recognize collaboration at the horizontal and vertical levels**. As I have described, Ohio State is working with our peer institutions of higher education, local school districts, the State of Ohio and industry at many different levels. Each of our partnerships is critical to the success of our STEM programs.
- **Encourage national partnerships to make STEM "contagious" through social networking and viral education reforms**. For example Teach for America, the School for Everything and teachertv in the United Kingdom rely a great deal on information and social technologies that attract and invite talented minds to work together. A national and state STEM education strategy can be greatly augmented by a digital media and social networking strategy. Another way to make STEM contagious is to form public and private partnerships around "high leverage" problems using network strategies, structures and tools to promote the flow of high value knowledge and the development and exchange of powerful policies and practices.
- **Provide sufficient resources**. The funds provided through the American Recovery and Reinvestment Act for the Race to the Top and Investing in Innovation grant programs offered significant incentive for institutions to change the way we educate students and prepare citizens to lead the world in the new knowledge economy. It is important to ensure that the National Science Foundation is well connected to these Department of Education efforts and that NSF funding is appropriate. For example, it's been almost a decade since NSF had a program specifically targeted to preparing science and math teachers. While the NSF provides scholarships for students through the Noyce program, it is important to provide some core funding for universities to better develop their teacher preparation programs to go along with this support for students.

In conclusion, I want to thank you for the opportunity to testify before this committee on such an important issue. This moment presents us with the greatest of opportunities: to wholly reinvigorate and reshape STEM education programs and to create a fully rounded system of education that is truly pre-K though life, one in which our interdependencies are our greatest strengths. Without question, you have a difficult job ahead. I respectfully urge you to move boldly, act quickly, and seek first-order change. And know that America's universities, and especially The Ohio State University, will be working with you to achieve our goals.

BIOGRAPHY FOR E. GORDON GEE

E Gordon Gee, among the most highly experienced and respected university presidents in the nation, returned to The Ohio State University after having served as Chancellor of Vanderbilt University for seven years. Prior to his tenure at Vanderbilt, he was president of Brown University (1998–2000), The Ohio State University (1990–97), the University of Colorado (1985–90), and West Virginia University (1981–85).

Born in Vernal, Utah, Gee graduated from the University of Utah with an honors degree in history and earned his J.D. and Ed.D degrees from Columbia University. He clerked under Chief Justice David T. Lewis of the U.S. 10th Circuit Court of Appeals before being named a judicial fellow and staff assistant to the U.S. Supreme Court, where he worked for Chief Justice Warren Burger on administrative and legal problems of the Court and Federal judiciary. Gee returned to Utah as an associate professor and associate dean in the J. Reuben Clark Law School at Brigham Young University, eventually achieving the rank of full professor. In 1979 he was named dean of the West Virginia University Law School, and in 1981 was appointed to that university's presidency.

Active in a number of national professional and service organizations, Gee served as a Trustee for the Harry S. Truman Scholarship Foundation and as chairman of the Kellogg Commission on the Future of State and Land Grant Universities. He is a member of the National Commission on Writing for America's Families, Schools,

and Colleges, founded by the College Board to improve the teaching and learning of writing. He also serves as co-chair of the Association of Public and Land-Grant Universities' Energy Advisory Committee.

Gee is a member of the Board of Governors of the National Hospice Foundation, the Advisory Board of the Christopher Isherwood Foundation, and the Board of Trustees of the Christopher Columbus Fellowship Foundation, an independent Federal Government agency established to "encourage and support research, study and labor designed to produce new discoveries in all fields of endeavor for the benefit of mankind." He also is a member of the Business-Higher Education Forum.

Gee has received a number of honorary degrees, awards, and recognitions. He was a Mellon Fellow for the Aspen Institute for Humanistic Studies and a W.K. Kellogg Fellow. In 1994, he received the Distinguished Alumnus Award from the University of Utah as well as from Teachers College of Columbia University. He is the co-author of eight books and the author of numerous papers and articles on law and education.

Gee's daughter, Rebekah, is an assistant professor of clinical medicine in the Department of Obstetrics and Gynecology at Tulane University and a Norman F. Gant/American Board of Obstetrics and Gynecology/IOM Anniversary Fellow.

Chairman GORDON. Thank you, President Gee. So I learned some new words here, P to 20, K to life and hardware to thoughtware.

Dr. GEE. I am always available.

Chairman GORDON. Thank you for the addition to my vocabulary, and tag, Dr. Wadsworth, you are next.

STATEMENTS OF DR. JEFFREY WADSWORTH, PRESIDENT AND CEO, BATTELLE MEMORIAL INSTITUTE

Dr. WADSWORTH. Good morning, Mr. Chairman and distinguished Members of the Committee, and thank you, Representative Fudge, for your overly kind introduction.

I am the second Tennessean on the Committee, and if I don't sound like I am from Tennessee, that is because I am really from east of Tennessee.

Gordon Battelle back in 1920 wrote a very prescient will, and Battelle Memorial Institute was founded in 1929 on three principles that I think you will recognize. Conduct scientific discovery was the first. The second and very importantly was translate those discoveries into practical applications that would benefit the economy and society. And thirdly, he declared that with the proceeds of that work, we should reinvest in the education of men and women. So you can see a very strong fundamental base in the principles of Battelle that apply today. We started with 40 people in 1929, 80 years ago. We closed our books this year at $5.6 billion. It started with $3.5 million which in today's terms is about $40 million startup. We employ 20,000 people, mostly in the United States, in 100 different locations.

We applaud the leadership in Congress and the White House on the *America COMPETES Act*. It is exactly what is needed. At Battelle, we have a firsthand understanding of the issues. Those 20,000 people we employ, 40 percent of them will be retirement eligible in five years. That is 8,000 people we have to replace. And we look at the source terms for replacing those people, they are both going down: foreign nationals who come and stay, and homegrown science and technology graduates and people in other disciplines. Increasing pull term to reduce source terms, that is a train wreck and that is why this subject is so important.

So 10 years ago, we invested $10 million to create a company called Battelle for Kids. Today, it is an independent organization

and a leading national provider of services across the country. It will do tens and tens of millions of revenue in the next couple of years. They work on value-added assessment, data-driven decision making and old-school reform. They measure, measure and measure performance, and that capability is becoming increasingly recognized as core to advancing our capabilities at schools.

Having done that, we then established an operating unit within Battelle focused on education. I want to emphasize, this isn't a separate foundation. It is not a disconnected entity. It is a core part of what we do and we now think of it as a line of business, and it is focused on STEM education and partnerships and it is fully integrated into what we do, and our goal is very clear, our ambition is very clear. We believe in STEM competency being available for all students, not just a select few, and we focus our efforts on supporting students at high risk of being denied the opportunity to have a STEM education. It could be because of their race, their socioeconomic background, their family situation, anything that reduces their chance of accessing a high-quality education, that is where we focused our efforts.

Now, what are we good at? We are actually good at complex program management, public-private partnerships, systems engineering, things like that. We manage seven of the Nation's major laboratories, and these involve hundreds of partnerships, and it turns out that in our view, it is this ability to bring complex teams together in a systems approach to education that is where we can make the greatest contribution. So we engage directly with public education partners, like-minded corporations and foundations.

What have we learned? First of all, we believe in using our skills in STEM to create STEM networks. In other words, we use our scientific skills to create networks of institutions. The Metro Early College High School mentioned by my colleague, President Gee, is a prime example. Metro uses project-based learning centered on the students. Now, what does that mean? It means that a student, instead of saying, "why am I studying algebra II," says, "oh, that is how I can use mathematics to solve a problem." We are graduating students. For example, one is interested in combining journalism and engineering studies because he wants to increase public understanding of technology and its implications. Another student is passionate about interior design, but how do you apply sustainable products. These kinds of experiences are the sort that could indeed create new industries. So we are using STEM to create STEM networks and to produce students who have an intrinsic interest in using that.

Our engagement of Metro lead to scale, so we started off in Columbus but then we joined with the Bill and Melinda Gates Foundation and they have been a huge asset to us, leveraging our investment, and we created the Ohio State—with Ohio State University and the State of Ohio, we created a public-private STEM Learning Network, and this was in order to go to scale. So since opening in 2006, we have helped design 10 new STEM middle and high schools across Ohio, and indeed as far away as Richland in the State of Washington. All are open to students of all ability. They are drawn in using a lottery system. We get D students and A students. And it turns out, as Gordon described, they end up

graduating with very high competencies. In less than three years, we have had over $100 million invested. High schools now serve 3,000 students and more than 100,000 students and 1,000 teachers have been connected in.

I would like to comment on the Carnegie Corporation's Opportunity Equation report that was recently published, and they call for us to tap into the vast resources we have in our institutions of higher learning, museums and other science-rich community institutions, to essentially do school differently. They are saying we have to do it differently and we agree. Battelle's work also aims at doing schools differently through partnerships designed to spread innovations.

Having gone to the broader Ohio network, we now seek to go and create multi-state networks. So right now we are currently creating networks across Ohio, Tennessee, North Carolina and Washington as we expand our philosophy and our investments.

We believe that partnerships have to be deeply engaged, and . . . I am running out of time. In Cleveland, there is a very interesting public STEM high school in a building on the General Electric Nela Park Campus, where employees from GE work side by side with teachers and students. Another example closer to home is the Mid-Ohio Food Bank where food distribution and hunger issues involve logistics and economics.

So let me conclude. We think there are three principles that you should look for in investments. One is design for scale, one is design for sustainability and the third is to measure, measure and measure and hold people accountable to those goals that we have set. Thank you, Mr. Chairman.

[The prepared statement of Dr. Wadsworth follows:]

PREPARED STATEMENT OF JEFFREY WADSWORTH

Good morning, Mr. Chairman and distinguished Members of the Committee. My name is Jeff Wadsworth and I am President and Chief Executive Officer of Battelle Memorial Institute. I want to thank you for inviting me to speak today on this important topic and to join with the other witnesses this morning—several of whom I know and work with personally on education programs as you have heard in their testimonies.

To set some context, I will begin with a brief overview of the organization that I currently lead, and compare its mission with the role of this Committee. In the late 1920s, our founder Gordon Battelle established Battelle Memorial Institute through his will. Gordon Battelle was a visionary and part of a family of successful industrialists and humanitarians. He believed that scientific research was central to industrial competitiveness. Through his will, Battelle Memorial Institute was established with three founding purposes: (1) conduct scientific discovery, (2) translate discoveries into practical applications of benefit to the economy and to society, and (3) utilize the proceeds from these activities to benefit education of men and women for employment.

What began with several dozen people in Columbus, Ohio more than 80 years ago is today a global non-profit research and development enterprise with revenues of $5.6 billion. We employ more than 20,000 people and operate in many locations around the world. The majority of our staff work in more than 100 sites across the United States. In addition, Battelle operates seven national laboratories for the Department of Energy and the Department of Homeland Security, including: Oak Ridge National Laboratory (operated by UT–Battelle, in conjunction with the University of Tennessee), National Renewable Energy Laboratory (operated by the Alliance for Sustainable Energy), Pacific Northwest National Laboratory, Idaho National Laboratory (operated by Battelle Energy Alliance), Lawrence Livermore National Laboratory (operated by Lawrence Livermore National Security), and the National Biodefense Analysis and Countermeasures Center (operated by the Battelle National Biodefense Institute).

At Battelle, we have a first-hand understanding of the urgency addressed by the America COMPETES Act and we applaud the leadership in Congress and the White House on this issue. The talent available to replace the 40-plus-percent of Battelle scientists and engineers eligible to retire in the next few years is becoming increasingly scarce. A solid foundation in STEM education beginning in the K–12 years must become the rule—not the exception—for every student growing up in the United States.

The tie between education and economic development has never been more important than it is today—a view we share with this Committee. Although we have grown significantly over our history, the will of Gordon Battelle represents the constant guiding instrument for our organization. The role of Battelle's management team is to continuously interpret the will in a contemporary context and constantly search for the best and highest use of our human capital and facilities.

Like many organizations with a high content of science and technology, we are strong advocates of STEM education and proud of our history of support to K–12, college, and workforce training programs. In 2001, we made a decision regarding the contemporary "best and highest use" of Battelle's financial resources and human talent in the area of education improvement. That decision ultimately led to integrating our education efforts in STEM as a full operating business of equal standing and priority to our core research and development businesses in Energy, Health and Life Sciences, National Security, and Laboratory Management. **We are aimed at STEM competency for all students, not just a select few**. In particular, we are joining with others in efforts to support students that are at high risk of being left behind due to any circumstance—their race, socioeconomic status, family situation—that reduces their chances of accessing a high quality education. Our efforts concentrate on K–12 STEM education, but as you will hear in my testimony, it is carried out through close partnerships with higher education leaders.

Battelle demonstrates one of the basic tenets of STEM collaboration espoused by experts in the field. Corporations are finding that their core competencies in logistics, communication and broadcasting, research and development, and information technology have tremendous value in the education sector. This is especially the case in STEM education because these organizations simultaneously provide authentic models of what STEM careers look like to students and teachers.

Battelle's core skills are in program management, public/private partnerships, systems engineering, and product design. These are coupled with our experience in management of multi-billion dollar assets such as U.S. National Laboratories that involve hundreds of simultaneous partnerships. We have translated this combination of competencies to the STEM education arena as we directly engage public education partners and like-minded corporations and foundations. I want to highlight for this Committee what we are learning along the way and offer some recommendations on ways the Federal Government can accelerate progress.

We are seeing high value in an approach that "uses STEM to create STEM." Metro Early College High School—described earlier by President Gordon Gee from The Ohio State University—is a good example of this principle at work. Metro uses project-based learning with STEM as the fundamental language for instruction. Art, history, composition, language, engineering, physics, mathematics are not separate disciplines. They are integrated into student-led projects as the core of learning in the school. A goal of project-based learning is to develop relevance. Relevance is actually quite easy to spot. It's when a student replaces the all too familiar: "*Why would I ever need to know this?*" remark with, "*Oh . . . so that's how that works!*"

OSU and Battelle joined with 16 public school districts in central Ohio as founders of Metro. But for OSU and Battelle—with adjacent campuses that house the nation's largest land grant university and the world's largest independent research and development organization—creating a 400-student personalized learning STEM high school a mile away was not the sole objective.

The design goal was to establish Metro as an authentic demonstration laboratory with real students and teachers under real world conditions. OSU would co-construct Metro's curriculum with teachers and STEM practitioners at Battelle, and consequently transform the way OSU trained teachers from the outset. The school would be lottery based and non-selective. Mastery would be required in order to earn credit for each subject. Ohio-based KnowledgeWorks would provide support in school design, essential in the expansion of the Metro concept.

The fundamental design principle at Metro was the partnership itself. That is—we wanted to establish a school involving multiple public school districts, anchor higher education two-year and four-year institutions, and committed business that collectively commit to the design, start-up and continued governance of a school. Once established, the school would serve as a "platform" for proactively transferring

learning and teaching practices to districts in its region and facilitate STEM education practices into those districts. Platform schools would be connected to other platform schools to amplify their impact.

As a demonstration school, Metro has met its objectives so far. Chosen by lottery without regard to their prior academic performance when they entered ninth grade, Metro's entire senior class will graduate and all have received admission to college. Not all will choose the traditional STEM studies in higher education—in fact, many will not. But all have a mastery of STEM fundamentals that will serve them well in whatever endeavors they choose. The operative word here is "choose" because all of their options remain open. Students' choices about college pursuits reveal their command of STEM. One student is interested in combining journalism and engineering studies because he wants to increase public understanding of technology and its implications. Another student is passionate about interior design and the application of sustainable products. These types of experiences are how new industries are born.

Our deep engagement at Metro led to scale—a statewide effort using similar design principles. Since opening in 2006, teachers and leaders at Metro also have helped to design and open 10 new STEM middle and high schools across Ohio and as far away as Richland, Washington. All are open to all students, of all abilities. Informed by experiences with Metro, Battelle worked with the Bill and Melinda Gates Foundation, The Ohio State University, and the State of Ohio to form the public/private Ohio STEM Learning Network. Battelle's education group manages this network with in-kind resources, and provides grants from the Gates Foundation and Battelle that are co-invested with regional funds. The network, called the OSLN (see *www.osln.org*), is a living laboratory of collaborative excellence. In less than three years, 10 STEM platform schools and 26 K–8 STEM programs of excellence have been created through this network. More than $100 million has been invested by public and private partners. The high schools now have 3,100 students; the K–8 programs reach more than 100,000 students district wide; and more than 1,000 teachers are involved.

Each school and program implementation is tailored to local, on-the-ground conditions. But all 36 schools and programs in Ohio, and the more than 300 partners that are at the core of the five regional "hub" collaborations (Akron, Cleveland, Cincinnati, Dayton, Columbus), have agreed to identical commitments regarding how they will participate with each other and their responsibility to actively share tools, practices, and human talent.

Educational systems are too strained to apply much focus and effort to effective collaboration. They are understandably focused on their own performance. We believe that careful network design and interface management are essential ingredients in scaling high quality education innovations. The basic formula for Battelle's network management is not a one-size-fits-all approach based on replication. While we are a highly disciplined organization in the way we apply design to solve engineering problems for our clients, our approach to managing networks of diverse partners is centered on relationship management and creating reciprocal value for the committed stakeholders. We place a deliberate focus on engineering the *interfaces among stakeholders*—across the K–12 to higher education continuum, and across education/industry/state government. This focus enables partnerships in various locations to leverage their strengths and maintain their distinctiveness, while benefiting from the work and progress of others operating in the network.

Statewide efforts are leading to multi-state efforts. A key to Battelle's success as a research and development organization is putting partnerships in place. We are applying these same skills to link schools and regions together in Ohio to accelerate STEM education innovation. **The natural extension is to link states together in a similar systematic fashion**. Battelle now is working with national organizations including the Bill and Melinda Gates Foundation and the National Governors Association to create multi-state networks. We currently are connecting networks across Ohio, Tennessee, North Carolina, and Washington, and adding other states and private corporations in this process. In all cases, we are building incentives for reciprocal agreements among states and regions. Committed collaboration is a requirement for participation.

Partnerships must be deeply engaged and not be cheerleaders from the sidelines. As I indicated earlier, STEM education is enhanced when industry and private partners engage their core skills with educators. In Cleveland for example, GE Lighting has converted one of the buildings on its Nela Park Campus to house a Cleveland Public STEM High School. GE employees work side-by-side with teachers and students without the need to leave the workplace. Students see professionals at work. Battelle is also organizing a community of practice with our na-

tional laboratory partners so they can tap into the state networks and amplify their education outreach efforts.

Advocates make the argument that STEM is a 21st century survival skill, but most programs pigeonhole STEM only where scientists and engineers work. *STEM does not take place just in laboratories—it can be found everywhere*. At Battelle, we are encouraging and funding STEM field sites and requiring connections of these sites to the regional schools that participate in the networks. In this context, a field site is a location where STEM experiences naturally occur. A good example is the Mid-Ohio Food Bank. Food distribution and hunger issues involve logistics and an understanding of data analytics. Students take on projects that are designed to improve the efficiency of food distribution, the use of community gardens, and new ways to increase local production. The direct application of STEM to social justice issues is a powerful motivator and offers relevance especially to students who come from poverty. Botany is taught inside a park conservatory and students learn about community gardens as a route to community self-reliance.

Data matters and information sharing matters even more. Ten years ago, while we were exploring the best and highest use of our own human talent, Battelle helped to launch a school support organization through a $10 million initiative called Battelle for Kids. Today, Battelle for Kids is a leading national provider of services related to value added assessment, data driven decision making and whole school reform. Battelle for Kids currently is working with 20 school districts across Appalachia Ohio on a comprehensive approach to connect college and career ready standards to teacher quality and school redesign. Broadening and deepening the access of students to high quality STEM teachers and educational experiences is an essential piece to the overall effort in Appalachia.

Despite many great examples of STEM initiatives and successes, there is little evidence they have had significant collective impact on STEM education nationwide. Indeed, there is plenty of evidence that suggests many of them are operating in isolation. Even the best teachers have few peers to call upon and little in terms of best practice and content that they can exploit for their students. The need for better instructional supports for teachers and students will only grow more acute as the states adopt fewer, higher, and clear world-class standards.

The reaction to this challenge is often seen as a logistical problem—create accessible databases, maps and inventories of programs and others will be able to more readily find solutions rather than having to reinvent them. The nation now has hundreds of databases of STEM initiatives that exist funded by states, Federal agencies, and private sources. Most are useful, but almost instantly out-of-date at the moment of creation. The lists also are incomplete because they often don't capture work in process by grass roots innovators who don't have the time, awareness of such databases, or see value in contributing to these works. The information is also most useful to the "STEM-literate"—those who already understand STEM's value in a complete education. The "STEM-uninitiated"—the majority of educators and communities that are arguably the most in need—are not affected by these databases no matter how good.

Battelle provides solutions to some of the world's most important challenges. This work gives us the opportunity to connect with nearly a thousand government and private sector clients and partners each year, including some of the world's leading corporations and governmental agencies. Collaborative innovation is one of our strengths and it is embedded in our core values. Bringing educators and the key stakeholders that support education together with system developers and STEM professionals opens up entirely new and desperately needed innovations in the way we design, deliver and sustain education that makes a difference for all children and all communities. There are more than 200,000 scientists and engineers employed by the Federal Government. These STEM professionals are vital to both the economic and educational future of the nation. We must find better ways to connect and develop STEM talent across generations, geography and organizational boundaries. Such grand efforts always begin and end with collaboration and all of us need to work very hard to recognize and reward partnerships that make STEM education relevant and readily accessible.

In closing, I want to thank this Committee again for the opportunity to recap our perspectives about K–12 STEM education. As this Committee continues its important oversight of programs across the science and technology spectrum, we urge consideration of three important themes that I have underscored in my testimony: (1) provide incentives that create large-scale partnerships, (2) base incentives on efforts that build systems that last beyond the lifetime of individual programs, and (3) require information sharing as a specific design criteria.

I would be pleased to answer any questions from the Committee. Thank you.

BIOGRAPHY FOR JEFFREY WADSWORTH

Jeff Wadsworth has been President and CEO of Battelle Memorial Institute since January 2009. Battelle is the world's largest nonprofit research and development organization, executing about $5B of work annually and employing about 21,000 people. Formed in 1925 as a charitable trust and headquartered in Columbus, Ohio, Battelle counts among its successes the development of the Xerox machine, pioneering work on the compact disc, and a number of innovations in medical technology, telecommunications, environmental waste treatment, homeland security, and transportation. Battelle has spun off new ventures and companies in fiber optics, pharmaceuticals, energy, electronics, and informatics. Its principal businesses today are fee-for-service contract research, laboratory operations, and commercial ventures, executing more than 5,000 projects for some 1,500 industrial and government clients throughout the world.

Jeff formerly led Battelle's Global Laboratory Operations business, where he oversaw Battelle's management or co-management of eight major laboratories: six national laboratories of the U.S. Department of Energy, representing more than $3B in annual business (Pacific Northwest National Laboratory, Brookhaven National Laboratory, National Renewable Energy Laboratory, Oak Ridge National Laboratory, Idaho National Laboratory, and Lawrence Livermore National Laboratory); the Department of Homeland Security's National Biodefense Analysis and Countermeasures Center; and a renewable energy laboratory in Kuala Lumpur, Malaysia, designed, built, and operated by Battelle for the private sector. In March 2009, a consortium including Battelle was awarded a contract to manage the National Nuclear Laboratory of the United Kingdom's Department of Energy and Climate Change.

Jeff was educated at Sheffield University in England, where he studied metallurgy, earning a bachelor's degree in 1972 and a Ph.D. in 1975. He was awarded a Doctor of Metallurgy degree in 1991 for his published work and received the highest recognition conferred by the university, an honorary Doctor of Engineering degree, in July 2004.

Jeff came to the United States in 1976 and has worked at Stanford University, Lockheed Missiles and Space Company, and Lawrence Livermore National Laboratory. In 2002, he joined Battelle and served as a member of the White House Transition Planning Office for the U.S. Department of Homeland Security. From 2003 to June 2007, Jeff was director of Oak Ridge National Laboratory, the Department of Energy's largest multipurpose science laboratory.

Jeff has authored or co-authored nearly 300 scientific papers and 1 book, and he has been granted 4 U.S. patents. His many honors and awards include three honorary doctorates, two honorary professorships from Chinese universities, and election to the rank of Fellow of three technical societies. He was elected a member of the National Academy of Engineering in 2005.

Jeff and his wife Jerre live with their two Parson (Jack) Russell terriers in Upper Arlington. They have three adult children; two live and work in California, and one in Vermont.

Chairman GORDON. Thank you, Dr. Wadsworth. And just for your information, the Carnegie and the Gates Foundations have each submitted statements for our record.

I am afraid we are going to have to be going to vote soon so we are trying to get at least our first two questions. Dr. Simons, as mentioned earlier, you have a deep knowledge of Noyce and math by virtue of being a scholar, setting up a program that has been replicated there. So do you have any recommendations regarding the Noyce program specifically, and additionally, ways in which it could be strengthened or improved upon? And beyond Noyce, how can NSF and other Federal agencies best support improved teacher recruitment and retention in the STEM fields?

Dr. SIMONS. That is a long question. Generally speaking, I am rather pleased with the Noyce program except for its size. I think it should be bigger. The grants that they make on an individual basis could be bigger.

Chairman GORDON. How big should it be?

Dr. SIMONS. Well, it depends on the size of the program. They have a fixed-size grant which is independent of the size of the program to which they are giving it. These grants could vary with the number of people involved, the number of teachers being trained or whatever rather than just be a flat amount. But of course, those flat amounts are a good start but again, they were too small.

I think the Noyce program is a very good template. I think it could be substantially expanded, and what we learn from that might allow us to do an even more far-reaching program, perhaps with the National Science and Foundation and perhaps housed elsewhere. But I am very thankful for what has been done so far with that program.

Chairman GORDON. Thank you.

President Gee, with your experience at Ohio State, do you have any—I am not asking you to be critical, you know, you are not being critical, you are being helpful if you can give us any suggestions on how Noyce could be better improved.

Dr. GEE. I think that Dr. Simons made the same point and that is the fact that obviously this is a program that has worked. I think what we have to do right now is, we have to invest in the things that are working. Those that are working, we invest in. Those that are experimental and not working, then we have to put to the side. And so I would say two things. One is the fact that you need to probably increase the amount of grants, but you need to increase the size of it.

Mr. Chairman, I also want to make another point. We were talking about this last evening, and that is the fact that it can't simply be the National Science Foundation. There has to be a number of other entities in this country, including Federal agencies, that are starting these kinds of initiatives. If we just continue to turn to the National Science Foundation or to the Department of Education, we will not have the kind of results we need to have, and opportunities about and that is one of the things this Committee can encourage.

Chairman GORDON. President Gee, to give you a—we agree with you. Let me tell you what we have done on this committee. We are starting an inventory of all the STEM education all across the Federal Government and we are finding that if you just push a button and say STEM education, you will find some will float to the top but you have to go deeper really to find it, and we are finding hun-

dreds of programs. And so we are trying to create a—both inventory them and create an umbrella that will be better coordinate those. So as I was saying with Dr. Wadsworth earlier on another matter, it is easier to save a dollar than appropriate an additional dollar. So if we can get better use through synergy, and we are again in the process of that investment and hopefully we will find ways to make those dollars go further.

Mr. Hall, you are recognized.

Mr. HALL. Dr. Simons, I could listen to you all day, and I almost did. But let me tell you something, you were saying something, you were firing bullets every bit, and I was intrigued. Even I could understand what you were saying. And I suggest to you, Mr. Chairman, does their testimony that they submitted go into the record? If it doesn't, it sure should because everybody ought to read it. I think it is the best set of opening statements I have ever heard. They were great, to the point and just exactly what we needed.

With that, I had a question I wanted to ask about Metro Early College High School, a secondary school that is a success story, equivalent to the Morris Elementary School. Dr. Wadsworth, I concur with you that a one-size-fits-all approach to replicating these schools can't work but different communities have different needs. I am sure you realized it when you were developing the Ohio STEM Learning Network. Could you maybe just elaborate on how you were able to successfully tailor the Metro model for other communities, and for other elementary and other middle schools?

Dr. WADSWORTH. Yes, that is an excellent point. I think there are some underlying principles that need to be in place, and after that, it does indeed need to be tailored to a particular area. So I think of it in terms of the 'what' and the 'how'. The 'what' is to get more kids into this area and to provide some of the underpinning partnerships, the agreements that are necessary to create new schools. The detailed design has to flow from the local community. For example, rural areas in southeast Ohio have to be different than, you know, city-based schools but the underlying principles of bringing business partners in, forming complex teams and allowing scale to progress are principles that need to be common to all of them.

Mr. HALL. Sometime I would like to visit the Metro Early College High School.

Dr. WADSWORTH. We would love to have you.

Mr. HALL. And I once again want to say it is the best opening statements, and I am going to—I won't say I am going to reread them; I am going to read them, by golly, and I thank all of you for being here. I yield back whatever time I have.

Chairman GORDON. You can see I have a good partner here.

Ms. Fudge is recognized.

Ms. FUDGE. Thank you, Mr. Chairman.

Dr. Wadsworth, I really like what you said about the direct application of STEM to social justice issues. I believe that nearly all of the problems that we face as a society require some type of STEM solution, from affordable and energy-efficient housing to child nutrition and obesity. How can we help to raise awareness of the intimate connections between these issues and STEM fields?

Dr. WADSWORTH. Thank you for the question. I really just echo the sentiment you have raised which is that when a child sees the

application of STEM to a real problem, that is the most stimulating way to engage them into the field, and I would urge all Members to visit the Metro High School. You will be greeted by students who will show you around. You will go into chemistry classes, which in some cases, believe it or not, are being taught in Mandarin because the teacher is from China and the students asked to learn Mandarin, and you will go into complex lessons which correlate literature with film interpretations of the literature. It is not just about chemistry and math. You will see this constant engagement of how you bring mathematics and science to solving complex social problems, and it is the engagement of the students and the realization that these skills can be applied across the spectrum that I think is so exciting.

Ms. FUDGE. Thank you, Mr. Chairman.

Chairman GORDON. Mr. Smith, you are recognized.

Mr. SMITH. Thank you, Mr. Chairman.

Chairman GORDON. Excuse me. I am sorry. Mrs. Biggert is recognized.

Mrs. BIGGERT. Thank you, Mr. Chairman. This is an ongoing thing, it seems like. I even moved down here so I would—sorry.

Thank you all for being here. I also serve on the Education Committee and yesterday we had a hearing with Secretary Duncan about, you know, what is going on and what the budget is for education, and as we look at our education system and see the low ranking that we have in this world, it seems like time is a-wasting and we really haven't increased the overall education for kids and it really worries me. One of the issues that Secretary Duncan raised was the fact that in China, you know, the kids go to school all the time and the focus is on education. It sounds like it is pretty rigid and something that our country would not want, you know, the type of education, but I do think that we really need to take a whole new look at it and I think what you are doing is really, you know, the opportunity for the future. Hearing, you know, like in Ohio, we just need to increase this type of education and look to the 21st century where it is just not the traditional go to school from 9 to 3 or 8:30 to 3 or whatever the timing is and really to expand this program.

So you talk about partnerships, you talk about, you know, the Federal Government. What can we do? You know, I go into schools and talk to the kids, and I have seen a dramatic increase in the number of students that really want to go into science, to be engineers and to be the mathematicians. They used to want to be Michael Jordan, then they wanted to be President. That has changed a little bit too. But how do we engage the students that don't have the access to your programs and how can we increase it?

Chairman GORDON. Excuse me, Mrs. Biggert. Before they answer, let me tell the Members, because I know people are going to start to peel off because we only have five minutes, although it will be a long five minutes, as we know. Rather than set a time specific for when we will return, let me ask everyone to come back, you know, promptly after the last vote, and you might want to grab some of your compatriots on the way, and with that, I think President Gee, you were starting to answer Mrs. Biggert's question. Go right ahead.

Dr. GEE. Well, I am going to be very swift hopefully. Two things. One is, there is an interesting phenomenon in this country that we really don't talk about and that is the fact that indeed we have some real challenges in our K–12 system, but think about this: all of a sudden we come and enter our university system, and the university system in this country is far and away the best in the world. And so how is it that we have a K–12 system that is not as good, and then we have a university that is the best in the world? And I think we need to do some deconstruction which allows us to take a look at that. I do have some views on that. But nonetheless, I think that is something that is important for this committee to take a look at.

In terms of the partnership issue, I think as I stated earlier, the opportunity for us right now is to really reinvent. The thing about it is, is what we have done is we have gotten into this very sterile view that it is just about X. Rather, now what we have to do is, we have to question everything, we have to start anew. I sit next to Ellen here. I mean, the notion of what can happen in her world and my world is not so far. Actually it is now complementary and that is what we need to—those are the kinds of partnerships. We just need to look at each other and say, that is precisely what we are going to do.

Ms. FUTTER. I would like to add to that if I could. As someone who sat on the Carnegie Commission that spoke so explicitly about doing school differently, as was cited, they really mean through these cross-sector partnerships, and it goes so much to the heart of what so many of you have raised today in terms of how do you get families engaged, how do you get children engaged. At the Museum, people are engaged. They may first be engaged by an exhibition and the exhibition might be on the topic of food, which goes directly to the question of obesity and a major public issue, or it might be an environmental subject or it might be human health, whatever it is. But it is not just the exhibition, which of course is where it can begin for a youngster and for families, but that we are also going to put together materials that can be used in the curriculum by teachers in training, by extending what is learned in the exhibition to the classroom, and can be done online. So this becomes a sustained initiative that is at the Museum, in the school, at home, empowering a broad swath of key players in enhancing science outcomes across this country.

Mrs. BIGGERT. Would it help if we had something like Sputnik or something that the whole country gets behind? You know, what you are doing, you know, you said you can go to all these things but if we really had some way to really focus in on this and say we are going to change the nature of education.

Ms. FUTTER. There is no question but that Sputnik played that role, and finding a similar kind of clarion call or lever would be exceedingly helpful, but frankly, funding it and doing it will get us a long distance and we are very grateful to participate in your activities today for that reason.

Chairman GORDON. Well, energy independence and stability is our new Sputnik.

So I think where we are now is, to our panel, we are going to adjourn. It will probably be about 30 minutes—oh, recess. Excuse

me, excuse me, excuse me. Recess with Mr. Hall's permission. We are going to go vote. We will come back. Quite frankly, I suspect that we will lose a few Members on the way, although, you know, they are holding on. And so we might allow you to have one more round of general discussion, and you are welcome, we have a room over to the side to have coffee, water. Dr. Simons, Mr. Finkel might take you aside for something that you might have an interest in doing also.

[Recess.]

Chairman GORDON. Ranking Member-designate Smith has just arrived. Let us see. I think that Mrs. Biggert was the last witness so Dr. Baird, we will—and let me also say to everyone that at noon we are going to have to—oh, I am sorry. Mr. Wilson was next. At noon we are going to start to—two of our members have to leave, so we will see how we are going to deal with it.

Mr. Wilson.

Mr. WILSON. Thank you, Mr. Chairman. I was trying to get myself organized here.

My question is to Dr. Gee. Dr. Gee, OSU has been a real leader in establishing partnerships with various companies, organizations, schools, and as a result—which has been a better OSU—a better educated workforce and better communities. Why do you feel OSU has been so successful in establishing these partnerships, and how can the Federal Government be helpful in encouraging similar collaborations around the country?

Dr. GEE. I think two things. First of all, I appreciate that, but we haven't always been that successful. The truth of the matter is, is that I think that Ohio State—and President Futter and I were just talking about this—universities in general have been sort of isolated, arrogant. We felt that we knew what the world was about and we did not want to engage in relationship building. I think that the last five or six years have clearly demonstrated to institutions that we can no longer—particularly universities and colleges, we can no longer go it alone, that we really do need to develop partnerships, and by the way, the partnerships I am talking about across the spectrum, I believe in many ways the most powerful partner in the university setting is with our colleagues in the community college sector. And by the way, I want to be on record. I believe that the community colleges are probably the most important educational institute in this country. They are really the front door to the American dream and we need to understand that. We need to work very closely with them. And so we have worked very closely with a number of institutions. I will just make one note, that is, we have created very recently the first of its kind program with a community colleague which is a pathway to medical school, starting with the community college and working with them to be able to develop ways right into our medical school. And so I think the reason for our success is the fact that there is an ability to understand and cherish the fact that we do learn much from these partnerships, and I don't want to embarrass Jeff who is sitting right next to us. All of a sudden we discovered that gee, you know, with this magnificent friend called Battelle that we do have powerful reasons to have partnerships and I think that that is a driving force too.

Mr. WILSON. Thank you. And this question is for all or any who would like to respond, but the Sixth District of Ohio, which I represent, is largely rural where educational resources, opportunities can be very scarce. How can the opportunities being developed in Columbus, Ohio, and other urban areas throughout the country through innovative STEM programs be made applicable to Appalachia and other rural areas of this country?

Ms. FUTTER. I will take a shot at that if I may because I was very taken also when Ranking Member Hall made the point earlier about the limited resources that we face. One of the great things about museums and other institutions of this type is that they really are storehouses of resources, and just to give you some sense of what that means, in our institution alone, which I use as an example because it is what I know best, we have 32 million specimens and artifacts as collections, and that is everything from a gigantic T. Rex to an equally gigantic meteorite, and it goes on and on from there. These are things that create wonder and excitement and that are the gateway to learning, but beyond that, we have over 200 practicing scientists and we have been training teachers as well as young students. We are the only museum in the United States authorized to grant Ph.D.s in comparative biology.

So what this means is an opportunity and a window for the general public, for teachers, for students to engage with real things—that is the power of reality—to see real science in practice and to engage with scientists and to have an opportunity to get a window on the scientific method, and that is not unique to an urban location. I heard your comment on Appalachia. There are institutions across this country with this kind of capacity. They may not all be big museums. It may be a 4H, it may be a nature center, but there will be within a region resources that can be accessed for people who have the opportunity to learn from them all over the country.

Mr. WILSON. Thank you. Anyone else?

Dr. GEE. Can I just chime in for one second, because that is like a home-run ball for me. Let me just read to you from a publication, the Mathematics Coaching Program, which comes out of our College of Education and Human Ecology, and our dean is right behind us, Representative Wilson. This is a direct quote from it. This is this Mathematics Coaching Program which is where we work with the rural schools. "One of the amazing events is that the first Appalachian school in this program moved from academic watch to excellent school improvement status in three years," so it shows that in that—and by the way, this is the history of the great land-grant universities. I mean, it is not about what we do in Columbus, it is about what we do in all of the 88 counties in Ohio. It is about the notion of 4H and extension and all of those programs. It is the people's university making the difference to all of those folks, and that is a great story right there. So let us celebrate that one.

Chairman GORDON. Thank you, Mr. Wilson.

We are going to have to—I don't mean to be heavy-handed here, but Mr. Smith and Dr. Baird are our—in terms of when I was in Sunday school, we used to get, you know, badges for attendance. They get the best attendance award so I really want them to have an opportunity, and then we are going to have to shut things down. So we are going to go to Mr. Smith and then Dr. Baird.

Mr. SMITH. Thank you, Mr. Chairman, and I will try to be quick. This is a very important subject obviously, and I am grateful for the panel here. Perhaps the Chairman is already working on this. I would love to see a second panel. And certainly I am grateful for your input as well. I would like to see a second panel consisting of a school board member, a current or former science teacher and a school administrator, those folks who are constantly fighting the battle of filling empty positions or recruiting and hiring the most effective and important, and while I am grateful that we are able to pay some good teachers, perhaps I would say it still isn't enough, and yet probably the best reward for a teacher, for example, locally back home would be an elementary teacher attending an Air Force Academy graduation where a student graduates, a former student of hers graduates with honors and, you know, catapulting that student out into the science world ultimately after obviously some service to our country. But I am just wondering if any of you would weigh in on the obstacles that do exist for those school board members or school administrators wishing to hire folks who can't seem to get the right person for whatever reason, if any of you would wish to comment on that.

Dr. SIMONS. Well, I am not sure I understood the question but certainly one obstacle faced by school boards if they want to hire exceptional people, and I would say again in STEM education which is most competitive, is the flat salary scale imposed by the unions. So I am not against unions but I am against flat salary scales that don't recognize again the law of supply and demand. So to the extent that unions could be more flexible in their approach to salaries, that might make it easier to do things.

Dr. GEE. Let me just respond because I think that really is a great question. We all kind of looked at each other, is the fact that I think if you gave us truth serum or I gave you truth serum, what we would understand is the fact that what we have done is, we have created a system in this country in which we do not reward creativity, energy and agility among our teachers or anywhere else. The second thing is, we have created a system in this country in which we always say to our kids and at our universities, well, if you can't be a doctor, if you can't be a lawyer, if you can't be an engineer, you can always be a teacher. So I spent some time in Germany. The word layer in German is of the highest order, the word "teacher," and we need to change that concept in this country. So it is about creating a high-performance culture through a reward system, and that is how you are going to get to that point.

Ms. FUTTER. And related to that direct point, obviously to get the best people teaching in STEM, we have to give them the proper training. They have to see and engage in real science and learn what the scientific method, the scientific process is, and in that way be able to communicate to young people the excitement of discovery, the detective story of science. So teacher training, which is something that all of us are so focused on at this table, is key to this.

Mr. SMITH. Well, I will admit that I didn't appreciate science as much growing up as I do now with the practical implications and the public policy application as well. So I just hope that we can more appropriately treat teachers as professionals, because they

are, and yet we have a system that I am afraid does not treat teachers as professionals and certainly we need to focus on that. Thank you.

Chairman GORDON. In full disclosure, Mr. Smith was offered a teaching position in Tennessee but we didn't offer him enough and so he went off and did other things. And I will also say that at the Subcommittee level that we did have that exact panel that you had recommended and so we do have that input into this legislation.

Dr. Baird is recognized.

Mr. BAIRD. I thank the Chairman. I want to thank our distinguished panelists for being here, but more importantly still, for your work on a daily basis.

I want to put about three things out quickly, and this is coming from somebody who has taught statistics and research methods at the university, and as an untenured professor completely revised our statistics and methods class so that it made sense to people who wanted to learn it. A few things. I have twin boys who will turn five in three days, and I want them to learn basic math, and one of the ways you would think you might be able to do it is to log online and get some free software. I will tell you it is abysmal, and I would just encourage you, you know, in the next couple of days, imagine you are a parent of three- to five-year-olds and you want to log on and get something. Now, you find math games but they are terrible by and large. They spend a whole lot of time walking a duck through a park so he can stack two logs and say "two" but it took you five minutes to get to that, and so the first point is, I just would encourage you to do this because that is the seed corn at some level.

The second point is, Vern Ehlers and I are both proponents of at least a voluntary national curriculum so that math teachers around the—not to take away the creativity of the individual structure and all the hands-on pedagogy that is so essential, but so that across the country, we know our kids are getting a standard curriculum, and there are two benefits to this. One, as a parent of teenagers, I had the experience of trying to remember how quadratic equations worked, and I did it pretty well but it was a rusty brain that was trying to do this, and that is a brain of somebody who has had that training. The average parent can't help their kids with math past about the 6th grade, if that, and I don't mean that critically or elitist. It is a fact. We do almost nothing to help those parents help their kids with their homework. They run screaming from the room, ask your older brother, ask your neighbor, whatever. We need to do more to help the little kids learn with software and games that are free for everybody. Secondly, we need to help the parents help their kids in some fashion, empower and educate them.

And then finally, one thing we neglect—and I applaud your effort to teach high school—to teach people who will go back into high schools. My experience at the college level was, a lot of liberal arts majors desperately need basic math courses but who is there to teach it? Your math department is filled with people who are so darn smart, to ask them to teach liberal arts people is a waste of their time and an obstruction to their career. We need a whole cadre of people who teach at the university level, who teach math

in a comprehensible, usable fashion so that our broad society gets it, including colleagues in this institution who may not have—myself included in many ways. So I just throw those three sets out. I would welcome your thoughts on any of them.

Dr. SIMONS. Well, I would like to start with your colleagues, and I would be delighted to come down here once a week and give some lectures to the Congressmen and Senators about math, and I wouldn't even ask to get paid, if I could duck out for a cigarette every once in a while.

You know, everything you said makes sense. It is very difficult for parents, and I think a lot of the professors at universities do have some sympathy, professors in the mathematics department, for the kind of folks you are talking about. I think it is not as dismal as that. When I was a professor, I taught a whole remedial course which I found—it was pretty interesting, actually, and these were kids who came to the university, just didn't know much, and the cutoff was fractions. If a kid could add fractions and subtract fractions, he was in good shape, he would be OK. But two-thirds of the people just couldn't do fractions and, you know, that is 4th, 5th grade stuff. So the parents don't know, and maybe if we get a little smarter as a country in another couple of generations, more parents will know, but it is really a problem.

Mr. BAIRD. Well, one of my models of the national curriculum, and Vern and I have discussed it, is if you had that, then you could coordinate parent help literature on TV or more easily on the Internet so a parent could say OK, anywhere in the country I know that my 5th-grade kid is at this lesson level. They are going to have illustrated tutorials online and we can sit down and the parent can get it and say oh, OK, I get it. If we did——

Dr. SIMONS. That makes a lot of sense. If you got different school districts to agree to all that, I think it would be fine. But I don't know if it is possible but I think is a darn good idea.

Mr. BAIRD. Politically it may not be.

Ms. FUTTER. I would add several things to that. First, your comment on parents is so central to both math and science, and it is just indisputable. One of the great things about informal institutions is family engagement, and this is a place where families learn together, and by tying it then to these cross-sector programs with the schools, it also has a formal dimension, a systematic dimension, as the Chairman alluded to at the beginning.

Second, I think common standards are critical. The Carnegie—IAS [Carnegie Corporation of New York—Institute for Advanced Study] Commission requests not only for common standards but that they be fewer, clearer and higher. It is not just a morass of standards, it is getting the right ones and making them clear.

Your comment on the liberal arts struck a particular chord with me as a former college president where we introduced at Barnard College a requirement in the freshman year in quantitative reasoning, but it had to do with all kinds of things like music, like the Constitution, and I think tying math and science to pressing ideas is one of the great strategies. And it is something that we do in the Museum, whether it be energy policy, human health or any of the other many, many topics that we can take up but the public attention and interest in the major issues of our time, and that also

ties back to the workforce and where they can later fit in with jobs through the right training.

Dr. GEE. I will just add a couple of things. First of all, I will just say that there is no substitute for good parental involvement. I mean, it is absolutely essential. And I think that that is one of the issues we are going to have to address in STEM and other things is, how do we get parents engaged and how do we not have them view our public schools particularly as places they send their kids to get away from them, and I think that is enormously important.

The second thing, and this is a long discussion, but what you are talking about, as someone who has taught at a university, you know that our reward and recognition structure needs to be totally reexamined in order for us to be able to say that there is more than one way to salvation and those who teach are going to be rewarded and rewarded well simply not as a passage, and I think that those are important discussions that we can have at some other time.

Dr. WADSWORTH. I would just add, common standards, I agree. Achieve is trying to look at that as well. I am on the board of Achieve. I would just observe, my own children went to a very, very good public school in Menlo Park, California, and mathematics was terrible. So I can only imagine how difficult it is in other schools.

Dr. GEE. This is the final comment. I was just going to say that mathematics is very intimidating. Every time I go and visit with our math department, very distinguished math department, I take Valium before I go. They scare the hell out of me so I have to do that.

Chairman GORDON. Well, this is such an important discussion and I am sorry it has been bifurcated. In continuing with the unusualness of how we have dealt with this, let me say those panelists that need to leave now, please do so. We have just—Gabrielle Giffords, who is the Chair of our Space and Aviation Subcommittee, has just come in and she will have a question for those that are left, but those that have to go catch a plane, whatever it might be, please go right ahead.

Ms. Giffords, you are recognized.

Ms. GIFFORDS. Thank you, Mr. Chairman, and I want to thank and welcome the panelists for being here today. I will keep it brief. I know that we have votes and we are likely to be called out.

I think it is interesting when listening to the panelists and the discussion that the backdrop behind all of this is our Nation's struggling economic situation, and while we have a lot of bills that we are working on and a lot of plans here in the United States Congress to improve our short-term problems, oftentimes I feel like we are not having the most important part of that discussion, which is our long-term education investment and involvement, and STEM education is absolutely everything. I often say to groups that I meet with back home in my State of Arizona, if you really want to look into the future, just take a look at your 4th-grade math scores. That is the indication of where we are going to be 20 years from now, 50 years from now, frankly. It is all at the 4th grade a lot of that is determined.

I was really proud of the COMPETES bill that was led by the Chairman a couple of years ago, and our job in the Congress, I think, is to continue to support the COMPETES bill and to have

experts like yourself articulate why COMPETES really matters, and a lot of that discussion has taken place today, but reality is going back to my home State of Arizona. The United States Chamber of Commerce gave Arizona a D in academic achievement and an F in postsecondary and workforce readiness. Also, Arizona has the second highest student-to-teacher ratio in the country and is second to last in terms of per-pupil expenditure. So some of these statistics are real reminders about what is going to happen in the second fasting growing state in the country.

So my questions that I present to our two panelists are really, how is it that we effectively communicate, particularly to the industries that are out there, to other decision makers, the importance of STEM education? How do we connect the dots to the industries that are going to depend on this future workforce? Because there is a crisis that is brewing, and with so many retiring engineers and scientists, so much of the workforce is leaving, I don't think the general public has really heard that message loud and clear. So if I could just hear from the panelists about that?

Dr. WADSWORTH. It is a curiosity to me that we lead the world in the most advanced scientific facilities without a question, you know, so somehow there is this tremendous disconnect between the fact we have the greatest university system, we have the greatest research facilities and yet we don't, somehow, appreciate the investment that is necessary. And I think most of us who lead organizations eventually spend our time, a lot of our time on education because all roads lead back to Rome, and I think what you are seeing is a start of a more intense conversation about the need to change policy, put more money in, get everyone involved. It is not just about teachers at schools, it is about businesses, institutions playing a role, because many different departments have educational needs and they need to be encouraged to spend their resources on it as well. And at the end of the day I think it is a lot about partnerships and recognizing the need to—the other thing that I find—and then I will shut up—is the more you study it, the more you drive down the age chain. So you start worrying about kids by age three who are disadvantaged, and the single biggest connector is family income. The biggest correlation between educational success is with family income, and that is a real problem because we know what happens when a child is raised in a disadvantaged environment. It is a very complicated problem.

Ms. GIFFORDS. Dr. Simons?

Dr. SIMONS. Well, you have asked a question about communication, about which I am not a great expert. But I will make one point, one idea. As part of what we do in Math for America, is give these fellowships and awards to people to come into teaching and we pay them and so on, and it is quite an honor. Now, if this program were to be made truly national with tens of thousands, maybe even 50,000 slots for national fellowships for STEM, let us say, high school teachers, and if you got one of these fellowships and you were a teacher or about to become a teacher you would get, say, $20,000, $25,000 a year. You would be known as a National Teaching Fellow. You would get it because you knew the subject or whatever. There would be some hurdle, of course. But that would—if there were a reasonable number of these things,

that would cover—there is 350,000 roughly teachers of math and science in our schools. So if you had 50,000 or 60,000 or 70,000 of these people who were national teaching fellows, first of all, it would be a tremendous injection of brains into the system. But second of all, the existence of that program, which maybe your neighbor's kid got or whatever, would really—people would hear about it, right? If you do things in large numbers, a finite number, which I am certain you could, it would communicate a message that this is a high-class thing. It would, I think, raise not only the awareness but the sense of importance of this education. So that is an idea. And if you want to prepare such a bill, I will be delighted to help in its drafting.

Ms. GIFFORDS. Thank you, Dr. Simons.

Mr. Chairman, just in closing, I am a proud product of public schools. I am here today because of teachers and administrators and folks that cared about our community and were really dedicated to teaching kids, and not only does it pain me to see what is happening now in my home State of Arizona, but across the country, where as the *Rising Above the Gathering Storm* report indicated, other countries are gaining momentum and our country is falling behind. And we can't allow that to happen. So this is important. I mean, we have got to keep, you know, marching ahead and banging the drum and really figuring out those ways that both policy—but also in terms of being able to communicate effectively why this matters, and I am excited to work with you on it, Mr. Chairman. Thank you.

Chairman GORDON. Thank you, Ms. Giffords.

You know, this is sort of an odd day here, but through the preparation for this hearing and discussions that our staff has had with yours, this is one of a variety of hearings that we have had all coming together. We hear a lot of common denominators and this is going to help us as we put the final touches on our COMPETES bill.

So with that, let me say that the record will remain open for two weeks for additional statements from Members and for answers to follow-up questions, and we would also make it available for the witnesses if you have additional statements that you would like to make over these next two weeks, and so the witnesses are excused and the hearing is now adjourned.

[Whereupon, at 12:17 p.m., the Committee was adjourned.]

Appendix:

Additional Material for the Record

STATEMENT BY VARTAN GREGORIAN, PRESIDENT,
CARNEGIE CORPORATION OF NEW YORK

Carnegie Corporation of the New York appreciates the opportunity to submit this testimony to the U.S. House Committee on Science and Technology (Committee) on the reauthorization of the America COMPETES Act.

From the work of Euclid to Ptolemy to Newton to Descartes, mathematics has laid the foundation for modern science. And from the time of the Renaissance on, science itself has been central to the development of modern society and the primary engine of global progress. Successes achieved in almost every field of human endeavor—medicine, transportation, commerce, communication, engineering, security and defense, to name just a few—owe an incalculable debt to the evolution of math and science.

As the Committee knows, in recent years the worldwide spread of technological advances has not resulted in an equally robust appreciation of mathematics and science among Americans. Now, however, we have entered into a new phase of globalization characterized by knowledge-based economies and fierce competition; the United States can no longer afford not to be fully engaged with math and science and their application to teaching and learning. If we believe, as the great education reformer Horace Mann did, that "education is the engine of democracy," then the strength and progress of both American society and our democracy depend on our ability to mobilize around this work, with clear goals and great determination.

ROADMAP FOR REFORM

Nine months ago the Carnegie Corporation of the New York–Institute for Advanced Study Commission on Mathematics and Science Education (Commission) released "The Opportunity Equation: Transforming Mathematics and Science Education for Citizenship and the Global Economy." The report lays out what we believe is the definitive roadmap not only for the reauthorization of the America COMPETES Act, but also education reform overall. The report and the two years of study and deliberation that went into it are truly unlike any reform effort that has come before.

Firstly, the Commission that authored the report did not just call for reform. Rather, its ultimate goal—its challenge to the nation—was far bolder: the United States must *mobilize* for *excellence* and *equity* in mathematics and science education. The Commission believed that the magnitude of the challenge demands transformative change in classrooms, schools, education systems and beyond. Educators, students, parents, universities, museums, businesses, scientists, mathematicians, and public officials at all levels will need to embrace a new understanding that the world has shifted dramatically—and that an equally dramatic shift is needed in educational expectations and the design of schooling. As a society, we must commit ourselves to the reality that *all* students can achieve at high levels in math and science, that we need them to do so for their own futures and for the future of our country, and that we owe it to them to structure and staff our educational system accordingly.

Only through a national mobilization for mathematics and science learning will the need for change be made apparent to all Americans and the resources and commitment to the effort be brought to bear. In short, we need to *mobilize* in ways not unlike how the Nation fought and won two world wars, overcame the Great Depression, landed a man on the moon and secured civil rights for people of color. We believe that's how our fellow citizens, educators, and policymakers must begin to view it.

Secondly, *all* students, not just a select few, or those fortunate enough to attend certain schools, must achieve *much higher* levels of math and science learning. By higher levels, we mean the requisite math and science skills to understand the natural world, the built environment, systems of society, and the interactions among them that will determine the future of our nation and planet. These are competencies that all Americans must have if they are to contribute to and gain from the country's future productivity, understand policy choices, and participate in building a sustainable future. Knowledge and skills from science, technology, engineering, and mathematics, the so-called STEM fields, are crucial to virtually every endeavor of individual and community life. Therefore, all young Americans should be educated to be "STEM-capable," no matter what educational path they pursue, or in which field they choose to work.

Thirdly, success in achieving excellent math and science learning for all students requires that math and science be placed *more squarely at the center* of the educational enterprise. Making improvements in only math and science education is not

enough. Rather, we need to give at least equal weight to driving fundamental change throughout our educational system—in the nation's schools, school districts, and institutions of higher education.

Finally, the "Opportunity Equation" goes beyond generalities. It lays out a comprehensive program of action, describing concrete steps that a range of stakeholders—from labor and business to Federal and state government, school districts, colleges and universities, non-profit organizations, and philanthropy—can take. As the Committee undertakes the reauthorization of the America COMPETES Act, we urge it to use the report as a roadmap for reform.

STRENGTHENING THE AMERICA COMPETES ACT

The reauthorization of the Act could very well be a defining moment in the history of math and science education reform. Through reauthorization the Committee, the Congress and the Nation have the opportunity to define what the Federal Government's role will be in leading this reform for the next decade and beyond. With "Opportunity Equation" as our guide, we at Carnegie Corporation of New York believe the Committee should reauthorize the Act in accordance with these fundamental principles:

EXCELLENCE AND EQUITY: MOBILIZING FOR MATH AND SCIENCE LEARNING

As one of the most important expressions of national education policy, the Act should explicitly support the principle of higher levels of mathematics and science learning for *all* American students. We must place even our most disconnected students on pathways to graduation and postsecondary education. Moreover, our schools must provide more opportunities for the most successful students in math and science to accelerate beyond what is traditionally available in high school. Excellence *and* equity are vital and must be pursued in tandem.

Put Math and Science Front and Center. To achieve the goals laid out in "Opportunity Equation," the Commission believes that improvement in math and science outcomes, especially by historically underperforming groups, should be a benchmark in the design and evaluation of school improvement efforts at all grade levels and subject areas, including literacy, social studies, art, and service learning.

U.S. Department of Education (ED) should build improvements in math and science learning into *all* of its major reform initiatives, as it's doing with the $4.35 billion *Race to the Top* (RttT). For example, RttT places an emphasis on funding innovative strategies for recruiting, credentialing, rewarding, and retaining math and science teachers.

The Act should endorse the joint efforts of the National Governors Association and the Council of Chief State School Officers to develop Common Score Standards in mathematics and English language arts. The Act should also endorse the development of standards in science, which "Opportunity Equation" strongly recommends, through the newly launched effort by the National Research Council to develop a framework for "next generation" science standards for elementary and secondary schools.

Finally, the Act's existing STEM education programs should be funded, which has not yet happened since the Act's first passing and which *Education Week* reported on just last week.

National and State Campaigns to Get the Public Behind Reform. The Federal Government should mount broad campaigns to increase public awareness of math and science as central to the revitalization of the economy and social mobility, as well as critical to success in a wide range of careers in many fields.

Expand Opportunities for Excellence. Our schools must provide more opportunities for the most successful students in math and science to accelerate beyond what is traditionally available in high school. From afterschool programs to summer institutes to advanced coursework, we should not hold back our most promising students by limiting them to the resources within the walls of their schools.

INNOVATION IN EDUCATION: SUPPORTING CHANGE

As the Commission discovered in its two years of study, there's been considerable innovation in the education sector, especially in recent years. New "best practices" and ways to disseminate them abound. Higher-quality assessments in mathematics and science have been developed, as have technology-based learning innovations. Nevertheless, as compared to other sectors, "(e)ducation has long suffered from a lack of high-quality, dedicated research and development capacity," according to the Commission's findings. The "Opportunity Equation" report concludes, as follows:

Finally—and this will be as important as anything to our long-term success—the American educational system must upgrade its own capacity to innovate. We need to get smarter about developing and testing new ideas, tapping and advancing professional knowledge, and putting best practices to use.

Support Innovation through an 'i3' for STEM. Carnegie Corporation of New York supports the Administration's FY 2011 Budget proposal to sets aside a portion of ED's Investing in Innovation Fund (i3) to support STEM projects. As Education Secretary Duncan explained, i3 for STEM would provide seed money for fresh ideas, help grow promising programs and scale up to a national level program with proven results.

Incentives for Sharing with Federal Programs. The amount of private research and development, both among non-profit and for-profit education organizations, has never been greater. As importantly, major funding is available to finance this change—from the Federal Government as well as foundations. We've also learned a great deal over the past few years about what's working in education and what innovation in education looks like; examples include such success stories as New Leaders for New Schools, Teach for America, and The New Teacher Project. Private organizations could be incentivized to share their best practices and new knowledge with Federal programs for replication, dissemination, and scaling up.

Leverage the Government's Vast Research Assets. The Federal Government has worked closely for decades with both industry and higher education on research and development, funding, and supporting innovation in defense, agriculture, aerospace and medicine, among others. The Federal Government should connect the education sector with these same companies, industries, and universities, and their innovation infrastructures, resources, scientific knowledge, and creativity.

One avenue could be the creation of an Education Innovation Incubator, similar to Offices of Technology Transfer found at many companies, universities and governmental organizations. Federal research agencies could create and operate such an office for the benefit of education, tapping private research enterprises for new technologies that are readily transferrable to the education sector.

Creating Incentives for Innovation in High-Need Areas. Meaningful incentives must be built into programs and grants to encourage the development of promising practices in high-need areas and answers to tough research questions. The need for such research is pressing in a number of areas: high-quality standards; assessments; professional development; teacher education; teacher evaluations; and partnerships with cultural, research and academic organizations.

Support Promising Practices. In recent years government and private organizations have created an array of innovative approaches to improving math and science learning. These endeavors and others like them in their embryonic stage should be supported with funding and incentive systems to encourage expansion and even more innovation.

Examples of promising practices and programs that should be encouraged, scaled up, and replicated include the Ohio STEM Learning Network; Texas Center for Science, Technology, Engineering, and Mathematics, which has established new models of STEM high schools and STEM teaching; the Teaching Institute for Excellence in STEM, which has shown how to grow new models and implement strengthened STEM education; North Carolina Museum of Natural Sciences' distance education program; and Urban Advantage, a partnership between the American Museum of Natural History and New York City Department of Education, which is being replicated in three cities. Many additional promising practices are noted in the "Opportunity Equation."

BETTER COORDINATION OF FEDERAL MATH AND SCIENCE EDUCATION ACTIVITIES

As the Committee knows, the Federal Government's math and science education activities are varied, numerous, and often isolated. They're located in dozens, maybe hundreds, of agencies or offices. More than fifty years after Sputnik made math and science education a Federal priority, no permanent and on-going means exists to connect and coordinate the many math and science *education and research* activities across agencies.

Interagency Council. Carnegie Corporation of New York supports the creation of a permanent interagency panel to coordinate both educational activities and research programs in the areas of math and science. We need a venue and body to connect the best minds in the Federal Government in these two critical areas.

Linking *Race to the Top* to Other Initiatives. RttT is one of the most ambitious and best financed reform initiatives in recent memory. We applaud the U.S. Department of Education's inclusion of STEM as a competitive priority in RttT. A

next step that could strengthen STEM education would be to improve the linkages between RttT and the best minds and programs in math and science education at Federal agencies. Such integration of math and science education reform into overall reform efforts is essential to successfully placing math and science more squarely at the center of the educational enterprise.

TEACHING AND PROFESSIONAL LEARNING: MANAGING FOR EFFECTIVENESS

Classroom teachers are the primary asset of the American educational system, and they deserve savvy, strategic management. School systems need to recruit and develop qualified candidates for teaching and leadership roles, place them intelligently and equitably in the right positions, cultivate their skills, sustain their commitment over time, and monitor and manage their performance with relevant metrics. The Federal Government should offer support in these critical areas:

Increase the supply of well-prepared teachers of math and science. The Federal Government should support the development of integrated programs of professional learning that engage all teachers in incorporating science and math learning across the curriculum. Through alternative certification and expanded recruitment, the Federal Government should encourage the creation of a strong science and math teacher corps.

The government should also support the dissemination of effective human capital management practices in areas such as teacher recruitment, hiring and retention, and compensation.

Improve professional learning. The Federal Government should continue to support and expand its efforts to provide opportunities for teachers to experience powerful science and math learning themselves. This includes support for programs that strengthen partnerships with science-rich institutions that create new learning opportunities for educators. The Congress should also increase its support for the Federal Government's various teacher institutes, scholarships and fellowships to expand the supply of well-trained math and science teachers. The talent within the government is an extraordinary asset—the Nation should continue to leverage it for excellence in the classroom.

Efforts to expand the use of master teachers and other strategies that strengthen practice, encourage continuous learning, and improve career satisfaction should also be supported.

CONCLUSION

Carnegie Corporation of New York urges the Committee to consult closely the findings and recommendations of the "Opportunity Equation" report. If not a roadmap, it certainly offers valuable, well-reasoned and -researched guideposts for reform, many not found elsewhere. A summary of the recommendations relating to the role of the Federal Government can be found in Appendix 1.

We appreciate this opportunity to share our views and recommendations on how the Nation can make the necessary improvements in math and science learning. We look forward to working with the Committee throughout the reauthorization process and urge it to take bold steps commensurate with the extraordinary economic and social challenges facing the country. There is no time or effort to waste.

APPENDIX 1

Summary of the "Opportunity Equation" Report's Recommendations for Federal Action

The report's recommendations were presented in four priority areas; following are the recommended Federal roles in each:

Higher levels of mathematics and science learning for all American students

- Mobilize the Nation to improve math and science education for all students
  - Mount campaigns that generate public awareness of math and science as central to the revitalization of the American economy and social mobility for young Americans
  - Increase public understanding that math and science are connected to a wide range of careers in many fields—virtually any secure and rewarding job in any sector of the economy
  - Build understanding and will among policymakers and education, business, and civic leaders to close the gap between current education achievement and the future knowledge and skill needs of students
- Place mathematics and science at the center of school improvement, and accountability efforts
  - Make improvement in math and science outcomes, especially by historically underperforming groups, a benchmark in designing and evaluating school improvement efforts at all grade levels for all students
  - Incorporate math and science learning as part of the expected learning outcomes of initiatives in other areas, including literacy, social studies, art, and service learning

Common standards and assessments

- Establish common math and science standards that are fewer, clearer, and higher and that stimulate and guide instructional improvement and galvanize the Nation to pursue meaningful math and science learning for all Americans
  - Endorse the National Governors Association and CCSSO Common Core Standards Initiative process and the creation of common, national standards that are fewer, clearer, and higher in mathematics in English language arts; urge the Common Core states to tackle science standards in the next round of development
  - Support research and development activities that strengthen our collective understanding of what all students need to know and be able to do in order to succeed in college, thrive in the workforce, and participate in civic life
  - Take steps to increase public understanding of the connection between better standards and better math and science education for all students
- Develop sophisticated assessments and accountability mechanisms that, along with common standards, stimulate and guide instructional improvement and innovation in mathematics and science
  - Incentivize development of higher quality assessments in mathematics and science for use by states and districts to evaluate teaching and learning and guide instructional improvement
  - Fund research on the effects of new standards and assessments on student performance and on instruction

Improved teaching and professional learning, supported by better school and system management.

- Increase the supply of well prepared teachers of mathematics and science at all grade levels by improving teacher preparation and recruitment
  - Invest in the analysis of supply and demand for science and math teachers, especially in high-need school districts and schools

- Support recruitment programs for math and science teachers; experiment with scholarships and pay incentives
- Alter certification requirements to allow qualified candidates to enter teaching by innovative and rigorous alternative routes; enable museums, research institutions, and others to become teacher certifiers
- Develop integrated programs of professional learning and quality improvement for teachers of science and mathematics; engage all teachers in professional learning that enables them to incorporate science and math learning across the curriculum
- Make policy changes necessary to create an effective talent corps for schools, including principals and teachers, especially science and math teachers; encourage the dissemination of effective human capital management practices in areas such as teacher recruitment, hiring and retention, and compensation

- Improve professional learning for all teachers, with an eye toward revolutionizing math and science teaching
  - Create and incentivize opportunities for teachers to experience powerful science and math learning themselves
  - Cease support for professional development in science and math that is disconnected from teaching practices in schools; replace with investment in strategic and coherent collaborative offering that link coherent, sustained professional learning, rich in relevant science and math content, to direct practice changes in instruction in schools
  - Promote professional learning that engages teachers in data analysis, identification of students' differentiated learning needs, and assessment of school-level interventions
  - Hold school leaders accountable for the professional learning environment in their schools and districts
  - Strengthen partnerships with science-rich institutions; use those partnerships to open new learning opportunities for educators
  - Invest in sophisticated online professional development systems that facilitate learning communities and cyberlearning by teachers, along with research to enable the improvement of those systems
  - Expand the use of master teachers and other strategies that strengthen practice, encourage continuous learning, and improve career satisfaction
- Upgrade human capital management throughout US schools and school systems toward ensuring an effective teacher for every student, regardless of socio-economic background
  - Make higher science and math achievement the overarching goal for system improvement; structure specific improvement strategies to meet that goal
  - Experiment with strategies to improve job satisfaction of effective teachers of science and math at all grade levels
  - Raise compensation strategically to attract, retain, and reward effective science and math teachers; compare different methods
  - Development data systems that enable meaningful teacher assessment on student achievement
  - Identify and promote leadership opportunities (such as positions as coaches and mentors) for teachers with demonstrated effectiveness in raising student achievement in mathematics and science
  - Give effective teachers a more prominent voice in education policy development

New designs for schools and systems to deliver math and science learning more effectively

- Enhance systemic capacity to support strong schools and act strategically to turn around or replace ineffective schools
  - Create aligned data, accountability, and knowledge management systems across K–16 education to support research and development for improvements in policy, practice, and strategy to increase student achievement, graduation, and post-secondary success; ensure that science achievement is included in the early generation needs

- Develop data and accountability systems that enable schools to use data to inform instructional improvement by individual teachers and schoolwide; data on science achievement, especially in middle and high schools
- Make the policy and management changes to generate and accelerate innovation, and facilitate connections to increase the talent and math and science assets available in schools
- Foster a more rigorous approach to ongoing professional learning, focused on keeping teachers up to date with emerging science and math knowledge and on effective, differentiated pedagogical techniques
- Make policy changes and take administrative action to end policies and practices that result in persistent low achievement, and, in particular, close and replace schools that are low-performing
- Stimulate the production of ideas and products that will support school and classroom innovations to increase math and science achievement through a variety of public funding sources beyond education including economic development, energy, and environmental quality departments
- Identify school models and innovations in school design and instruction that have shown substantial achievement gains in mathematics and science, especially for under-performing middle and high school students
- Remove barriers and pro-actively grow and scale effective school models through innovative governance and management arrangements with educational entrepreneurs; integrate with strategic human capital reforms
- Call for research in areas where innovations do not exist or where there is a need for new knowledge, including basic research, implementation research, and tool development to advance

- Tap a wider array of resources to increase educational assets and expand research and development capacity
  - Narrow the gap between research and practice in improving science and math education by designing innovative partnerships between K–12 education and universities, cultural and scientific institutions that are accountable for joint strategies for improving student achievement
  - Bring innovation and design approaches to bear on improving math and science education in the K–12 educational system by developing R&D capacity and external resources (such as consulting firms, private-sector companies, universities)

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