

PRIVATE SECTOR PROGRAMS THAT ENGAGE STUDENTS IN STEM

HEARING

BEFORE THE

SUBCOMMITTEE ON RESEARCH AND TECHNOLOGY
COMMITTEE ON SCIENCE, SPACE, AND
TECHNOLOGY

HOUSE OF REPRESENTATIVES

ONE HUNDRED THIRTEENTH CONGRESS

SECOND SESSION

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**PRIVATE SECTOR PROGRAMS THAT ENGAGE
STUDENTS IN STEM**

THURSDAY, JANUARY 9, 2014

HOUSE OF REPRESENTATIVES,
SUBCOMMITTEE ON RESEARCH AND TECHNOLOGY
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY,
Washington, D.C.

The Subcommittee met, pursuant to call, at 10:06 a.m., in Room 2318 of the Rayburn House Office Building, Hon. Larry Bucshon [Chairman of the Subcommittee] presiding.

LAMAR S. SMITH, Texas
CHAIRMAN

EDDIE BERNICE JOHNSON, Texas
RANKING MEMBER

Congress of the United States
House of Representatives

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

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Subcommittee on Research and Technology

Private Sector Programs that Engage Students in STEM

Thursday, January 9, 2014
10:00 a.m. to 12:00 p.m.
2318 Rayburn House Office Building

Witnesses

Panel I

Mr. Dean Kamen, Founder, For Inspiration and Recognition of Science and Technology
(FIRST), Founder and President, DEKA Research & Development Corporation

Mr. Hadi Partovi, Co-founder and CEO, Code.org

Dr. Kemi Jona, Director, Office of STEM Education Partnerships, Research Professor, Learning
Sciences and Computer Sciences, Northwestern University

Dr. Phillip Cornwell, Vice President for Academic Affairs, Professor of Mechanical
Engineering, Rose-Hulman Institute of Technology

Panel II

Ms. Ellana Crew, 12th Grade, South River High School, Edgewater, Maryland

Mr. Brian Morris, 12th Grade, Chantilly Academy, Chantilly, Virginia

Mr. Daniel Nette, 11th Grade, George Mason High School, Falls Church, Virginia

Mr. Vishnu Rachakonda, 12th Grade, Elcanor Roosevelt High School, Greenbelt, Maryland

U.S. HOUSE OF REPRESENTATIVES
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
SUBCOMMITTEE ON RESEARCH AND TECHNOLOGY

HEARING CHARTER

Private Sector Programs that Engage Students in STEM

Thursday, January 9, 2014
10:00 a.m. – 12:00 p.m.
2318 Rayburn House Office Building

Purpose

On Thursday, January 9, 2014, the Subcommittee on Research and Technology will hold a hearing to review science, technology, engineering and mathematics (STEM) education initiatives developed and conducted by private organizations to learn what is being done by these organizations and industry to support STEM education and to ensure the federal government can leverage, not duplicate, these initiatives.

Witnesses

Panel I

- **Mr. Dean Kamen**, Founder, For Inspiration and Recognition of Science and Technology (*FIRST*), Founder and President, DEKA Research & Development Corporation
- **Mr. Hadi Partovi**, Co-founder and CEO, Code.org
- **Dr. Kemi Jona**, Director, Office of STEM Education Partnerships, Research Professor, Learning Sciences and Computer Sciences, Northwestern University
- **Dr. Phillip Cornwell**, Vice President for Academic Affairs, Professor of Mechanical Engineering, Rose-Hulman Institute of Technology

Panel II

- **Ms. Ellana Crew**, 12th Grade, South River High School, Edgewater, Maryland
- **Mr. Brian Morris**, 12th Grade, Chantilly Academy, Chantilly, Virginia
- **Mr. Daniel Nette**, 11th Grade, George Mason High School, Falls Church, Virginia
- **Mr. Vishnu Rachakonda**, 12th Grade, Eleanor Roosevelt High School, Greenbelt, Maryland

Overview

The Administration's fiscal year 2014 (FY14) budget request proposed over \$3 billion across over thirteen different agencies of the federal government for science, technology, engineering and mathematics (STEM) education, a 6.7 percent increase over FY12 enacted levels. Despite this level of federal spending, American students rank 26th in math and 21st in science among the 34 nations who comprise the Organization for Economic Cooperation and Development in a survey reported last month.¹ Over 510,000 students age 15-16 years old were surveyed in 2012 with standardized testing methods.

¹ <http://www.oecd.org/pisa/keyfindings/PISA-2012-results-US.pdf>

This survey also reported:

"...the Slovak Republic, which spends around USD 53 000 per student, performs at the same level as the United States, which spends over USD 115 000 per student. Similarly, Korea, the highest-performing OECD country in mathematics, spends well below the average per-student expenditure."

STEM and the American Workforce

A STEM-educated workforce is necessary for preserving American capacity for innovation and discovery and for ensuring U.S. economic strength and competitiveness in the international marketplace of the 21st century. According to the National Science Board Science and Engineering Indicators 2012, "the S&E workforce has for decades grown faster than the total workforce... The number of workers in S&E occupations grew from about 182,000 in 1950 to 5.4 million in 2009."² As demand for skilled STEM workers continues to grow the U.S. will work to produce the workers required to fill those employment needs. The looming retirements of the baby-boomer generation and current unemployment rates have exacerbated a U.S. workforce in flux for many generations.

According to a 2007 report from the U.S. Department of Labor, "[i]ndustries and firms dependent upon a strong science and math workforce pipeline have launched a variety of programs that target K-12 students and undergraduate and graduate students in STEM fields."³ Finding ways to improve STEM education activities beyond the scope of the federal government, including best practices, is key to the future technical and economic competitiveness of our nation.

Many industry sectors, non-profit organizations, entrepreneurs and educational institutions are working in a variety of ways in order to bolster the STEM related workforce pipeline. Involvement in K-12 initiatives and support for undergraduate and graduate work fall within the broad scope of these STEM initiatives. Partnerships with education providers, STEM focused competitions, and other opportunities have become important pieces of private sector efforts to strengthen the STEM workforce. Industry and philanthropic organizations may offer financial or technical support for students, professional development opportunities for teachers, and technology for classrooms as a way to encourage interest in and support for STEM education. Understanding the work these organizations are undertaking in the STEM fields will inform the federal government's role, help to reduce duplication of effort, and leverage existing programs.

² National Science Board. 2012. *Science and Engineering Indicators 2012*. Arlington, VA: National Science Foundation (NSB 12-01). P. 3-8.

³ http://www.doleta.gov/Youth_services/pdf/STEM_Report_4%2007.pdf, p. 6

Chairman BUCSHON. The Subcommittee on Research and Technology will come to order.

Good morning, everyone. Welcome to today's hearing titled "Private Sector Programs that Engage Students in STEM," which we all know is a very important subject.

In front of you are packets containing the written testimony, biographies and Truth in Testimony disclosures for today's witnesses. I now recognize myself for five minutes for an opening statement.

I am happy to call to order the first Research and Technology Subcommittee hearing of the new year. Today we will learn about private sector initiatives in science, technology, engineering and mathematics, or STEM, education and how these companies, businesses and organizations engage students in these important fields.

A report released by the National Science Board in 2012 indicates that the science and engineering workforce historically grows faster than the total workforce. Although the science and engineering growth rate has maintained a higher rate than the total workforce, the last decade has seen much lower growth.

One of the most essential aspects to keeping America at the forefront of STEM innovation, advancement and development is engaging students at a young age and keeping them interested in pursuing STEM degrees and careers.

As a cardiothoracic surgeon and father of four children between the ages of 9 and 20, I understand that such programs and activities are necessary to enhance America's economic growth and competitiveness. With the federal government spending nearly \$3 billion across 13 federal agencies on STEM education programs each year, we must ensure the government is leveraging rather than duplicating private sector STEM education initiatives.

Our hearing today will provide a unique opportunity for our first panel of witnesses to discuss the innovative projects and programs taking place at their private sector business and educational institutions, and for our second panel of witnesses to discuss their personal experiences with these types of initiatives.

I look forward to hearing from all of our witnesses and I would like to thank them for their participation and offering their time and insight into the private sector's success in STEM education.

[The prepared statement of Mr. Bucshon follows:]

PREPARED STATEMENT OF SUBCOMMITTEE ON RESEARCH AND TECHNOLOGY
CHAIRMAN LARRY BUCSHON

I am happy to call to order the first Research and Technology Subcommittee hearing of the year. Today we will learn about private sector initiatives in science, technology, engineering and mathematics, or STEM, education and how these companies, businesses and organizations engage students in these important fields.

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I look forward to hearing from all of our witnesses and I would like to thank them for their participation and offering their time and insight into the private sector's success in STEM education.

Chairman BUCSHON. At this point I recognize the Ranking Member, the gentleman from Illinois, for an opening statement, five minutes.

Mr. LIPINSKI. Thank you, Chairman Bucshon. I want to thank all of our witnesses for being here today.

One of the reasons that I had joined this Committee when I first came to Congress is because of my strong interest in working to improve math and science education in this country. I am one of only a dozen engineers in the House and Senate, and my wife was a math major in college and, unlike me, her STEM training led her directly into a career as an actuary. So from my own family experiences and what I have seen and heard from others, I am very aware of how important it is that we do a good job of engaging and educating our students at all levels in STEM fields.

But with the release last month of the latest PISA results, we were reminded yet again of the troubling statistics on the state of U.S. math and science education. U.S. K–12 students rank in the middle of the pack in international comparisons of math and science aptitude. We see the problems at all job levels. I am constantly hearing from manufacturing companies in my district that they have a hard time finding employees who have even basic math and science skills. In higher education, we have far too few students pursuing and completing degrees in certain STEM fields to meet the needs of domestic industry. For example, less than 2.4 percent of college students graduate with a degree in computer science, despite tremendous demand for these skills, and that number has dropped over the last decade.

Our troubles start from the earliest grades and are part of a negative feedback cycle that we have to break. Students who aren't learning the necessary skills by the time they graduate high school are much less likely to pursue, and to succeed, in STEM fields in college. When we lose an undergraduate student from a STEM field, we lose a scientist or engineer who could potentially pursue a career in teaching the next generation.

We know these to be complex problems with no easy or one-size-fits-all solution. That is why partnerships between the private sector, Federal and state governments, colleges, universities, local school districts, national labs, science museums, zoos and aquaria, and all types of nonprofits are more important today than ever. The United States still has some of the best K–12 schools, colleges and universities in the world, and our top students at all levels compete easily with the top students from around the world. That is why I am glad we have witnesses here today that can speak to the types of STEM partnerships needed to engage young minds at an early age and keep them engaged in STEM fields. In particular, Northwestern University's Office of STEM Education Partnerships

connects K–12 teachers and students to world-class STEM resources of Northwestern University and corporations in the state of Illinois such as Boeing, Baxter, Google, Hewlett Packard, IBM and more. I am especially proud as a graduate of Northwestern with my degree in mechanical engineering.

Today’s hearing focuses on private sector and university STEM engagement programs. I look forward to hearing from these accomplished individuals who have dedicated their careers to improving STEM engagement and learning in their communities and across the Nation. I also look forward to hearing from the students who have participated in the FIRST Robotics competition.

But I also want to say a few words about the Federal role in this partnership. The federal government invests \$3 billion in STEM education across 14 agencies. While that is a large dollar figure, it is important to put that number in perspective. Less than half of that is focused at the K–12 level. Federal investments in K–12 education overall account for only ten percent of total U.S. funding for K–12 education, and the Federal share of STEM funding is likely much less than ten percent. So the Federal role is limited, but it is also unique and necessary.

The National Science Foundation is the single most important source of research, development, and testing of innovative new models for STEM education. The federal government also has an unrivaled ability to convene stakeholders and to leverage private sector investment in STEM education. Entrepreneurs like Mr. Kamen and Mr. Partovi did not have to start from scratch. They are smart businessmen investing in, perfecting, and expanding evidence-based ideas and programs. So while the federal government cannot begin to solve our STEM education challenges alone, we would be remiss to ignore the important role the government does play. I hope that this Committee will continue to exercise its oversight authority to ensure that we get the most out of our relatively small but critical Federal STEM education programs.

I want to thank Chairman Bucshon again for calling this hearing, and the witnesses as well for taking the time today to offer their insights and experiences.

With that, I will yield back.

[The prepared statement of Mr. Lipinski follows:]

PREPARED STATEMENT OF SUBCOMMITTEE ON RESEARCH AND TECHNOLOGY
RANKING MINORITY MEMBER DANIEL LIPINSKI

Thank you, Chairman Bucshon, and thank you to all of the witnesses for being here today. One of the reasons I joined this Committee is because of my strong interest in working to improve math and science education in this country. I am one of only a dozen members of the House and Senate who has an engineering degree. My wife was a math major in college and—unlike me—her STEM training led her directly into a career as an actuary. From our own family experiences and what I have seen over the years, I am very aware of how important it is that we do a good job of engaging and educating our students at all levels in STEM fields.

But with the release last month of the latest PISA results, we were reminded yet again of the troubling statistics on the state of U.S. math and science education. U.S. K–12 students rank in the middle of the pack in international comparisons of math and science aptitude. We see the problems at all job levels. I constantly hear from manufacturers back home that they have a hard time finding employees who have even basic math and science skills. In higher education we have far too few students pursuing and completing degrees in certain STEM fields to meet the needs

of domestic industry. For example, less than 2.4% of college students graduate with a degree in computer science, despite tremendous demand for these skills, and that number has dropped over the last decade.

Our troubles start from the earliest grades and are part of a negative feedback cycle that we must break. Students who aren't learning the necessary skills by the time they graduate high school are much less likely to pursue, and to succeed, in STEM fields in college. When we lose an undergraduate student from a STEM field, we lose a scientist or engineer who could potentially pursue a career in teaching the next generation.

We know these to be complex problems with no easy or one-size-fits-all solution. That's why partnerships between the private sector, Federal and state governments, colleges, universities, local school districts, national labs, science museums, zoos and aquaria, and all types of nonprofits are more important than ever. The U.S. still has some of the best K-12 schools, colleges, and universities in the world, and our top students at all levels compete easily with the top students from around the world. That's why I'm glad we have witnesses here today that can speak to the types of STEM partnerships needed to engage young minds at an early age and keep them engaged in STEM fields. In particular, Northwestern University's Office of STEM Education Partnerships connects K-12 teachers and students to the world-class STEM resources of Northwestern University and corporations in the state of Illinois such as Boeing, Baxter, Google, Hewlett Packard, IBM, and more.

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But I also want to say a few words about the federal role in this partnership. The Federal Government invests \$3 billion in STEM education across 14 agencies. While that is a large dollar figure, it's important to put that number in perspective. Less than half of that is focused at the K-12 level. Federal investments in K-12 education overall account for only 10 percent of total U.S. funding for K-12 education, and the federal share of STEM funding is likely much less than 10 percent. So the federal role is limited, but it is also unique and necessary. The National Science Foundation is the single most important source for research, development, and testing of innovative new models for STEM education.

The federal government also has an unrivaled ability to convene stakeholders and to leverage private sector investment in STEM education. Entrepreneurs like Mr. Kamen and Mr. Partovi did not have to start from scratch. They are smart businessmen investing in, perfecting, and expanding evidence-based ideas and programs. So while the federal government cannot begin to solve our STEM education challenges alone, we would be remiss to ignore the important role the government does play. I hope that this Committee will continue to exercise its oversight authority to ensure that we get the most out of our relatively small, but critical federal STEM education programs.

I want to thank Chairman Bucshon again for calling this hearing, and the witnesses as well for taking the time to offer their insights and experiences with us today. And with that, I yield back.

Chairman BUCSHON. Thank you, Mr. Lipinski.

I now recognize the Chairman of the full Committee, the gentleman from Texas, Mr. Smith.

Chairman SMITH. Thank you, Mr. Chairman.

First of all, let me comment on the atmosphere I ran into when I entered the room before the hearing officially began and the gavel came down, because it was an atmosphere unlike almost any other hearing I have walked into. The atmosphere was almost festive, and people were excited because they are interested in this subject, and I think we are excited also about what we are going to hear from our witnesses today in the case of both panels. This is a subject that fascinates us, I think, and we all realize it is absolutely a key to the future prosperity of this country. So it was fun to walk into that kind of an environment.

Mr. Chairman, to achieve the innovations of tomorrow, we must better educate American students today. The federal government

spends nearly \$3 billion each year on science, technology, engineering and math education activities. These programs are found primarily at the National Science Foundation and the Department of Education.

Today we will hear from leaders and experts from private sector organizations that focus on engaging students in STEM education. Two of them were established for this express purpose. We need to learn what is taking place outside of the federal government so we can be sure we are not spending taxpayer dollars on duplicative programs, and we need to more effectively use taxpayers' dollars to gain the most benefit for our students and our country. It is critical to understand what is working and how we can build on that success.

The leaders of these organizations and the student participants here today are in a good position to provide us with useful information.

A well-educated and trained STEM workforce will promote our future economic prosperity. But we must persuade our Nation's youth to study science and engineering so they will want to pursue these careers. Great strides are being made in STEM education by the organizations represented here today, FIRST and Code.org, and by institutions like the Rose-Hulman Institute of Technology and Northwestern University.

Unfortunately, American students still lag behind students of other nations when it comes to STEM education. American students, according to one poll, rank 26th in math and 21st in science. This is not the record of a country that expects to remain a world leader.

We need to ensure that young adults have the scientific and mathematic skills to strive and thrive in a technology-based economy. You can't have innovation without advances in technology, and the STEM students of today will lead us to the cutting-edge technologies of tomorrow.

The students participating in our second panel are proof that a STEM education can prepare our next generation of scientists, engineers, entrepreneurs and leaders.

Mr. Chairman, thank you, and I look forward to hearing from our witnesses today.

[The prepared statement of Mr. Smith follows:]

PREPARED STATEMENT OF FULL COMMITTEE CHAIRMAN LAMAR S. SMITH

To achieve the innovations of tomorrow, we must better educate American students today. The federal government spends nearly \$3 billion dollars each year on science, technology, engineering and math (STEM) education activities. These programs are found primarily at the National Science Foundation and the Department of Education.

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We need to ensure that young adults have the scientific and mathematic skills to strive and thrive in a technology-based economy. You can't have innovation without advances in technology. And the STEM students of today will lead us to the cutting-edge technologies of tomorrow.

The students participating in our second panel are proof that a STEM education can prepare our next generation of scientists, engineers, entrepreneurs and leaders. I look forward to hearing about the STEM programs and activities of our witnesses.

Chairman BUCSHON. Thank you, Chairman.

I now recognize the Ranking Member, the gentlelady from Texas, Ms. Johnson, for her opening statement.

Ms. JOHNSON. Thank you very much, Mr. Chairman, and thank you for holding this hearing.

I would like to start by asking all of the students that are present to stand. I want to congratulate you, and I am truly impressed by your leadership and your accomplishments. You should be very proud because you will be our leaders of tomorrow. Thank you for standing.

Unfortunately, too many students across the country do not have the opportunities to participate in inspiring STEM activities or to receive a high-quality STEM education. Once again, our students were just in the middle of the pack in the latest international test of science and math proficiency. I had a long visit just last night with the minister of education from Japan, and we talked about that a lot.

We can no longer depend on our top few percent to maintain a strong and vibrant economy with good, high-paying jobs in our own communities. Our competitive edge will be lost if we do not vastly improve STEM education in this country for all of our students.

We know that this is a complex challenge that no entity can solve alone. There is no silver bullet. And there is a role for all the key stakeholders, public and private. Today we hear from two entrepreneurs and two education leaders in STEM education. I congratulate them for their important work and thank them for taking the time to provide their insight to this Committee today.

But I also want to emphasize the important and unique role of the federal government in improving STEM education. Many Federal STEM programs, including those supported by the National Science Foundation and the Department of Education, are making a difference in universities, community colleges, and K-12 across the nation. There are also many valuable programs being funded through other Federal science agencies, such as NASA, NOAA and the Department of Energy. These agencies are filled with thousands of scientists and engineers who can make a difference in their own communities for students across the country. As working STEM professionals, the real life work that they do using STEM is so inspiring to our students. Take an astronaut to the classroom. You will see what I am talking about.

But the Federal role is more than that. The National Science Foundation is the premier STEM education research organization in the country. For decades, NSF has been a leader in developing the most effective and inspiring STEM curricula and programs in and out of the classroom. When the private sector invests in STEM education, they are looking for proven programs with proven outcomes. The National Science Foundation more than any other organization is responsible for building that evidence base. I hope this Committee will continue to exercise its responsibility to conduct oversight of NSF's and other agencies' STEM education programs.

Today, though, I look forward to hearing from the experts on the first panel about their programs and how we measure that impact. I also look forward to hearing from the students about what initially sparked their interest in STEM, and what role their teachers, parents and other mentors have played in helping them to reach their goals.

I thank all of you for being here today to share this experience. I want to see the United States move from 26 to one. When I came here over 20 years ago, we were number 18. We are going backwards. We are challenged. We have got to meet that challenge. Thank you.

[The prepared statement of Ms. Johnson follows:]

PREPARED STATEMENT OF FULL COMMITTEE RANKING MEMBER
EDDIE BERNICE JOHNSON

Good morning and thank you Chairman Bucshon for holding this hearing. I want to start by congratulating the students who are here today and welcoming you to the Committee. I am truly impressed by your leadership and your accomplishments, and you should all be very proud.

Unfortunately, too many students across the country do not have opportunities to participate in inspiring STEM activities or to receive a high quality STEM education. Once again, our students were just in the middle of the pack in the latest international test of science and math proficiency. We can no longer depend on our top few percent to maintain a strong and vibrant economy with good, high-paying jobs in our own communities. Our competitive edge will be lost if we do not vastly improve STEM education in this country for all of our students.

We know that this is a complex challenge that no one entity can solve alone. There is no silver bullet. And, there is a role for all the key stakeholders, public and private. Today we hear from two entrepreneurs and two education leaders in STEM education. I congratulate them for their important work and thank them for taking the time to provide their insight to the Committee today.

But I also want to emphasize the important and unique role of the federal government in improving STEM education. Many Federal STEM programs, including those supported by the National Science Foundation and the Department of Education, are making a difference in universities, community colleges, and K-12 schools across the nation. There are also many valuable programs being funded through other federal science agencies, such as NASA, NOAA, and the Department of Energy. These agencies are filled with thousands of scientists and engineers who can make a difference in their own communities and for students across the country. As working STEM professionals, the real life work that they do using STEM is so inspiring to our children.

But the federal role is more than that. The National Science Foundation is the premier STEM education research organization in the country. For decades, NSF has been a leader in developing the most effective and inspiring STEM curricula and programs in and out of the classroom. When the private sector invests in STEM education, they are looking for proven programs with proven outcomes. NSF, more than any other organization, is responsible for building that evidence base. I hope this Committee will continue to exercise its responsibility to conduct oversight of NSF's and other agencies' STEM education programs.

Today though, I look forward to hearing from the experts on the first panel about their programs and how they measure impact. I also look forward to hearing from the students about what initially sparked their interest in STEM, and what role their teachers, parents, and other mentors have played in helping them to reach their goals. Thank you all for being here today to share your experiences with us.

Chairman BUCSHON. Thank you.

If there are Members who wish to submit additional opening statements, your statements will be added to the record at this point.

At this time I am going to introduce our first panel of witnesses. Our first witness today is Mr. Dean Kamen. Mr. Kamen is an inventor and entrepreneur and the founder of For Inspiration and Recognition of Science and Technology, otherwise known as FIRST, and founder and President of DEKA Research and Development Corporation.

Our second witness is Mr. Hadi Partovi. Mr. Partovi is an entrepreneur and an investor who was on the founding teams of Tellme and iLike, and worked on Facebook, Dropbox and others as an investor and startup advisor. He co-founded the education nonprofit Code.org. Mr. Partovi is a graduate of Harvard.

Our third witness is Dr. Kemi Jona. Dr. Jona is a Professor of Learning Sciences and Computer Science at Northwestern University. He is the founder and Director of Northwestern's Office of STEM Education Partnerships. Dr. Jona holds a Ph.D. from Northwestern and a B.S. in computer science and psychology from the University of Wisconsin-Madison.

Our fourth witness, from my district, is Dr. Phillip Cornwell, Vice President for Academic Affairs and Professor of Mechanical Engineering at Rose-Hulman Institute of Technology in Terre Haute. Dr. Cornwell received his B.S. degree in mechanical engineering from Texas Tech University and his M.A. and Ph.D. from Princeton.

Our witnesses should know spoken testimony is limited to five minutes. There will be some latitude given.

And I now recognize Mr. Kamen for five minutes to present his testimony.

**TESTIMONY OF MR. DEAN KAMEN, FOUNDER,
FOR INSPIRATION AND RECOGNITION
OF SCIENCE AND TECHNOLOGY (FIRST),
FOUNDER AND PRESIDENT,
DEKA RESEARCH &
DEVELOPMENT CORPORATION**

[video]

Mr. KAMEN. You have to do what the voice of God tells you.

Firstly, thank you, Chairman Smith, thank you, Chairman Bucshon, thank you, Ranking Member Lipinski, and thank you, Ranking Member Johnson. Each one of you has made comments that make this seem like it is going to be real easy. I think everybody understands the problem, everybody understands the importance of reinvigorating the entire generation of American kids to be leaders in the world in science and tech.

Maybe this is unusual for you. I don't know much about Washington but it seems like everybody comes here asking for some-

thing. I can tell you, I as DEKA Research am not asking you for anything for me or my company, and I as the founder of FIRST am not asking you for anything for FIRST. FIRST has 3,500 corporate sponsors now. FIRST has 160 universities that are desperate to help get these kids into their system. They gave us last year over \$18 million in scholarships to give out at our championship. We will have more this year.

I am not asking you for them, but there are a few tens of millions of kids in this country that don't have access to FIRST. They are not capable of leveraging what these 3,500 corporate sponsors that are donating 120,000 world-class scientists and engineers. You can't buy these people. You couldn't afford them, and you can't buy passion. They do it because they care, because they are serious adults and professionals and parents. They know that we have got to invigorate kids to do something like this, so I am here to ask you to figure out how to get FIRST available to all these schools, and by doing that, you will be able to leverage what FIRST has put together over the last 25 years, and I think it will be a winner for everybody.

My little red light is on, so I guess I have to shut up.
[The prepared statement of Mr. Kamen follows:]

House Committee on Science, Space, and Technology
Before the Subcommittee on Research and Technology
Private-Sector Programs that Engage Students in STEM

January 9, 2014

Testimony by Dean Kamen
Founder & President, DEKA Research & Development Corporation, and
Founder of *FIRST*[®]

Chairman Bucshon, Ranking Member Lipinski, and Members of the Subcommittee, my name is Dean Kamen. I am an inventor, entrepreneur, and founder of a not-for-profit organization called *FIRST*[®], which stands for the *Foundation for Inspiration and Recognition of Science and Technology*. I want to thank the Subcommittee for inviting me to testify about the private sector's role in meeting a critical need in America today: specifically, the need to change our culture so that youth are inspired to become Science, Technology, Engineering, or Mathematics (STEM) majors in college and go on to rewarding STEM careers, thereby keeping the United States at the forefront of innovation. *FIRST* does exactly that. *FIRST* has already demonstrated that it works, by engaging young people in grades K through 12 in fun, hands-on, after-school programs and competitions that connect the concepts they study in the classroom to real-world experiences and applications.

I am not here today to ask for your financial support of the *FIRST* organization. *FIRST* is generously supported by more than 3,500 corporate sponsors, both through financial support and through more than 130,000 volunteers and technical mentors. However, I am here to ask you to support schools, especially underserved schools, to gain access to *FIRST*, so that every child in America can discover his or her passion for innovation, while meaningfully preparing to

contribute to the STEM economy and workforce. Specifically, by directing the fees collected through the H-1B visa program, we can inspire and fund a home-grown STEM workforce that will become the technical leaders and entrepreneurs of the future, keeping the U.S. innovation pipeline second to none.

Change the Culture, Change the Future...

Those of us who have witnessed firsthand the power of innovation and scientific research and development can offer a simple message to America and Congress: close the STEM-skills gap and you will help close the budget deficit. Innovation has been the lifeblood of our country's economy fueled by a long-term partnership between the federal government and our nation's scientists, technologists, and engineers. Since World War II, that partnership has accounted for significant technological breakthroughs and contributed in a very meaningful way to our economic success. It has been stated that innovation and technological change may be responsible for as much as three-quarters of our economic growth¹. I am here today to encourage you to 'pay it forward' for future U.S. innovators, the ones who will invent the things we have not yet conceived of or even imagined. We are in a heated competition for the hearts and minds of kids, fighting for their attention in a world that too often points them in the wrong direction. That is a loss for all of us because somewhere out there are kids who can potentially cure cancer, eliminate infectious diseases, or build an engine that does not pollute. They may not know it yet, but they are the future, and you can help inspire them to pursue those paths and provide them with the skills to seize those opportunities.

¹ L. Rafael Reif, *The innovation deficit*, The Boston Globe (December 29, 2013) at <http://www.bostonglobe.com/opinion/2013/12/29/the-innovation-deficit/SiURF7gov1MRsMG6314caN/story.html>; Arti Rai, Stuart Graham, and Mark Doms, Patent reform: Unleashing innovation, promoting economic growth & producing high-paying jobs (April 13, 2010), US Department of Commerce, at http://www.commerce.gov/sites/default/files/documents/migrated/Patent_Reform-paper.pdf

FIRST is all about changing our culture...for the better. More than 20 years ago, I saw a culture where celebrities and sports stars were celebrated and revered, and scientists and engineers were not. I believed then, and still believe now, that our collective future depends on getting more kids from every background and every part of the country interested in and turned onto STEM so that they might seek education and careers in these fields. When you walk into a high school, there are trophies for baseball, basketball, soccer and even cricket—but do you ever see a trophy case for a *Sport for the Mind*[™]? *FIRST* builds that trophy case in a few extremely fortunate schools—today it is full of medals, trophies, awards, and ‘bragging rights’—with the help of many of the country’s CEOs and leading technology and innovation companies. In fact, our sport is the only one where every kid can turn pro—there are jobs out there for each of these kids. Unfortunately, *FIRST* is still not available to millions of kids and many of the schools that most need this program.

What Is *FIRST*?

With the help of a few visionary corporate sponsors, *FIRST* was established in 1989 as a 501(c)(3) not-for-profit public charity with a mission to inspire young people to become science and technology leaders and innovators, by engaging them in exciting, mentor-guided, robotics and research programs that build science, engineering, and technology skills; inspire innovation; and foster self-confidence, team building, and leadership. By working directly with world-class volunteer scientists and engineers, each team of students engages in the process of designing and building real robots that compete in an exciting competition that is similar in many ways to the other sports that have proven so effective in capturing their time, attention, and passion for excellence. *FIRST*, however, develops skills that will enable these students to pursue exciting careers where millions of jobs await properly skilled professionals. Like the other exciting and

engaging high-school sports, the *FIRST* competition season includes local, regional, and a national championship which will once again this year be hosted in a 76,000-seat arena in St. Louis, Missouri.

While in-classroom STEM exposure is necessary, it is not sufficient to spur enough students' interest in these fields. The hands-on, after-school *FIRST* experience is engaging and highly effective in motivating students to become scientists and engineers. This after-school setting gives young people the unique opportunity to learn through solving real problems and hitting a few dead ends along the way, thereby creating an experience necessary for future research, experimentation, and innovation and developing the persistence that STEM fields require. Indeed, *FIRST* is effective: *FIRST* participants are 66% more likely than non-participants to attend college on a full-time basis and twice as likely to major in science or engineering; among women this number grows to four times more likely².

Igniting Young Minds...

As the world moves ever closer to a truly competitive global economy, the challenge to develop lasting interest in science and technology among the country's young people has never been more critical. These youth will propel our collective futures. And that is what *FIRST* is all about—giving kids the opportunity to develop the muscle between their ears; to gain experiences that will directly affect their futures and ours. But, *FIRST* is much more than a 'techie' competition. It's a cultural agent of change that brings all types of people together in a multi-generational, multi-talented way to make an impact on how kids perceive themselves and whom

² Alan Melchior, et al, *More than Robots: An Evaluation of the FIRST Robotics Competition Participant and Institutional Impacts* (2005). Waltham, MA: Center for Youth and Communities, Brandeis University.

they choose for role models. The skills they learn along the way guarantee them extraordinary career opportunities in a host of exciting fields.

Building Blocks to Innovation...

FIRST learning never stops. From ages 6 to 18, four *FIRST* programs help kids master skills and concepts they will use over and over as they progress from one level to the next, and into college and a career. The four *FIRST* programs include:

- Junior *FIRST*[®] LEGO[®] League (Jr.FLL[®]) for grades K-3
 - *Teams design and construct a model with motorized parts using LEGO elements, and present their research journey on a “Show Me” poster.*
- *FIRST*[®] LEGO[®] League (FLL[®]) for grades 4-8
 - *Teams build LEGO-based autonomous robots and develop research projects based on a real-world challenge that changes annually. (The 2014 Challenge topic involves preparing for, surviving, and recovering from natural disasters.)*
- *FIRST*[®] Tech Challenge (FTC[®]) for grades 7-12
 - *Students learn to think like engineers. Teams develop strategy, build robots using a reusable kit of parts, and compete in exciting, real-time head to head tournaments..*
- *FIRST*[®] Robotics Competition (FRC[®]) for grades 9-12
 - *Teams compete with 120-lb. robots in this varsity Sport for the Mind™, combining the excitement of sports with the rigors of science and technology. Teams have only six weeks to design, create, and build their robot, followed by seven weeks of gracious, but intense, competition.*

FIRST Impact...

Over the past 23 years, more than a million youth in this country, assisted by hundreds of thousands of adult volunteers and thousands of corporate sponsors, have discovered that they can be anything they want to be, and their life paths have been changed forever. Here are a few figures that show the meaningful scale and impact of *FIRST*:

- Approximately 12,750 schools in the U.S., or 10% of U.S. schools, currently participate in *FIRST* programs.
- Nearly 250,000 U.S. students are currently engaged across the four *FIRST* programs.
- More than 30% of all *FIRST* students are women and minorities.
- *FIRST* students are assisted by an ecosystem of more than 130,000 committed volunteers, mentors, and coaches, from both schools and corporate sponsors, who contribute more than eight million volunteer hours annually.
- *FIRST* and *FIRST* teams are supported by more than 3,500 corporate sponsors, large and small.
- A recent survey of *FIRST* alumni shows that 89.6% are either majoring in a STEM field in college or are working in a STEM profession³.
- In 2013 alone, more than \$18 million in college scholarships, up to and including full tuition, were available to *FIRST* participants from 156 providers, including 133 U.S. colleges and universities who actively recruit these students. The scholarship dollars and participating schools continue to grow annually.

³ Non-published report, *FIRST* Research & Evaluation, *FIRST* Alumni Study (2011).

More to do...

More than two decades of effort and investment by hundreds of thousands of adult volunteers, thousands of companies (*FIRST* is supported by two of every five Fortune 500 companies), sports and entertainment moguls, and federal and state government leaders have grown our organization into a national and global force for change. However, we are still far from reaching our goal to be available to every school across the country. Many more students and teachers deserve the opportunity to get involved and benefit from *FIRST*.

FIRST does not yet reflect our national demographics. Too few underserved schools are able to participate. While industry provides the volunteer mentors and most of the resources required to create and deliver these season-long exciting events, schools need to have at least the resources to leverage this great opportunity. Without resource such as a space to build, stipends for teacher coaches, and support for travel to competitions, schools are unable to participate.

The reality is that *FIRST* already reaches many suburban school districts—where money and engineering mentors are available. The biggest roadblock for making inroads in inner-city and rural communities is the lack of funds to pay teachers stipends to participate in after-school STEM programs.

FIRST has taken initial steps to target underserved communities by working with many great technology organizations, including one major government organization, NASA. Specifically, NASA has graciously provided mentors and funding, for which *FIRST* is extremely appreciative. One great example of NASA's support is the exuberant "Mohawk Guy" from the control room of the Mars "Curiosity" Rover landing. He is a *FIRST* mentor, and many *FIRST*

alumni have become NASA engineers. In addition, NASA has even adopted *FIRST*'s six-week build process to address various challenges. This is already a great return on taxpayer dollars.

We believe the Federal government has a role to play and the unique ability to extend these types of programs so they are accessible to all students across the country. The federal government can provide additional STEM funding by establishing a grant program for schools in underserved communities so that students and teachers in those communities are able to participate in *FIRST*. Also, although we recognize the program is outside the Committee's jurisdiction, it would be helpful for continued support from the Committee to fund AmeriCorps VISTA's STEM program. This program helps fill the skills gap in disadvantaged school districts. *FIRST* is currently the lead partner for AmeriCorps VISTA's efforts to support after-school STEM resources. Unfortunately, this organization does not have the necessary funds to provide a comprehensive nationwide effort.

As I've already noted, *FIRST*'s goal is to insure that every kid in America has access to a *FIRST* program at every school in the United States. In the near term, *FIRST* seeks to reach one million active student participants in the U.S., approximately four times the number of U.S. students currently involved in *FIRST* programs. Those one million students will go a long way to fill the STEM workforce pipeline. Call me the eternal optimist, but I know we can do it. We have the infrastructure in place, we have the passionate volunteers, we have the enlightened self-interest of the Fortune 500, and we have the drive to see this mission accomplished.

Congress Can Accelerate our Progress...

FIRST represents an exceptional opportunity for motivated individuals, educational institutions, and corporations to get involved in the promise of tomorrow. It takes an active and

engaged community to make these types of cultural changes. And that is where and how Congress can assist *FIRST* and ultimately our country's future trajectory. I have seen individual bills that are a laudable effort to solve pieces of the problem. However, I would like to see a comprehensive bipartisan bill that will truly have an impact on providing a pipeline of American-grown STEM workers and professionals.

Congress can and should help inspire our youth and leverage and support this private-sector led program. I have asked the *FIRST* Regional Directors across all 50 states to reach out to Members of this Committee, as well as other Members of Congress, to invite you to local and regional *FIRST* events. You can demonstrate your support for the achievements of young people and their families in your District by attending and speaking at these events. At these events, you will also witness firsthand the excitement, passion, and engagement of our youth in the application of STEM knowledge and innovation.

We also need your support to insure that schools and students everywhere have access and resources to participate in *FIRST*. To overcome the roadblock for making private-sector STEM programs available in inner-city and rural communities, we strongly encourage Congress to pass legislation that directs H-1B visa fees to enable underserved inner-city and rural schools to participate in *FIRST*.

Every year this country imports more than 100,000 workers under the H-1B visa program from countries around the world because the U.S. does not produce enough American-born STEM graduates. Corporations are willing to pay enormous sums of money to gain access to those educated workers, amounting to more than one billion dollars spent annually to overcome this issue. Incidentally, as the economies of emerging countries, such as India, Russia, Brazil,

and China, continue to grow, our ability to solve our domestic STEM shortage by importing workers will decline, as foreign engineers and innovators see better opportunities for growth and wealth in their home countries.

I would like to ask for the Subcommittee's support to direct a portion of those dollars collected from corporations for H-1B visa fees and invest them in home-grown STEM workers, to fuel the next generation of U.S. entrepreneurs and innovators with local youth. Specifically, these fees should support efforts to enable underserved inner-city and rural schools to participate in *FIRST*.

With strong support from generous corporate partners, we will continue to pursue our mission to make *FIRST* programs available and accessible to every student who wants to participate. However, support from this Subcommittee and other leaders in Washington will enable us to reach our goal more quickly and more specifically impact students in underserved inner-city and rural areas.

As I noted, our Regional Directors will be reaching out to your staff, and we would be honored for each of you to come to our events in your state or region to demonstrate the importance Congress places on STEM education. Our *FIRST* "March Madness" season will have more than 90 events throughout the country. Each of you is also invited to attend the *FIRST* World Championship and Festival that will be held in St. Louis, Missouri from April 24th through 26th, 2014 at the Edward Jones Dome.

These competitions are a unique experience, which I am certain you will enjoy. I am also confident that you will be moved and inspired by the intelligence, creativity, passion, and professionalism of our youth. You will see firsthand that the economic and innovative future of

America is incredibly bright, especially if we can engage and inspire kids from all backgrounds and geographies.

I thank you for your time, your attention, and your support in maintaining the United States' leadership in innovation for the next 200 years.

Dean Kamen is an inventor, an entrepreneur, and a tireless advocate for science and technology. His roles as inventor and advocate are intertwined—his own passion for technology and its practical uses has driven his personal determination to spread the word about technology's virtues and by so doing to change the culture of the United States.

As an inventor, he holds more than 440 U.S. and foreign patents, many of them for innovative medical devices that have expanded the frontiers of health care worldwide. While still a college undergraduate, he invented the first wearable infusion pump, which rapidly gained acceptance from such diverse medical specialties as chemotherapy, neonatology, and endocrinology. In 1976, he founded his first medical device company, AutoSyringe, Inc., to manufacture and market the pumps. At age 30, he sold that company to Baxter Healthcare Corporation. By then, he had added a number of other infusion devices, including the first wearable insulin pump for diabetics.

Following the sale of AutoSyringe, Inc., he founded DEKA Research & Development Corporation to develop internally generated inventions as well as to provide research and development for major corporate clients. Kamen led DEKA's development of the HomeChoice™ peritoneal dialysis system for Baxter International Inc. The HomeChoice™ system allows patients to be dialyzed in the privacy and comfort of their home and quickly became the worldwide market leader. Kamen also led the development of technology to improve slide preparation for the CYTYC (now Hologic Inc.) ThinPrep® Pap Test. Kamen-led DEKA teams have also developed critical components of the UVAR™ XTS™ System, an extracorporeal photophereisis device marketed by Therakos, a unit of Johnson & Johnson, for treatment of T-Cell lymphoma. An advanced prosthetic arm in development for DARPA should advance the quality of life for returning injured soldiers. Other notable developments include the Hydroflex™ surgical irrigation pump for C.R. Bard, the Crown™ stent, an improvement to the original Palmaz-Schatz stent, for Johnson & Johnson, the iBOT™ mobility device, and the Segway® Human Transporter.

Kamen has received many awards for his efforts. Notably, Kamen was awarded the National Medal of Technology in 2000. Presented by President Clinton, this award was in recognition for inventions that have advanced medical care worldwide, and for innovative and imaginative leadership in awakening America to the excitement of science and technology. Kamen was also awarded the Lemelson-MIT Prize in 2002, and was inducted into the National Inventors Hall of Fame in May 2005. He is a Fellow of the American Institute for Medical & Biological Engineering, and has been a member of the National Academy of Engineering since 1997.

In 2010, Dean hosted the Planet Green television series *Dean of Invention*.

In addition to DEKA, one of Dean's proudest accomplishments is founding *FIRST*® (For Inspiration and Recognition of Science and Technology), an organization dedicated to motivating the next generation to understand, use and enjoy science and technology. Founded in 1989, this year *FIRST* will serve more than 300,000 young people, ages 6 to 18, in more than 60 countries around the globe. High-school-aged participants are eligible to apply for more than \$16 million in scholarships from leading colleges, universities, and corporations. Studies have shown that *FIRST* Alumni are highly motivated to pursue careers in science and engineering, thus fulfilling Dean's goal of inspiring the next generation of technological leaders.

Chairman BUCSHON. Thank you very much.
I now recognize Mr. Partovi for his testimony.

**TESTIMONY OF MR. HADI PARTOVI,
CO-FOUNDER AND CEO, CODE.ORG**

Mr. PARTOVI. Thank you very much. My name is Hadi Partovi. I learned to program early when I was young. I studied computer science at Harvard, and this set up my career with an early job at Microsoft.

Sorry. I think you already heard me. I started my early career as a computer scientist. I learned to program young and I studied computer science at Harvard, and this set up my career with a great job at Microsoft. I co-founded multiple companies and was an early investor in some of our country's most successful startups.

Starting from nothing, I am now living the American dream, and this is because of my foundation in computer science. Computer science fuels the American dream, and I am here not to testify on behalf of the organization I founded, Code.org, but I guess in support of the field, in support of computer science, and the reason is because 90 percent of our schools don't teach computer science.

I want to play a short video from the supporters of Code.org to give you, in their words, why this field is important.

[Video shown.]

So my organization's goal is to bring computers science to all the schools of this country, and people often confuse what is computer science. When I went to school, every student and every school would teach how to dissect a frog or how electricity works, and I believe in this 21st century, it is equally important to learn how to dissect an app or how the Internet works, and this is fundamental not only to millions of careers in technology but even for students who don't ever want to pursue a career in technology. For people who want to become doctors or lawyers or accountants or elected officials, it is important to understand how the world around us works.

Speaking about the careers in computer science, the Bureau of Labor Statistics projects 1.4 million jobs over ten years being created in this field, and the National Science Foundation projects only 400,000 graduates going into the field. That adds up to a million jobs in the gap between jobs and students, which adds up to \$500 billion in salaries.

What is more, these jobs are in every state and every industry. This isn't about Google or Microsoft having trouble hiring skilled laborers. Only one-third of computing jobs are in technology. The rest are in banking, manufacturing, government, retail, et cetera.

If there is one thing I want you to remember from today, it is the charts I am showing up here.

[Chart]

The chart on the left shows you the amount of time high school students spend in all of STEM and the small sliver that is computer science. The chart on the right shows the jobs in all of STEM and the very giant segment that is computer science, and you wonder, why is there a mismatch there? Because 90 percent of our schools do not even teach this field. And of the tiny sliver that do study computer science, only 15 percent are girls, and less than

eight percent are Hispanic Americans and African Americans. It is a huge problem for our country, and our policies don't support it. In 33 of 50 states, computer science doesn't even count towards high school STEM requirements, and of the billions of dollars of federal money that you all mentioned being spent on STEM, almost none of it goes to computer science because of regulatory barriers we want to have you guys help remove from the system.

People often ask me, can our students learn this, can our teachers teach it, why are we not focusing just on basic math, which we are already failing at, and we proved last month that our students can learn it. We ran a campaign called the Hour of Code. It was kicked off by the President, the House Majority Leader, Senators and Newt Gingrich in partnership with 100 companies—Google, Microsoft, Apple—the government, the College Board and many others. We had 20 million students participate with 17 million in the United States. One out of every four students in U.S. schools learned an hour of code and half of them were girls. It is an amazing accomplishment. To put this into context, the College Board AP Computer Science Exam has 32,000 students participating; the College Board AP Calculus Exam, 300,000; all of U.S. FIRST clubs, 350,000 students; the math SAT, 1.7 million. The Hour of Code had 17 million participants, and it goes to show that our kids can learn this.

So we have proven that America wants this, our students want it, our parents want it, and I am not talking about Code, I am talking about computer science. The question for you is, how do you answer the parent who asks, why isn't this foundational field being taught in my children's schools and how can the U.S. government remove the barriers that get in the way right now.

I have a very short video to show, 30 seconds of a girl who came back, one of the 17 million students in America who came back to her mom or dad after learning one hour of code.

[Video shown.]

Every kid in America can learn computer science. Ninety percent of our schools don't teach it. We can help fix this.

Thank you very much.

[The prepared statement of Mr. Partovi follows:]

US House of Representatives
Hearing: Private Sector Programs that Engage Students in STEM
Committee on Science, Space and Technology
Subcommittee on Research and Technology

January 9, 2014

Testimony of Hadi Partovi
Co-founder and CEO, Code.org

Chairman Bucshon, Ranking Member Lipinski, on behalf of Code.org and its advocacy arm -- Computing in the Core -- thank you for the opportunity to testify about our goal of giving *every* student in the United States access to computer science as part of their K-12 educational experiences. I also want to thank you for being cosponsors of the Computer Science Education Act (H.R. 2536) -- common-sense, bipartisan legislation that will improve computer science education.

I am Hadi Partovi, and I've spent most of my career as an entrepreneur and investor in technology. But before that I was lucky enough to be exposed to computer science early on. When I moved from post-revolutionary Iran to the United States as a teenager, it was my foundation in computer science that gave me the opportunity to study and teach the subject at Harvard University, begin my career at Microsoft in the 1990s, and then move on to found numerous successful startups. My background in computer science helped me become an early-stage investor or advisor to leading technology companies, including Facebook, Dropbox, airbnb, OPOWER, Bluekai, and others.

Introduction

Last month, over 17 million students across the United States participated in our "Hour of Code" campaign, giving them their first taste of computer science. This stunning result shows students clearly want to learn computer science, and we know that there is strong demand for these skills in the workplace.

When we talk about the "STEM" crisis in our economy and schools, we are really talking about a computing crisis. In fact, according to the Conference Board, demand for computing professionals is roughly four times higher than the average demand for all other occupations, with more than 580,000 jobs in computing open as of December 2013.¹ (For state-specific data from Subcommittee Members' home states, see Appendix 1.) Furthermore, more than half of all jobs in STEM fields will be in computing.² These are generally understood facts, but what is less well known is that almost every job --

¹ Source -- US Conference Board Help Wanted Online Service

² Source -- Code.org analysis of BLS 2010-2020 employment projections (we have not yet analyzed the BLS 2012-2022 projections released at the end of December).

medicine, law, business, and banking -- increasingly requires foundational familiarity with computer science. A 21st-century doctor, lawyer, or banker may not need to know how to write complex code, but they increasingly need to understand the inner workings of an app, a website, cookies, software security, and other technology basics.

Despite these facts, most K-12 schools do not offer computer science, and students are not expected to be exposed to it at any level. In fact, last year, only 1 percent of Advanced Placement (AP) students studied in computer science. And only a tiny fraction of that 1 percent are women and underrepresented minorities.³ Computer science is simply not part of what we call the “core” curriculum in our schools. It is an afterthought. As a result, cohort after cohort of students are being denied the knowledge and skills they need in our increasingly digital world. Our K-12 schools teach students how to dissect a frog, or how electricity works -- it’s time they also taught how to “dissect an app”, or how the Internet works.

It’s not easy to add a new, rapidly-evolving field to the K-12 curriculum, but it’s a challenge our schools must meet. The UK has already put in place a plan to bring computer science to every school, nationwide, starting in September. But in the US, when we talk about STEM, when STEM policies are translated to action, “STEM” is translated to mean the same fields we’ve taught for decades: biology, chemistry, physics, and calculus. These are important, foundational topics. But we need to focus the STEM conversation on a new field, a field that is driving 50% of new STEM jobs, a field that is increasingly foundational across all careers in science, business, government and law, a field that is not being taught in the majority of our schools. Today when we say “STEM”, computer science is ignored. We need to change that conversation.

This committee has heard many times from organizations and leaders within the computing community about the challenges and need to improve K-12 computer science education. I want to echo those remarks and build on them by describing how Code.org is bringing community and corporate leaders together to give students access to computer science education.

Introducing Code.org

Code.org is a non-profit dedicated to expanding participation in computer science education by making it available in more schools, and increasing participation by women and underrepresented students of color. Our vision is that every student in every school has the opportunity to learn computer programming.

I started Code.org in 2012 as a personal mission with my twin brother, Ali Partovi, setting out to make a video that would inspire students to take interest in computer science. That video “What Most Schools Don’t Teach”, starring Bill Gates, Mark Zuckerberg, and other tech heroes and celebrities struck a chord with Americans. Within one week it reached 10 million views and 10,000

³ Source: College Board

school districts contacted Code.org asking how they could get coding into schools. At the same time, a partnership of the Association for Computing Machinery, the National Science Foundation, the Computer Science Teachers Association (CSTA), the National Center for Women and Information Technology, Microsoft and Google joined with Code.org in a new strategy that leverages our consumer awareness while building off years of efforts by the computing community to bring computer science into schools.

The Hour of Code

In the last few years, I often thought about how impactful it could be to introduce every American student to computer science for just one hour. Everywhere I went, I heard people express how important computer programming skills are for today's generation of students, so when Code.org grew into a staffed organization only months ago, we decided to immediately challenge Americans to get behind this cause.

The Hour of Code campaign aimed to demystify computer science, to encourage students to try it for just one hour through online tutorials hosted by Code.org and others. Code.org itself developed an introductory computer science activity -- in collaboration with engineers from Google, Microsoft, Facebook, and Twitter -- that plays like a game, featuring video lectures by technology-industry leaders like Mark Zuckerberg and Bill Gates and artwork from popular online games, like PopCap Games' Plants vs. Zombies and Rovio's Angry Birds. We worked with other education organizations such as the National Center for Women and Information Technology, the Computer Science Teachers Association, the National Science Teachers Association, the National Council of Teachers of Mathematics and Khan Academy to help create the experience or distribute it to our public schools. We encouraged K-12 teachers, principals and districts to sign up their schools to participate during Computer Science Education Week in December, as well as after-school programs, parents, and individuals.

When Code.org announced the Hour of Code in October, the goal to teach 10 million students for 1 hour was an ambitious one. The vision proved to be an enormous success. Last month, 20 million students participated in computer science, including 1 in 4 students in kindergarten through 12th grade in the US. Perhaps even more astonishing was that half of these students were girls. As you can imagine, Code.org relies on statistics and analytics to measure progress, and the results of just this one week blew us away. In U.S. schools, more students participated in computer science during Computer Science Education Week 2013 than had ever taken computer science in the history of our K-12 system.

The results were widely covered by media. There were pieces in the *New York Times*, *Washington Post*, *Los Angeles Times*, *Miami Herald*, *Chicago-Sun Times*, *TIME*, *US News and World Report*, *Politico*, *Wall Street Journal*, *Forbes* and on Bloomberg Television and CNN. It was featured on the homepages of Google, Microsoft, Bing and Yahoo!. Every Apple retail store in the United States hosted an Hour of Code workshop. Stop and consider that these technology giants and fierce competitors were coming together for the first time in this common cause. In addition, the campaign was promoted broadly by the College

Board, Teach for America, NSTA, NCTM, CSTA, and state commissioners and superintendents of California, Hawaii, Washington, Massachusetts, and Tennessee.

Communities reported on local Hour of Code events everywhere from Louisville, KY, to Boise, ID, to Detroit, MI, to Houston, TX, to La Crosse, WI, to San Francisco, CA, to Harrisburg, PA, to hundreds more cities, towns and counties across America. In fact, in the Chairman and Ranking Member's states of Indiana and Illinois, more than 260,000 and 830,000 students⁴ participated in the Hour of Code. (See Appendix 1 for participation in each Subcommittee Member's state.)

What was even more stunning than the data on participation was the outpouring of support for the Hour of Code from educators. Too often our national narrative is how our schools, teachers and leaders are failing students. The Hour of Code story was much different. Teachers, principals and superintendents in every part of America took the initiative to bring this educational experience to their students. Over 12,000 U.S. schools signed up to host an Hour of Code event for the *entire* student body. We heard stories from teachers about students "working together for the first time to solve problems," or that they "didn't even know coding was something you could teach students", but that "it turned out to be one of the smoothest class periods we've ever had." Most importantly, teachers reported that students came back wanting more. In the past month, 10,000 teachers have signed up 500,000 students for our follow-on 20-hour, online Introduction to Computer Science course. This is a complete 20-hour curriculum that is in 10,000 classrooms today.

Parents also played a big part in the success of spreading this campaign. They have a deep sense of how important technology is today, but its creation is somewhat of a mystery. Every American feels that technology is moving so fast they can hardly keep up; technology is passing them by, and they don't want their children to fall behind too. The Hour of Code gave every parent the opportunity to open a window to the world of technology for their children and to better understand computer science themselves.

But one hour of code is only a first step. We have given 1 in 4 students in the U.S. a taste of computer science. But it raises the question: why isn't this a fixed part of our school system? Now local, state and national leaders need to come together to bring computer science into the core of our education system. Code.org, in collaboration with its partners both within and outside of the computing community, hope to work with our national leaders on this mission.

Bringing Computer Science to ALL Students

Code.org believes computer science should be part of the core curriculum in education, starting as early as elementary school. Our goals include: (1) Bringing Computer Science classes to every K-12 school in the United States, especially in urban and rural neighborhoods, (2) Demonstrating the

⁴ Based on Code.org analysis of Google analytics and geolocation data from Computer Science Education Week. Due to constraints on this analysis, there is a +/- 10% margin of error in the numbers.

successful use of online curriculum in public school classrooms, (3) Changing policies at the federal and state level to either remove barriers to K-12 computer science education or bolster its instruction, (4) Harnessing the collective power of the tech community to celebrate and grow computer science education worldwide, and, (5) Increasing the representation of women and students of color in the field of computer science.

Code.org's Programs

Our mission is carried out via three program pillars: educate, celebrate and advocate.

Educate

Our education pillar aims to create modern, engaging computer science curriculum for all levels of K-12 students and to partner with school districts to deliver instruction. We are bringing two high school computer science courses to scale -- Exploring Computer Science and AP Computer Science Principles:

- Exploring Computer Science⁵ is a nationally recognized introductory college preparatory computer science course and includes curriculum, professional development, and assessments. ECS is composed of six foundational units with lessons that are designed to promote an inquiry-based approach to teaching and learning foundational concepts in computer science and highlighting the computational practices and problem solving associated with doing computer science.
- Computer Science Principles⁶ is currently in a pilot phase that will inform the ultimate development of an AP[®] exam in 2016-2017; this course is far more than a traditional introduction to programming and the fundamental concepts of computing. It is a rigorous, engaging, and approachable course designed so that each student will understand how these concepts are transforming the world we live in and how each student can use the concepts in their own lives, studies, and in collaborating to participate in the transformation.

Both of these courses are designed to broaden participation in secondary computer science and prepare students for post-secondary experiences related to computing or college majors in computer science. They are supported by top experts within the computer science education community and have been developed with the support of the National Science Foundation and others, such as the College Board and the Computer Science Teachers Association. In addition, we are offering districts an Elementary Computer Science Program and a Middle School Computer Science Program, which consist of interdisciplinary modules that combine computer science concepts with Science and Math.

⁵ see, <http://www.exploringcs.org/>

⁶ see, <http://www.csprinciples.org/>

Our district partnerships encompass curriculum for elementary, middle and high schools and professional development for teachers. More information on our partnership program, including how you can help us bring computer science to the schools you represent, can be found at: <http://code.org/educate/districts>.

During Computer Science Education Week, we announced two of the largest of our partnerships -- agreements with Chicago and New York City. A particularly exciting element of the Chicago plan is a commitment to expanding computer science instruction to all students and making it a required course for all students within 5 years.

Celebrate

Our celebrate pillar works to neutralize negative stereotypes of the field, inform students of the benefits of studying computer science, and inspire them to do so. The focus of this area has been the Hour of Code effort noted in the previous section and our original video "What Most Schools Don't Teach." Today, the stereotype is that computer science is for genius nerds, often portrayed in the media as Asian or white teenage boys. Thanks to the Hour of Code campaign, 10 million girls learned an Hour of Code last month. We hope our continued efforts will break the stereotype permanently.

Advocate

Our advocacy pillar works on policy issues at the federal and state level, through our sister effort Computing in the Core. More detail on proposed federal policy reforms and recommendations are noted below. Our main goal is either removing barriers that hinder computer science instruction or passing policies that will bolster its instruction.

At the state level, our headline goal has been to "make computer science count," which means allowing existing courses to satisfy an existing core math or science graduation requirement. Making computer science courses "count" would not *require* schools to offer computer science or students to study it; it would simply *allow* existing computer science courses to satisfy a requirement that already exists. Only 17 states allow computer science to satisfy a core high school graduation requirement at present.

Computer science courses often do not count towards a student's required coursework -- they are treated as electives. Given the academic demands, college-bound students cannot afford to take computer science as an elective. AP Computer Science courses are about 50 percent larger in states that "count" AP CS compared to those that do not.⁷ And a study from the Computer Science Teachers Association shows a key driver for whether underrepresented groups (females and students of color) participate in computing courses is whether the CS course they are taking counts toward a graduation credit.⁸ This policy also helps student athletes, as the NCAA recently changed eligibility requirements to

⁷ Code.org analysis of College Board AP data

⁸ CSTA/My College Options, Annual Research Report 2013

allow rigorous computer science courses which count towards a mathematics or science credit in a school district to automatically meet NCAA student-athlete entrance requirements.

I should note that the Chairman's home state of Indiana is one that allows a rigorous computer science course to satisfy a "core" high school graduation credit. In fact, it made this change after local advocates brought the issues discussed in this testimony to Indiana state education leaders.

The support for this policy change is both bipartisan and growing. In 2013 six states -- Maryland, Idaho, Alabama, Wisconsin, Tennessee and Washington -- with both Republican and Democrat controlled leadership "flipped" from treating computer science as an elective to allowing it to count toward a mathematics and/or science course.

We are now increasingly beginning to look toward states where statewide policies and programs can support the expansion of computer science in K-12 schools. State education authorities should be planning their computer science offerings across the state just as they do other core academic offerings. We will be working with states to put new policies in place to make statewide computer science adoption a reality.

Partnerships

The successes of Code.org in large part are due to a unique combination of both private and public partnerships. Code.org supporters include dozens of the best-known tech companies and their founders, as well as the Computer Science Teachers Association, the Association for Computing Machinery and the National Science Foundation.

The Hour of Code campaign is an example of Code.org's ability to leverage a diverse partner network to execute a national awareness campaign. National student and teacher facing nonprofits like the Boys and Girls Club of America, The College Board, Teach for America, and NSTA were integral in mobilizing large networks of both in- and after-school participation. Similarly, large companies like J.P. Morgan and Zappos urged employees and local schools to participate, as well as hosted events at their headquarters for outside community members to join.

Additionally, the campaign had the backing of the computer science education community at large. We recruited other tutorial providers (both non and for-profit groups) such as Khan Academy, Codecademy, Scratch, and Tynker to showcase and promote their computer science curriculum through the Hour of Code campaign. This was beneficial in two ways: 1) it created additional promotional networks, and 2) it accounted for the fact that there is no one-size fits all curriculum.

Moving forward, Code.org hopes to expand and formalize current partnerships as well as establish new ones to build on our education and advocacy goals. Code.org isn't the only organization in this space, but we have established an unprecedented scale in computer science education by partnering with leading organizations and individuals from the tech industry, education non-profits, and government.

We don't expect to do everything ourselves; we expect to provide an overall umbrella for dozens of organizations (public or private) to collectively bring computer science to the nation's schools. Our founding roots come from warring tech companies (Microsoft, Google), education non-profits (ACM, NCWIT, CSTA), and government (NSF), and as such we expect to unite these three types of organizations in a public-private partnership until the national opportunity has been captured.

Federal Policy Reform to Strengthen Computer Science Education

When I started to educate myself on the reasons computer science isn't taught in our schools, I found what you all know--there are countless federal, state and local policies that determine what is ultimately taught in our schools. I have learned much about the No Child Left Behind Act, the Higher Education Act, Career and Technical Education programs, the Labor Department's workforce supports, the National Science Foundation's investments, America COMPETEs, Race to the Top, public investments in afterschool programs and other federal initiatives, policies and investments. Knowing that the goal of our public education system is to prepare our young people for success in college and/or the workforce, it is confounding to me that most schools don't even teach computer science. In the 21st Century, this has to change.

Computer science is not treated as a "core academic subject" in the Elementary and Secondary Education Act. It is not an element of the accountability rubric states put together as part of the improvement plans required by the federal government in return for Title I funds. Computer science teachers are not eligible for the same professional development supports as their math and science teacher colleagues. Getting certified to teach computer science is an ambiguous and confusing process in most states, and almost impossible in a few. A few changes to existing programs could make it much easier to give students the opportunity to learn computer science.

I am thankful that both the Chairman and Ranking Member and other members of this committee have supported modest, no-cost changes to the Elementary and Secondary Education Act that are proposed in the Computer Science Education Act (H.R. 2536) by cosponsoring the bill. And while they aren't members of this panel, I'd like to also thank Congresswoman Susan Brooks (R-IN) and Congressman Jared Polis (D-CO) for their leadership and vision in sponsoring this legislation and raising the issue of K-12 computer science education before Congress. Senators Bob Casey (D-PA) and Marco Rubio (R-FL) have introduced similar legislation (S. 1407) in the Senate, making the issue both bipartisan and bicameral.

The Computer Science Education Act makes simple changes to federal law to ensure computer science is at the table when local education decisions are being made. It is an important first step Congress can immediately take to improve student access to K-12 computer science education, and will empower local educational agencies to meet the enormous demand for computer science that the Hour of Code has uncovered. I hope more Members will sign on to the bill and ask leadership to consider it before the end of the 113th Congress.

More directly related to the purview of this Committee, I urge you to ensure that computer science is explicitly included as a focus of public investments and policy goals. Even the definition of “STEM” in existing statutes marginalizes public investments in computer science. “Science, technology, engineering and mathematics” doesn’t explicitly include computer science, which is problematic in the regulatory process at certain agencies and in the award process at others. I hope that revisions to any laws that include a definition of STEM will explicitly include computer science. When it is not explicitly included, it is quite often implicitly excluded, because it is easier for school systems to focus only on the topics they already teach, such as biology, chemistry, physics, or calculus.

There is some good news on this front. Recently, the National Science Foundation revised some of its education programs. The result is a new STEM-C program that will preserve the Math Science Partnerships program, and create a new emphasis on investments that focus on the improved teaching of computer science. We hope that other programs and agencies follow this lead and look forward to collaborating with the Foundation and its grantees to bring more and better computer science to our country’s schools.

The palpable interest in giving the country’s young people access to computer science has buoyed the policy efforts of Code.org, Computing in the Core and the members and supporters of both organizations. We will work on a number of policies to broaden access to computer science. For example, in America COMPETES, we will work to make sure that computer science teachers--prospective and practicing--are supported in the same way that math and science teachers are. In addition, we are hopeful that the National Science Foundation can help the field develop standards-based assessments for K-12 computer science. Congress will soon debate reauthorizing the Higher Education Act, and that statute addresses federal investments in teacher preparation programs. As you can imagine, there are few colleges that offer teacher education programs for computer science teachers. Changes to the Higher Education Act would catalyze reform in this area. Cybersecurity legislation, federal investments in research, efforts to nurture interest and success in the STEM fields, comprehensive immigration reform efforts that tie H-1B visa fees to a new STEM education fund and revisions to the E-Rate program are among the policies that we feel can be changed to support the teaching and learning of more computer science in K-12 schools. We hope you can be allies in our endeavors on Capitol Hill.

Conclusion

While I am encouraged by the response to the Hour of Code and Code.org to date, I know that much work lies ahead. We are building on years of work from so many people and organizations committed to the cause of expanding access to computer science, and we’re busily developing curriculum and recruiting professional development facilitators to get high-quality computer science courses in as many schools as possible--as soon as possible. As I said earlier, I have learned that changing education requires working with stakeholders of every size and policymakers of every disposition at the local, state and federal levels. As a result, Code.org and our partners are collaborating with districts on agreements related to teacher supports and classroom resources; we are working to get computer science to count as a high school graduation credit in as many states as possible; and, we are sharing our arguments with

you and your colleagues for changes to federal programs and policies that currently don't respect the importance of computer science in the educational landscape.

The modern day icons of the American Dream have gotten where they are through computer science. I truly believe that the availability of computer science to all kids is an issue that warrants immediate and aggressive action. And, thankfully, I'm not alone.

While the tech industry is known for many things, agreeing among themselves on big issues is not one of them. Except for this one. Apple, Google, Microsoft, Facebook, Amazon, SAS and so many others compete vigorously for talent, ideas and market share, and yet they have come together to support broadening access to computer science education. I'm proud of my colleagues and humbled by their trust on this important issue and hope that the tremendous success of the Hour of Code is only a sign of good things ahead.

With 17 million US students participating in the Hour of Code in December, I claim that our students have voted with their actions: that learning computer science is this generation's Sputnik moment, that it's part of the new American Dream, and that it should be available to every student, in every school, as part of the official curriculum.

I look forward to answering any questions you might have, and thank you again for the opportunity to testify today.

More information about Code.org, Computing in the Core and our partners, the Hour of Code tutorial, the inspirational videos that highlight the need for more computer science and the work of our talented team of engineers and education professionals is available on our website at www.code.org.

Appendix 1. Computer Science Data for Subcommittee Member States

Information on computing jobs, computer science graduates, the number of schools that teach rigorous computer science and Hour of Code participation in the states represented by Members of the Subcommittee on Research and Technology.

Alabama State Facts

- **3,541** open computing jobs
- (growing at **3.4x** the state average)
- **541** computer science graduates
- **26** schools teach computer science
- **187,000** students did the Hour of Code in Dec 2013

Arizona State Facts

- **9,913** open computing jobs
- (growing at **3.5x** the state average)
- **336** computer science graduates
- **33** schools teach computer science
- **300,000** students did the Hour of Code in Dec 2013

California State Facts

- **77,309** open computing jobs
- (growing at **4.3x** the state average)
- **4,324** computer science graduates
- **311** schools teach computer science
- **3,000,000** students did the Hour of Code in Dec 2013

Connecticut State Facts

- **7,926** open computing jobs
- (growing at **4.5x** the state average)
- **389** computer science graduates
- **65** schools teach computer science
- **180,000** students did the Hour of Code in Dec 2013

Florida State Facts

- **20,384** open computing jobs
- (growing at **3.6x** the state average)
- **1,833** computer science graduates
- **125** schools teach computer science
- **1,150,000** students did the Hour of Code in Dec 2013

Illinois State Facts

- **25,691** open computing jobs
- (growing at **5.1x** the state average)
- **2,691** computer science graduates
- **132** schools teach computer science
- **830,000** students did the Hour of Code in Dec 2013

Indiana State Facts

- **4,864** open computing jobs
- (growing at **3.5x** the state average)
- **1,152** computer science graduates
- **54** schools teach computer science
- **264,000** students did the Hour of Code in Dec 2013

Kentucky State Facts

- **3,411** open computing jobs
- (growing at **4.4x** the state average)
- **295** computer science graduates
- **34** schools teach computer science
- **144,000** students did the Hour of Code in Dec 2013

Mississippi State Facts

- **951** open computing jobs
- (growing at **4.3x** the state average)
- **203** computer science graduates
- **14** schools teach computer science
- **53,500** students did the Hour of Code in Dec 2013

New York State Facts

- **36,824** open computing jobs
- (growing at **4.9x** the state average)
- **5,037** computer science graduates
- **186** schools teach computer science
- **780,000** students did the Hour of Code in Dec 2013

Oklahoma State Facts

- **3,226** open computing jobs
- (growing at **3.6x** the state average)
- **416** computer science graduates
- **49** schools teach computer science
- **80,000** students did the Hour of Code in Dec 2013

Texas State Facts

- **42,016** open computing jobs
- (growing at **4.1x** the state average)
- **3,160** computer science graduates
- **376** schools teach computer science
- **910,000** students did the Hour of Code in Dec 2013

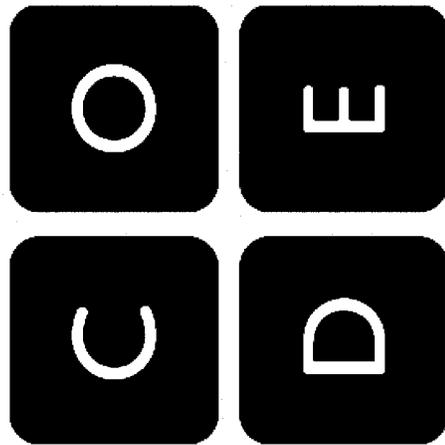
Washington State Facts

- **24,181** open computing jobs
- (growing at **3.9x** the state average)
- **794** computer science graduates
- **62** schools teach computer science
- **695,000** students did the Hour of Code in Dec 2013

Wyoming State Facts

- **304** open computing jobs
- (growing at **3.6x** the state average)
- **22** computer science graduates
- **3** schools teach computer science
- **40,000** students did the Hour of Code in Dec 2013

The data is based on information provided by The College Board, the Conference Board Help Wanted Online and other public resources. This information and other state-specific data are available on the Code.org website at www.code.org/promote/XX (XX is the two-letter state abbreviation).

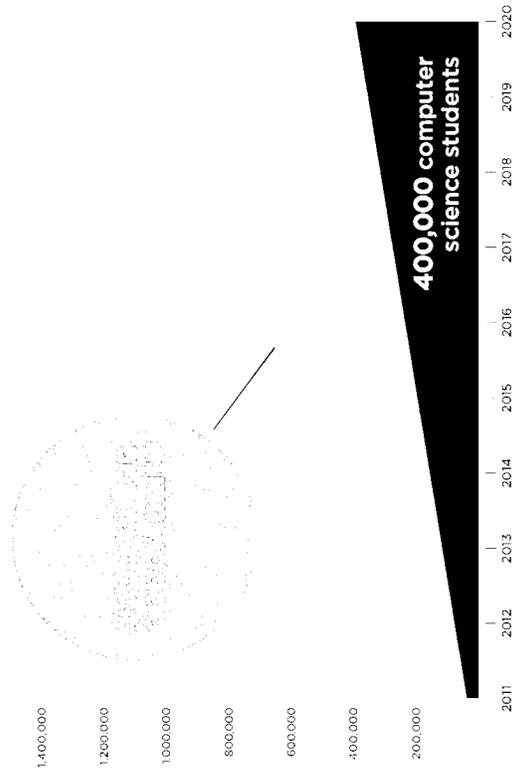




What is computer science?



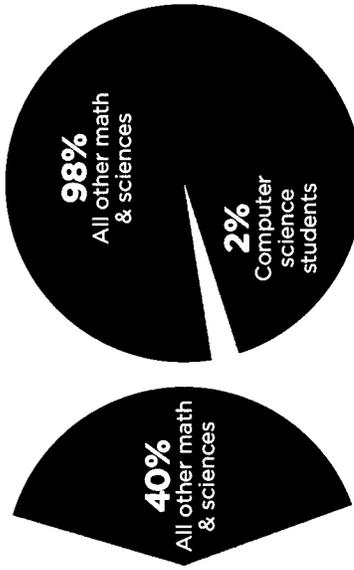
1,000,000 more jobs than students by 2020



Computer science is a top paying college degree and computer programming jobs are growing at 2X the national average.



The job/student gap in computer science



Less than 2.4% of college students graduate with a degree in computer science. And the numbers have dropped since last decade.



2012 High School A.P. Enrollment*

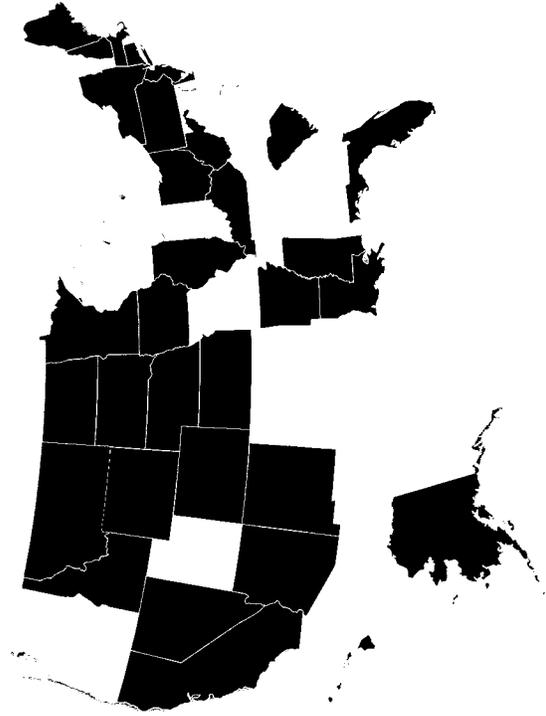
Exposure to CS leads to the some of the best-paying jobs in the world.
But 75% of our population is underrepresented.



Source: College Board



Computer science in America



in 33 of 50 states,
computer science
doesn't even
count towards
high school
graduation math
or science
requirements.

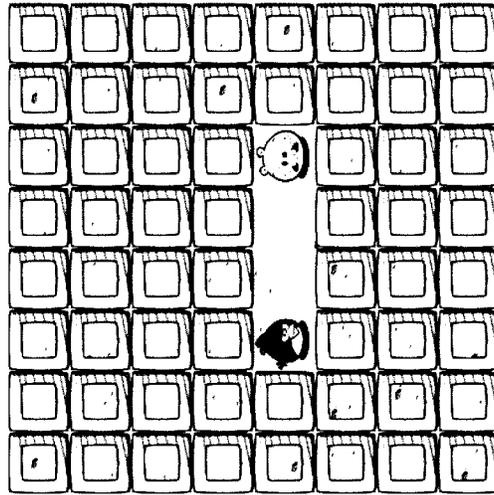


Can our students learn this?
Can our teachers teach it?

(Why not focus on basic math which
we're already failing at?)

C O
D E

.....20



Blocks

Assemble your blocks here: 3 / 3

left U
right U



X

Congratulations! You completed Puzzle 2.

You just wrote 3 lines of code!

The blocks for your program can also be represented in JavaScript:
 the way as most web-based programming languages:

```

moveForward();
moveForward();
moveForward();
  
```

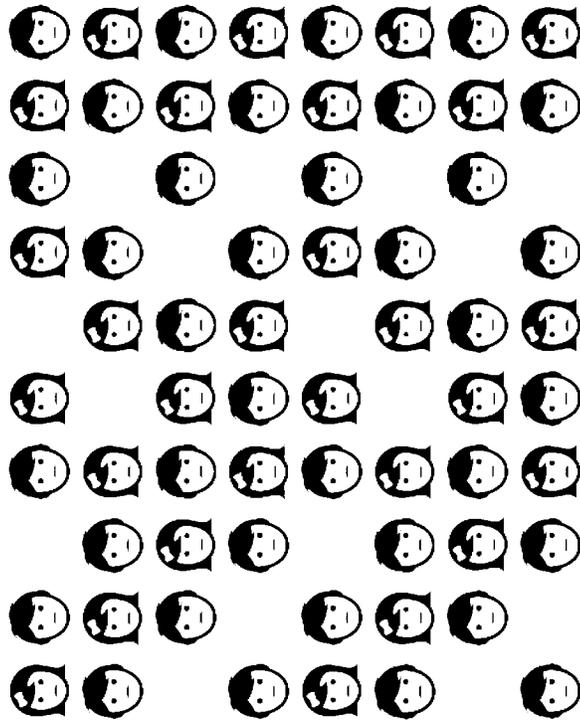
This pig is ruffling my feathers. Help me to find him!
Need help? See these videos and hints

#HourOfCode



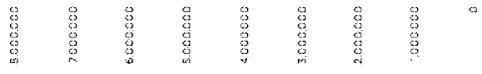
**15 million students
in 170 countries learned
an Hour of Code.**

#HourOfCode 



1 in 5 US students did an Hour of Code.

#HourOfCode 



More students tried computer science in US schools in one week than in all prior history.



Hadi Partovi

Co-founder and CEO, Code.org

Hadi is an entrepreneur and investor, and also co-founder of education non-profit Code.org. As an entrepreneur, he was on the founding teams of Tellme and iLike. As an angel investor and startup advisor, Hadi's portfolio includes Facebook, Dropbox, airbnb, Zappos, OPOWER, Flixster, Bluekai, and many others.

A graduate of Harvard University, Hadi began his career during the browser wars in the 1990s, when he was Microsoft's Group Program Manager for Internet Explorer. After the release of IE 5.0, Hadi co-founded Tellme Networks. Tellme was acquired by Microsoft for a reported \$800 million. Hadi ran the MSN portal for its only year of profit, where he delivered 30% annual growth and incubated Start.com. After leaving Microsoft a second time, Hadi co-founded iLike with twin brother Ali Partovi, and together they built the leading music application on the Facebook platform. In 2009, iLike was acquired by MySpace where both Partovis worked as Senior Vice Presidents.

Hadi is a strategic advisor to numerous startups including Facebook, Dropbox, OPOWER, and Bluekai, and serves on the board of TASER International. He is also an active angel investor with a wide range of investments.

Chairman BUCSHON. Thank you.
I now recognize Dr. Jona for five minutes for his testimony.

**TESTIMONY OF DR. KEMI JONA, DIRECTOR,
OFFICE OF STEM EDUCATION PARTNERSHIPS,
RESEARCH PROFESSOR, LEARNING SCIENCES
AND COMPUTER SCIENCES,
NORTHWESTERN UNIVERSITY**

Dr. JONA. Well, good morning, Members of the Committee. I would like to thank Ranking Members Lipinski and Johnson and Chairmen Bucshon and Smith for inviting me to testify today.

The mission of my office is to connect K–12 teachers and students to the world-class STEM resources of Northwestern University and beyond. To date, we work with a growing network of over 200 Chicago-area schools, over 600 teachers who reach approximately 48,000 students, and since I am sitting next to Hadi, I am proud to announce that next week Chicago Public Schools is launching Code.org’s computer science curriculum for all of its high schools, so we are really pleased to be part of that.

My testimony today focuses on three models that we have found successful in engaging industry partners in STEM initiatives. All three examples illustrate the importance of building in both scalability and sustainability, and all three have leveraged private sector support to expand and sustain federal investments. We are fortunate to work with many industry partners including Boeing, Hewlett-Packard, IBM, Motorola and Siemens.

The first example that I would like to share today is our work with Baxter International, a global health care company located outside of Chicago. Their generous support has created a Biotechnology Center of Excellence at Lindblom Math and Science Academy, which is a grade 7–12 public school located on the southwest side of Chicago that serves a predominantly minority and low-income student population. This Center of Excellence provides teachers with professional development, lab equipment and other resources focused on the important field of biotechnology. These are provided not just to Lindblom teachers but to teachers from across the district. In the last few years, we have trained 168 teachers from 115 different schools reaching over 20,000 students. This Center of Excellence model is building self-sustaining capacity in the Chicago Public Schools to improve the teaching of biotechnology across the entire district.

One of the curriculum offerings available to teachers is an innovative set of high school biology labs we developed in partnership with my colleague, Dr. Teresa Woodruff in our medical school. These labs are based on Dr. Woodruff’s NIH-funded research in oncofertility. The Center of Excellence model demonstrates the power of partnerships between the private sector, universities and public schools. The federal NIH dollars invested continue to pay dividends as hundreds of teachers and thousands of students each year benefit through the ongoing support provided by Baxter.

A second example I would like to share with you today is called Illinois Pathways. Illinois Pathways is a State of Illinois-led STEM education initiative that has created new public-private partner-

ships known as STEM learning exchanges. Each of the nine exchanges coordinates investments, resources and planning in STEM industry sectors like information technology, manufacturing, energy and research and development. This effort launched with \$2.3 million in Federal Race to the Top money and which was then leveraged to \$8.5 million in public and private matching funds. The Illinois Business Roundtable, an organization made up of CEOs and other industry leaders, has been a key driver of this initiative in our state.

Northwestern is a proud member of the Research and Development Learning Exchange. One of our signature projects is a mentor matching engine. This online resource pairs students with private industry mentors to conduct independent research in STEM fields. You can think of it as sort of like a Match.com for student researchers. By conducting mentors and students online, this Web site helps to level the playing field by facilitating access to mentors for students all across the State, especially in our rural and urban areas. The STEM exchanges have been instrumental in organizing previously uncoordinated private sector, university and school participation in STEM, and they serve as statewide distribution platforms for STEM education resources.

The third and final example I would like to share is our out-of-school program called FUSE. It is a project funded by the MacArthur Foundation and the National Science Foundation as well as companies including Motorola Mobility, Siemens and IBM. The goal of FUSE is to engage youth, especially those from underrepresented groups, in STEAM topics—and we add the arts and design to STEM—while fostering the development of important 21st century skills like creative problem solving, persistence and grit. Challenges are the core activity of FUSE studies, and I would like to play a short clip now that illustrates some of the fun and engaging challenges that we have developed with our private sector partners.

[Video shown.]

So FUSE currently has 20 challenge sequences in areas such as robotics, electronics, solar energy, jewelry design, and 3D printing. Some of the ones that are on the video exemplify this. The jewelry designer challenge is in particular very popular with girls, and it uses all of the same design and 3D printing skills that you need for advanced manufacturing and other skills. So FUSE is yet another example of a platform that can be scaled up to engage large numbers of youth in STEM or STEAM fields. For our industry partners, the modular challenge format that you see here and a focus on out-of-school-time learning is often more appealing than in-school curriculum development that can be very slow and bureaucratic. FUSE provides a dissemination network as new challenges are offered to youth at our growing network of 17 sites around the Chicago metro area.

So to wrap up, my key message today is that what has been missing from the recent discussions of federal STEM policy is a recognition of the importance of creating robust dissemination mechanisms, mechanisms that support the scalability and sustainability of high-quality STEM education programs developed with either federal or private sector support. To really engage students with high-quality STEM education, we need the leadership and support

of both the federal government and the private sector to create distribution platforms like the iTunes App Store or the Android Play Store for our smartphones to create the similar kinds of distribution platforms for STEM education resources like the examples I highlighted today.

Thank you.

[The prepared statement of Dr. Jona follows:]

Promising Models for Private Sector Engagement in STEM

Testimony to the U.S. House of Representatives,
Committee on Science, Space, and Technology,
Subcommittee on Research and Technology Hearing:
“Private Sector Initiatives that Engage Students in STEM”

Kemi Jona, Ph.D.
Professor, Learning Sciences and Computer Science
Director, Office of STEM Education Partnerships
Northwestern University

January 9, 2014

Good morning members of the committee. My name is Kemi Jona. I am a Professor of Learning Sciences and Computer Science at Northwestern University and serve as the Director of the University’s Office of STEM Education Partnerships. I am honored to be here, and I would like to thank both Ranking Member Dan Lipinski and Chairman Larry Bucshon for inviting me to testify today.

The mission of the Office of STEM Education Partnerships (OSEP) is to connect K-12 teachers and students to the world-class science, technology, engineering, and math resources of Northwestern University and beyond. Since I founded OSEP in 2006, we have grown to a staff of 13 including scientists, education researchers, curriculum development specialists, software engineers, and experienced K-12 educators. In that time, we have developed valuable insights and promising models for working with scientists and engineers (in both academia and industry) to engage students in the excitement of STEM fields. Further, I hope to share some of our lessons learned in how to do this in a way that is effective and efficient for these busy STEM professionals.

My testimony today will focus on three university, school, industry, and community partnership models we have found successful in engaging industry partners in STEM education initiatives and that bring the excitement of real world STEM fields to K-12 teachers and students, both in and out of the classroom. I begin my testimony with a brief background on OSEP and conclude with some lessons learned and recommendations for the committee consideration regarding strengthening the broader impacts policy at NSF.

As you will see from the examples presented, my key message to the committee is that what has been missing from the recent discussions about the proper role of federal STEM policy and funding is a recognition of the importance of creating robust dissemination mechanisms that support the scalability and sustainability of those high quality STEM education programs developed with federal or private sector support. One reason that we have seen such an explosion in the number of apps available on our smartphones is that the Apple and Android app stores are such powerful yet easy to use distribution platforms. To really engage students with high quality STEM education, we need the leadership and support of both the federal

government and the private sector to create the distribution platform for STEM education resources. We have begun this work in my home state of Illinois, as I will share with you next.

The Office of STEM Education Partnerships at Northwestern University

Founded in 2006, the Office of STEM Education Partnership's (OSEP, osep.northwestern.edu) mission is to connect K-12 students and teachers to the STEM resources of Northwestern University and beyond. Our goal is to develop university, school, industry, and community partnerships that advance K-12 STEM education. In order to achieve this goal, OSEP serves as a bridge between these diverse stakeholders to help leverage, maximize, and effectively utilize resources and expertise, build capacity, and catalyze cooperation. Through this work we are able to develop and implement innovative teaching and learning programs and technologies that close the gap between authentic STEM research and practice and K-12 STEM education.

Housed within the School of Education and Social Policy at Northwestern University, OSEP consists of 13 full-time staff including scientists, education researchers, curriculum development specialists, software developers, and experienced K-12 educators. We engage Northwestern University faculty from across the university in our work and partner with them to develop scalable and sustainable 'broader impacts' plans and activities as part of their federal grants from the National Science Foundation (NSF). This work helps to integrate current, cutting-edge STEM research and practice and K-12 education while deepening Northwestern University's connections with Chicagoland communities.

Internal, baseline funding for OSEP is provided by Northwestern University's Vice President for Research and the Dean of SESP while external funding comes from diverse federal, private foundation, and corporate grants.

In 2013, 37% of OSEP's funding came from federal grants, 28% from corporate grants and gifts, 26% from private foundations, and 9% from internal university support.

External funders include:

Federal: NSF, National Institutes of Health (NIH)

Corporate: Baxter International Inc., The Boeing Company, Google, Hewlett Packard's Catalyst Initiative, IBM, Motorola Mobility, Motorola Solutions, and Siemens Industry Inc.

Private Foundations: John D. and Catherine T. MacArthur Foundation and Jaquelin Hume Foundation

OSEP Network of Schools

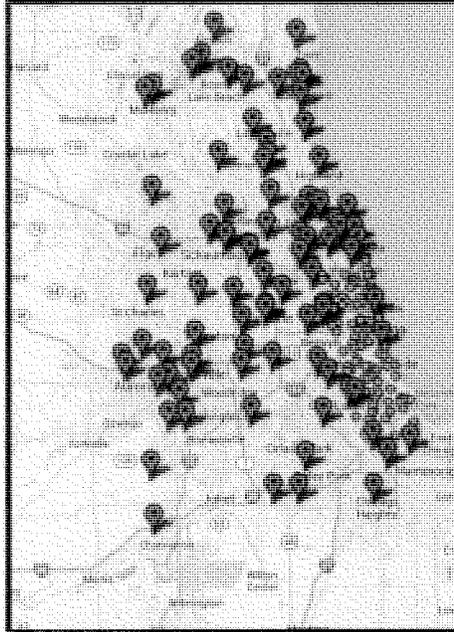
- **A growing network of over 200 Chicago-area schools**

- » 600+ teachers
- » Approximately 48,000 students

- **110 Chicago Public Schools**

(Shown in red on map)

- » 300+ teachers
- » Approximately 25,000 students



OSEP Programs

OSEP's **11 different programs** focus on teacher professional development (PD); STEM curriculum development; out-of-school time STEM learning; and the design and integration of learning technologies in the K-12 classroom. Our work focuses not only on the development, implementation, and evaluation of STEM education programming but also learning sciences research that helps to advance the understanding and practice of STEM teaching and learning.

OSEP's work is largely focused on the Chicagoland area however some of our programs, including the NSF-funded iLabs Network that provides online access to real laboratory equipment housed at Northwestern and other universities globally, are serving teachers and students all over the U.S. and around the world.

One of OSEP's signature programs is the **Institute for STEM Teaching and Research at Northwestern University (iSTAR@NU)**. This PD institute for middle and high school teachers provides STEM curricula, learning technologies, lab equipment and computer loaner programs, and in-classroom coaching and online resources to teachers throughout Illinois. OSEP works with numerous Northwestern faculty and industry partners to develop content and programs for iSTAR@NU and fund its operation. iSTAR@NU corporate sponsors include Baxter International Inc., The Boeing Company, Google, Hewlett Packard's Catalyst Initiative, Motorola Solutions, and Siemens Industry Inc.

In 2013 OSEP offered 13 different PD opportunities in a variety of different STEM content areas including environmental and earth sciences; computer science and engineering; biotechnology; and science communication. PD opportunities for teachers through iSTAR@NU include research and job shadowing experiences; workshops on new STEM curricula and technologies; symposia; and online courses. The demand for teacher PD continues to be high.

Participation in iSTAR@NU more than doubled from 155 to 320 between 2012 and 2013. These teachers are reaching an estimated 25,000 students.

iSTAR@NU is unique as it provides PD **plus** the support and resources needed to successfully implement innovative, research-based STEM education materials and most importantly, inspire and excite students. OSEP has an established track record of bringing innovation from university research and industry labs to the classroom in a way that other PD providers do not, thus helping teachers build content knowledge and keep current on modern STEM practices. The PD and in-class coaching and online resources also help teachers enhance their pedagogical skills and connect with and learn from other educators. The Next Generation Science Standards have a particular emphasis on incorporating authentic scientific practices and engineering design as cohesive strands through all science content courses. Importantly, iSTAR@NU works towards these goals in integrating cutting-edge research, content, and practices into everyday science learning. OSEP experience and current research on PD has shown that sustaining innovation in STEM classrooms requires all of the components provided by iSTAR@NU.

OSEP Partnerships

Partnerships are central to OSEP's work. Partnerships with Northwestern faculty, industry, schools, and community organizations enhance OSEP programs and provide real-world learning experiences in STEM for teachers and students. OSEP staff specializes in merging research and workplace-based STEM content knowledge and practices with the pedagogical expertise related to best practices in STEM teaching and learning.

The goals of our partnership initiatives vary. However, all of our work seeks to:

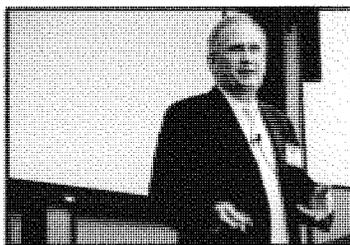
- Strengthen the collaboration between university, industry, and K-12 for STEM (science, technology, engineering, and math) education
- Enrich the current scope and impact of STEM at the middle and high school levels
- Increase student and teacher access and reach into STEM research and practice
- Firmly anchor education efforts in STEM in the best practices of teaching and learning
- Increase student awareness of and enthusiasm for STEM careers in both industry and academia.
- Illustrate through local examples of industry work in Illinois and university research at Northwestern, the diverse STEM career options available.
- Increase equity in STEM education, being mindful of both the achievement gap and barriers to careers in science.

How OSEP's Experience Can Inform Private Sector STEM Education Initiatives: Three Models

Working with diverse partners has led to the development of innovative program models that are invigorating teachers and exciting students about STEM. Below are some examples that showcase this partnership work at OSEP.

Model #1: Catalyzing Industry Partnerships with Schools for Scalable and Sustainable Impact on K-12 STEM Education

OSEP is currently working with 8 different industry partners in the Chicago area including Baxter International Inc., The Boeing Company, Google, Hewlett Packard's Catalyst Initiative, IBM, Motorola Mobility, Motorola Solutions, and Siemens Industry Inc. OSEP is also supporting Mayor Rahm Emanuel's 5 new Early College STEM Schools (ECSS) in Chicago Public Schools (CPS) by providing program and curriculum development support and expertise, mentoring programs, and teacher professional development opportunities to ECSS administrators, faculty, and students.



A leading example of our industry partnership activity is our work with **Baxter International Inc.** to support the **Biotechnology Center of Excellence (BCoE)** at Lindblom Math and Science Academy (LMSA), within CPS and located on the southwest side of the city. **While the BCoE is located at LMSA, it provides PD to teachers district-wide. The BCoE works to build capacity and a community of practice and provide lab equipment and teaching and learning resources focused on biotechnology education across CPS.**

The partnership's signature program, the *Biotechnology Professional Development Series*, provides biotechnology curriculum, lab equipment, research experiences, and a Biotechnology Symposium to teachers and connects them to world-class research scientists from Northwestern University and Baxter International. **This series launched in 2012 and 52 teachers from 28 different schools participated that year. Participation soared in 2013, more than doubling to 116 teachers from 87 schools. These teachers are reaching over 13,000 students.**

The Biotechnology Series includes 4 PD opportunities for teachers.

1. **Biotechnology Launch Symposium.** This daylong event, held at Northwestern University, kicks off the series. Teachers have the opportunity to listen and learn from acclaimed scientists from Baxter and Northwestern as they discuss their cutting-edge, biotech-focused research; tour state-of-the-art research facilities at the university; and experience hands-on biotechnology curriculum models led by experienced educators.

Teachers also receive lab equipment for their classrooms at the symposium. In 2013 **Baxter Chairman and Chief Executive Officer, Mr. Robert L. Parkinson, Jr., was the keynote speaker** (see photo at right). Parkinson was instrumental in establishing Baxter's Science@Work: Expanding Minds with Real-World Science education initiative that supports teacher training and student development in healthcare and biotechnology.

When asked to evaluate and comment on the Biotechnology Symposium, one teacher responded: *"Thank you for putting together today's Biotechnology Symposium. It definitely was a breath of fresh air to be out of the classroom to gain knowledge and experience all the while learning new tweaks to keep my students enticed and inspired in the world of STEM. I look forward to the summer trainings at Northwestern University with Baxter."*

2. **Survey of Biotechnology.** Teachers engage in hands-on PD that incorporates biotech lab skills, recombinant DNA, forensics, proteins, and bioinformatics.
3. **NUBIO** (Northwestern University Biology Investigations in Oncofertility). Teachers learn 6 lab modules that bring cutting-edge cancer biology research from the bench to their classroom.

*Both Survey of Biotech and NUBIO provide teachers with lab equipment and resources to support classroom implementation of the lab modules.

Teachers have made following comments when asked about the value of both Survey and NUBIO to their teaching and professional development:

"I increased both my knowledge and skill base. Getting a jump-start by having supplies to take back to the classroom helps to avoid budget as a reason not to do a lab is awesome! Also, now I have such a great group of people to work with and count on for support during the school year."

"I acquired confidence in skills and equipment that I haven't used in a long time and knowledge about research being done right now. I am excited to have my students use these skills!"

4. **Research Lab Experiences.** Teachers are immersed in research lab experiences that connect them with both Baxter and Northwestern University biotechnology research. In addition, teachers collaborate with scientists to write curriculum materials based on their lab experiences. This unique opportunity focuses on helping teachers to bridge bench research and their classroom teaching.

From one teacher who attended multiple offerings through the Series: *"Thank you so much for the great enrichment experiences you made possible for us. I learned so much, and during the next several months my students will benefit tremendously from all of this learning and the resources you made available for us."*

Importantly, NUBIO was developed in partnership with Dr. Teresa Woodruff from Northwestern's Feinberg School of Medicine and funding was provided by NIH Administrative Core (UL1RR024925, Administrative Core, Woodruff, P.I.) and R25 grants (RL5CA133836, R25, Jona P.I.) and 3RL5CA133836-02S1, R25 Administrative Supplement Grant, Jona P.I.).

NUBIO was conceived at the intersection of authentic scientific research and the high school classroom. NUBIO's purpose is to create lab-driven discovery of core biology content through the context of Dr. Woodruff's research on oncofertility. Oncofertility, a term in which Dr. Woodruff coined, translates reproductive biology, biotechnology, and biomedical engineering research to the clinical care of preserving fertility for cancer patients undergoing treatment.

OSEP's partnership with Dr. Woodruff and her team of scientists has also created a sophisticated web platform for students and teachers who are using NUBIO in their classrooms. The site includes videos and other resources that support the labs and student learning. Students can also connect with scientists who research oncofertility, find out more about topics and concepts they are studying, and find tips to help with the biotech techniques in the lab. (nubio.ci.northwestern.edu). The NUBIO lab modules have been developed into a full high school biology course that is being implemented at Lakes High School in Antioch, Illinois and Lindblom Math and Science Academy.

Model #2: Illinois Pathways: A Platform for Aggregating and Disseminating Statewide STEM Education Resources and Industry Engagement

Illinois Pathways (<http://www.ilpathways.com>), funded through Race to the Top, is a new and innovative State of Illinois-led STEM education initiative designed to support college and career readiness for all students. Supported by a partnership between the State of Illinois' education and economic development agencies, Illinois Pathways supports new statewide, public-private partnerships known as STEM Learning Exchanges. Each of the nine STEM Learning Exchanges is developing a network of statewide partnerships (between schools, industry, state government, and non-profits) that better coordinate investments, resources, and planning in STEM industry sectors that are crucial to economic development in Illinois and better utilize industry and public resources. The Exchanges are focused on delivering resources and supports for local pathway systems, to help local schools make clearer and more comprehensive connections with e-Learning and curriculum resources, lab space and equipment, teacher development, and student organizations that foster engagement between schools and the workplace. To that end, the Exchanges are simultaneously focused on expanding work-based learning opportunities for students and communities, to facilitate more job-shadowing and internship opportunities, as well as industry sponsored challenges which directly engage students with industry leaders.

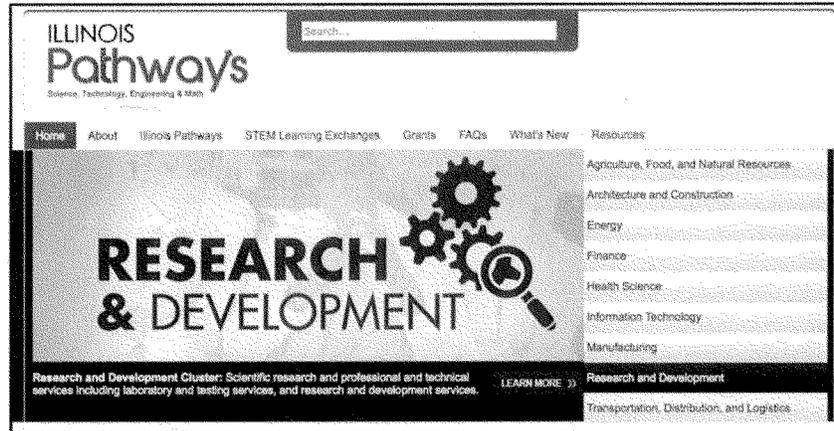
The Illinois Business Roundtable, an organization made up of CEOs and other senior leadership from over 60 of the top businesses in the State, has been a key driver of Illinois Pathways. Each Exchange has active engagement from a broad array of industry partners, which includes sponsoring student competitions, providing student internships, and participating in curriculum development. This initiative has been instrumental in bringing together previously uncoordinated industry, university, and school participation in STEM and the Learning Exchanges are focused on both consolidating and broadly disseminating the partnership work. The Learning Exchanges were launched with \$2.3 million in Race to the Top funds, and that was used to leverage \$8.5 million in public and private matching funds. See the appendix for supplemental material on Illinois Pathways.

In 2012 OSEP joined the Illinois Science and Technology Institute (ISTI) in their efforts to improve and expand student STEM research opportunities through the Research and Development Learning Exchange (RDLE). The RDLE is a true public-private partnership. More than forty private businesses, not-for-profits and civic institutions collaborated to support the development of an organization that received a seven-year grant of \$950,000 (\$430,000 guaranteed, \$520,000 subject to additional federal funding) from the Illinois State Board of Education (funded via Illinois' Race to the Top grant). To support this grant, ISTI committed to match \$100,000 in cash to seed the RDLE, and private partners have committed an additional \$117,000 in matching funds in just the first year of operation of the RDLE. In addition, coalition partners have committed programs, support and staff time worth in excess of \$1,000,000 to the RDLE.

RDLE coalition partners include private industry partners like Comcast, AT&T, Astellas, Abbvie, Abbott Labs, Baxter, Eaton, Kraft Foods, Takeda, GTL Resources, Northrop Grumman, Google, Motorola Solutions, Willdan Energy Solutions, and Wrigley. Not-for-profits and civic institutional partners include the Shedd Aquarium, Chicago Zoological Society, Brookfield Zoo, iBio Institute, ISTI, and Chicago Coalition for Science and Technology, as well as the State's two National Research Laboratories, Argonne National Lab and Fermi Lab. University partners include major research universities like Northwestern University, University of Chicago, IIT, University of Illinois, Loyola University, and Northern Illinois University.

The RDLE is in its first year of "beta-test" operation, with programs in place with fourteen schools (a map of all Illinois school districts involved across all the STEM Exchanges is provided in the appendix). The RDLE is currently providing three core services, which will include running six science challenges (which will touch more than 400 students at all fourteen schools), building a repository for regional R&D opportunities (available at www.stemlearningexchange.org), and building and hosting the Mentor Matching Engine (MME), an online resource designed to pair students and private industry mentors to conduct independent student-driven research in STEM fields.

As key partner in the RDLE, OSEP provides professional development for teachers and opportunities for high school students to showcase their research projects and network with undergraduates and graduate students at Northwestern. To date, and with funding from the Motorola Solutions Foundation, OSEP has provided over 60 teachers with the STEM Student Research Facilitation Course. Through this course teachers learn about in-school and out-of-school models for student research programs and acquire tools for implementing student research at their schools. These teachers are reaching over 5,000 students in Illinois.



Through research programs, students are able to experience the real world practice of science for themselves. They can develop their own research questions; design the project; conduct investigations and experiments; analyze data; write up and present the results to diverse audiences. Teachers are facilitators, guiding and supporting the student experiences, but the projects are student-driven. These programs offer many students their first opportunity to fully engage in inquiry-based experimental design, research methods, design thinking, and analyses of STEM research and practice. Through these research programs, they improve their understanding of the nature of science and develop important skills, such as critical thinking, problem solving, communication, collaboration, and creativity. Often referred to as 21st Century skills, these are essential to both college and career readiness and success and broader STEM literacy. When asked about the most important things she learned through a research program at her school one student responded:

*“One of the best things this (research) experience provided me with is **grit**. Learning how to solve problems and figure things out, ask good questions, and keep going and trying...this grit is what will help to make me successful in college and in a job. It also taught me how to work with others on a team and how to talk about what I learned and why it is important.”* (2013 STEM Summit, Stevenson High School, Student Panel)

Through research programs students are also guided and supported by STEM professionals. These mentor relationships are essential to successful research projects, as STEM professionals serve as the subject matter experts. These professionals also provide students with ongoing relationships that further support a desire to learn, investigate, discover, and innovate. They create a real-world connection to what a practicing scientist or engineer does every day and the many career paths in STEM. Importantly, research has shown that students who have the opportunity to engage in hands-on scientific research in conjunction with real-world scientists and engineers are significantly more likely to enter and maintain a career in science when compared to students who did not have those opportunities (Roberts and Wassersug, 2009).

When asked about his research experience, another student responded:

“I learned more from doing my project and this program than I have ever learned in any of my other classes. It made engineering come to life for me. Every student should have this opportunity.” (2013 STEM Summit, Stevenson High School, Student Panel)

Finally, student research programs directly align with and support the new Next Generation Science Standards (NGSS) and its focus on practices. To quote the NGSS framework, “scientific practices are the behaviors that scientists engage in as they investigate and build models and theories about the natural world. They also include practices of engineering, which are the behaviors that engineers engage in as they apply science and mathematics to design solutions to problems.” A focus on practices clarifies for students the relevance of the four STEM fields to everyday life, and engaging in these practices helps students become successful analytical thinkers who prepared for college and careers. High school research programs not only provide opportunities for students to learn these practices, but also to actively engage in the range of cognitive, social, and physical practices that true “inquiry” requires.

In order to support the ongoing development and growth of research programs for students in Illinois, OSEP and the RDLE, along with Illinois Mathematics and Science Academy, are working together to design and test the MME mentioned above. The MME is an online, invitation-based platform that brings together mentors, students, and teachers to collaborate on student research projects focused on the STEM fields. By connecting mentors and students online, the MME offers high quality mentoring experiences for students and mentors alike in a safe and secure environment. It also helps to level the playing field by eliminating geographic and

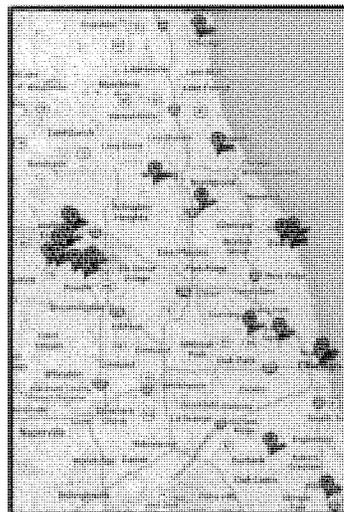


resource barriers and facilitating access for all students from any school to mentors from diverse STEM fields in industry and academia. The MME also provides industry and their professionals with a low barrier, high impact way to engage in STEM education. The MME is currently being piloted in 14 schools.

Model #3: FUSE: A modular platform for industry involvement in STEAM education

FUSE is a new kind of interest-driven learning experience being developed by researchers at Northwestern University with the goal of engaging pre-teens and teens in science, technology, engineering, arts/design, and mathematics (STEAM) topics while fostering the development of important 21st century skills including adaptive problem solving, creativity, self-directed learning, persistence, and grit. In particular, FUSE seeks to engage youth who may not yet have developed interests in STEAM fields, or are not already performing at a high level in STEAM, and to do so in more youth-accessible locations—like libraries, community centers, and schools.

FUSE Studios are located at 17 sites around the Chicago metro area in city and suburban public schools and public libraries (see map) and the program is focused on out-of-school time learning. FUSE will reach over 1600 youth in the 2013-4 academic year. There are an additional 23 schools and libraries on our waitlist and new studios will be added as capacity permits.



Challenges are the core activity at FUSE Studios. Each FUSE challenge sequence uses a leveling up model from gaming and is carefully designed to engage teens in different STEAM topics and skills sets. FUSE currently has 20 challenge sequences in areas such as robotics, electronics, biotechnology, graphic design, Android app development, fashion design and 3D printing. New challenges are always in development. See screen shot of FUSE Challenge gallery below.

FUSE is currently working on developing challenges with industry partners. "Challenge-izing" the professional practices of leading industries provides teens with real-world applications of STEAM knowledge and skills. FUSE has built a model for working in partnership with industry on challenge development. In 2012, FUSE collaborated with Motorola Mobility designers to create the Motorola Graphic Design challenge. A partnership with Christopher Duquet Fine Jewelry in Evanston, IL resulted in a very popular Jewelry Design challenge that uses 3D Computer Assisted Design (CAD) tools and 3D printers – exactly the skills needed in engineering design fields. In 2013, the FUSE team designed the Solar Roller Challenge with Siemens' Building Technologies Division and the Northwestern-Argonne Solar Energy Research Center. With the ultimate goal of "mastering the racetrack by getting a solar powered car through tunnels, distance tests, and more," the Solar Roller challenge stimulates youth engagement in and learning about solar energy, energy storage, and electronics. These concepts span physics, mathematics, and engineering and design.



Industry challenges provide teens with a new way to discover and pursue their interests in STEAM fields and to establish a pathway toward STEAM-related activity and study in the future. Industry challenges expose students to the diverse array of career opportunities in STEAM and connect them to real-world problems that scientists and engineers are working to develop solutions for everyday.

FUSE offers industry partners an outreach opportunity that is innovative, creative, and fun. For our industry partners, the modular challenge development format and focus on out-of-school time learning is low-barrier and more productive than focusing on in-school curriculum development that is slow moving and bureaucratic. Industry challenges also provide companies with a unique way to enhance their brand with respect to their corporate citizenship work and FUSE provides the dissemination network as the challenges are offered to schools, libraries, and other partner organizations throughout the city. The goal of FUSE is to engage a diverse body of teens across Chicago, the suburbs, and ultimately the U.S., in challenge-based STEAM engagement and learning.

Lessons Learned: How OSEP's experience can benefit both university and private sector STEM education initiatives

OSEP as a Platform

More than just a collection of individual programs, OSEP provides a *platform* that is built on staff expertise, a growing network of partnerships, and best practice models for STEM teaching and learning. This platform lowers barriers to faculty and industry participation in STEM education and creates new opportunities for engagement and collaboration in STEM education for diverse stakeholders including schools, industry, and universities. OSEP delivers efficiency, increased capability and capacity, and enables greater scalability and sustainability of both new and existing STEM programs. This capacity was initially built to serve internal university stakeholders, but we have seen that it can serve the needs of the private sector equally well.

The OSEP model is built on partnerships for greater impact, sustainability, and scalability in STEM education. As a bridge builder, convener, translator, and catalyst for and between diverse stakeholders, we are able to effectively align efforts and interests, maximize resources and expertise, leverage existing assets and mobilize additional support, and utilize and further grow existing networks and partnerships.

While well intentioned, the diverse stakeholders OSEP serves, especially university faculty and industry, face many challenges to engagement in K-12 STEM education. These challenges include:

- Lack of K-12 experience and expertise
- Broad cultural divide between K-12, industry, and higher education
- Industry and university scientists and engineers are experts in their disciplines, not education, program design & delivery, and evaluation
- Lack of capability, efficiency—enthusiasm for outreach does not equate to capability
- Significant differences in time, financial resources, and organizational capacity
- Schools and school districts are very large, complex organizations—difficult to navigate as an outsider and build effective partnerships
- Partner relationship building is extremely time intensive
- Sustainability and scalability

OSEP has developed the expertise to overcome these challenges and contribute to partnership and program development that can enhance both university and industry involvement in K-12 STEM education. Below is a summary of OSEP's assets and capabilities as developed from our experience in developing partnerships to improve K-12 STEM teaching and learning.

- OSEP has particular expertise on its team of educators, researchers, and software developers in **translating authentic, “bench” science research into high quality curricula for middle and high school STEM education**. OSEP is focused on making the cutting-edge science accessible and relevant to teachers and students. OSEP staff has the capability to merge the science content knowledge with the pedagogical expertise related to best practices in science teaching and learning and brings direct connections to academic and industry research scientists to teachers and students. Furthermore, OSEP has the experience and capability to evaluate the

impact of its work and collaborations through data collection and analysis of the effects on teachers and students.

- OSEP has built a **model to effectively partner with and maximize the expertise and resources of both Northwestern faculty and industry partners**. OSEP can leverage and has access to tremendous resources at Northwestern University. These resources include expertise in teaching and learning within the SESP; over 2,500 STEM faculty across the Weinberg College of Arts and Sciences, McCormick School of Engineering and Applied Science, and Feinberg School of Medicine; state-of-the-art facilities; and the buying power of a top university with respect to scientific equipment, technologies, and materials. OSEP also has in-depth experience in working with a growing network of different industry partners. OSEP serves as a bridge to connect very different groups—teachers, Northwestern faculty, and industry—who have little experience working together to build authentic STEM teaching and learning programs and materials.
- OSEP has **an extensive, and constantly growing, network of teachers and schools**. This network is key to not only recruiting teachers to participate in our professional development programs but also to help us understand and meet the needs of teachers and students as we refine current programs and develop new ones. This network also facilitates easy distribution of programs and materials and supports scalability to many more teachers and students
- OSEP has **in-depth experience in program development, implementation, and evaluation** with over 11 STEM teaching and learning programs currently being implemented across the Chicago area, Illinois, and around the world. OSEP programs include those that focus on the development of new curricula and learning technologies to out-of-school time projects that seek to engage and educate youth who have not yet developed interests in STEM.

OSEP is constantly working to identify, understand, and meet the needs of teachers and students. For example, our *STEM Student Research* program was developed alongside teachers who requested a PD program on how to implement independent student research in high schools. OSEP sought funding, developed the course, and is now offering the PD each summer and fall. It is this effort that is informing the Illinois Pathways' RDLE mentioned above.

- **OSEP focuses on and contributes to current research and state and national policies and efforts in STEM education**. Our staff publishes, presents, and disseminates our work and best practices in scholarly journals, at academic and K-12 education conferences, and to diverse audiences including educators, researchers, policy makers, and foundation and industry leaders.
- OSEP has a **growing number of federal, corporate, and private foundation** supporters that endorse our work and help us build programs and the infrastructure to support them. We are continually seeking new partnerships to help grow, improve,

build resources, and disseminate our programs, technologies, and materials to teachers and students.

- With OSEP, we have created **a platform for STEM outreach**, not just a set of individual programs. Just as in IT, a good platform supports ease of building on top of it and delivers more capability, more efficiently than building from scratch each time.

Strengthening and Expanding the NSF Broader Impacts Model

Every NSF grant recipient must demonstrate the broader impacts¹ of their research. OSEP provides institutional support to researchers in the design, development, implementation, and evaluation of their broader impacts K-12 education and outreach efforts in the Chicagoland community and across the state of Illinois.

Many of OSEP's current and most impactful programs have been developed through broader impacts partnerships with Northwestern faculty, including the NUBIO project mentioned above that was developed in partnership with Dr. Teresa Woodruff and from NIH funding.

Under the current model at OSEP and similar offices around the country, funding for researchers to do broader impacts activities is part of the grant and it's the responsibility of the individual principal investigator (PI) to do the work. OSEP, when asked to participate, only gets a very small portion of each PI's grant, which is typically not sufficient to implement an evidence-based broader impacts program that is sustainable beyond the life of the grant. Furthermore, the STEM faculty members that conduct NSF sponsored research and are expected to be the point person for implementing the broader impacts component of their awards are not usually experts in K-12 education.

While OSEP has been successful in sustaining many of its programs beyond federal funding and providing the necessary support and expertise for effective program development and implementation for broader impacts, this is not the case at most institutions. In recent conversations with subcommittee members' staff, OSEP has offered the following suggestions for improving the impact and effectiveness of the broader impacts policy.

The current America COMPETES Act includes language that encourages institutions of higher education to establish offices like OSEP to provide PIs with assistance in setting up evidenced based broader impacts programs. While this language is a move in the right direction, NSF could significantly strengthen the impact of their research by restructuring how broader impacts

¹ In 2013, NSF clarified the function of the broader impacts (BI) criterion and provided eight exemplar focus areas for BI including: fostering full participation of women, persons with disabilities, and underrepresented minorities in STEM; improved STEM education and educator development; increased public scientific literacy and public engagement with science and technology; improved well-being of individuals in society; development of a diverse, globally competitive STEM workforce, increased partnerships between academia, industry, and others; improved national security; increased economic competitiveness of the United States; and enhanced infrastructure for research and education.

work is funded. This is also an opportunity to improve the incentives for implementing high quality broader impacts programs, and for better tracking and accountability of the investments in broader impacts across NSF. Although outside the purview of the committee, it is recommended that other federal agencies with STEM missions including NIH, the National Oceanic and Atmospheric Administration (NOAA), the National Aeronautics and Space Administration (NASA), the Environmental Protection Agency (EPA), and the U.S. Geological Survey (USGS) might adopt a similar model.

The essence of our proposal is to shift the responsibility and funding for broader impacts from individual PIs to a shared responsibility between the PI and institutionally-supported broader impacts and outreach offices like OSEP that have the expertise to do this type of work. This shift might be accomplished in a number of ways:

- **Supplemental Awards.** Allow institutional programs with expertise in K-12 education, like OSEP, to apply for a supplemental grant in coordination with a PI to implement their broader impacts program (much as Research Experiences for Undergrads – REU – supplements are currently awarded). Funding would go directly to the institutional program but the PI would be required to take part in the development and implementation of the program. This would help ensure that broader programs are developed by K-12 STEM education experts and allow NSF to better track the impact of funding allocated to broader impacts work through the institutional program. This approach would also ameliorate the marginalization of funding for broader impacts work that currently occurs when PIs must trade off broader impacts dollars against dollars for research activities to fit under the grant budget limit.
- **Matching Awards.** For every dollar in the main award budget spent by the PI on broader impacts in coordination with an institutional center like OSEP, NSF could provide additional matching funds (up to some specified cap) over and above the main award budget limit for broader impacts activities. Both the original and matching broader impacts funding would flow directly to the institutional center, like OSEP, who would implement the broader impacts activities. This would incentivize institutions to set up offices like OSEP and encourage researchers to take advantage of their services. It would also help mitigate the zero-sum-game budgeting constraint currently preventing PIs from investing more in broader impacts work.

The shift from a PI-based to a shared PI and institutional-based broader impacts funding strategy would also benefit from direct investment by NSF in start-up funding to help establish offices like OSEP at universities across the country and ongoing funding to these programs to conduct systemic evaluations of the efficacy of broader impacts activities at their institutions.

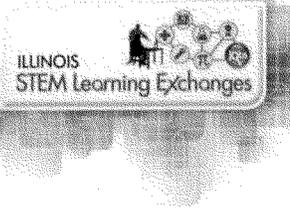
If done well and communicated appropriately these policy changes could be a big win for investigators and institutional broader impacts and outreach centers. Further, NSF will likely see better broader impacts results as a result of empowering K-12 STEM education experts to conduct the work along with PIs. From an agency perspective, NSF would achieve greater transparency and accountability for their investment in broader impacts by rolling up results

from a much smaller number of institutional offices rather than thousands of individual PIs.

NSF's model for broader impacts is widely seen to be among the most effective and successful among all federal agencies. To continue to strengthen our nation's future STEM workforce and science-savvy citizenry, other agencies (NIH, NOAA, NASA, etc.) should be encouraged to adopt similar models to encourage the scientists whose work is funded by those agencies to share their expertise and passion for STEM with the next generation. We need the best and brightest scientists and engineers, working in partnership with STEM education experts, to be active participants in broadening and deepening our students' engagement with the excitement of STEM disciplines and careers.

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ILLINOIS
STEM Learning Exchanges

STEM Learning Exchange Engagement in Schools and Districts

Since January 2013, the STEM Learning Exchanges have increased their effort to build their networks of support and reached out to districts and schools to create coalitions of interest and investment around sector specific "cluster" areas. The Learning Exchanges (or "Exchanges") are working with approximately **194 schools** (taking account for sector overlap in schools) and are meaningfully engaged and developing Career Pathway Systems for over **17,500 Illinois students**.

Each STEM Learning Exchange is developing a network of statewide partnerships (between schools, industry, state government, and non-profits) that better coordinate investments, resources, and planning in industry areas that are crucial to economic development in Illinois and better utilize industry and public resources. The Exchanges are focused on delivering resources and supports for local pathway systems, to help local schools make clearer and more comprehensive connections with e-Learning and curriculum resources, lab space and equipment, teacher development, and student organizations that foster engagement between schools and the workplace. To that end, the Exchanges are simultaneously focused on expanding work-based learning opportunities for students and communities, to facilitate more job-shadowing and internship opportunities, as well as industry sponsored challenges which directly engage students with industry leaders.

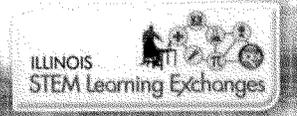
This document highlights some of the accomplishments of the STEM Learning Exchanges in the past year, with a focus on the crucial connections that the Exchanges made between schools and districts and their industry partners.

Measures of STEM Learning Exchange Engagement in Schools across Illinois

STEM Learning Exchange	# of Schools Exchange Meaningful Engagement	# of Students, Exchange Meaningful Engagement (based on 10% engagement)
Manufacturing LE	29	4093
Agriculture LE	80	3676
Energy LE	23	597
R&D LE	13	2701
Health Science LE	20	2600
IT LE	29	4194
Total	194	17862

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Since 2012, the Illinois Manufacturers' Association, which is the lead entity for the **Manufacturing Learning Exchange**, has engaged in comprehensive community outreach across the state, visiting each of the State's 48 Community Colleges, their numerous feeder high schools, and local manufacturers to develop relationships that have resulted in viable internships for students (with an anticipated expansion to over 500 additional internships by July 2014), externships for faculty, and program sustainability. The Exchange is establishing a Web-based library of comprehensive e-Learning materials from credentialed programs in a password protected environment that is end-user friendly and will be housed in the "Dream It-Do It" website. Additionally, this Exchange has worked with student organizations to support industry sponsored student-challenges and education competitions in machining, robotics, and/or welding in at least 4 regions by July 2014. Including its Race to the Top schools, the Manufacturing Learning Exchange is meaningfully engaged with approximately **29 high schools**.

The **Agricultural, Food, and Natural Resources Learning Exchange** is by far the most developed Learning Exchange, because of the State's longstanding focus on agricultural education, and is engaged in a meaningful way in **80 high schools** across the State. Since 2012, Learning Exchange has focused on building upon a successful model of Illinois agriculture education coordination, by combining the efforts of the Illinois FFA Association, the Illinois Leadership Council for Agricultural Education (ILCAE), and the Facilitating Coordination in Agricultural Education (FCAE) to create an infrastructure that can support coordination on student college and career development. This Exchange has focused heavily on increasing Supervised Agricultural Experience grants to schools across the State, focusing on providing workshops, resources, and mentorships for both students and teachers, and increasing resources to diverse groups, such as Illinois Agri-Women.

The **Energy Learning Exchange**, led by Illinois State University, has been capitalizing on increased attention to energy-related careers by leveraging existing partnerships with the Illinois energy education network, academic resources, and long-term business relationships to create an infrastructure that can support coordination on student college and career development. The Exchange is focused on cataloging existing Energy-related curriculum and lesson plans to be shared openly and easily with schools via the Illinois Shared Learning Environment (www.ilsharedlearning.org). The Exchange is also creating an online toolkit of workforce development and career programs for educators and employers which will help teachers, guidance counselors, and workforce development professionals become familiar with energy careers and energy career programs. The Exchange also sponsored "Careers in Energy Week" and is hosting a series of professional development workshops during the 2013 and 2014 summers called *Teaching Next Generation Energy Concepts with Next Generation Science Standards*, which includes a 2 week professional development workshop and follow up days throughout the school year. The Exchange is working intensely with approximately **23 high schools** across the State.

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The **Research and Development (R&D) Learning Exchange**, led by the Illinois Science and Technology Institute, has taken a “pilot” model approach to school engagement and is working intensely with **13 high schools** across the state to pilot R&D focused initiatives aimed at facilitating and sponsoring real-world applications to complex, industry-driven problems. Students work on variety of topics including: food safety, aerospace and defense, environmental sustainability, and behavioral economics. Students work in teams to project manage and apply what they learn in science, technology, engineering, mathematics, and social science to solve complex issues over the course of a semester. As part of this effort, the Exchange has focused on linking schools with an industry sponsored Resource Repository, where students and teachers can seek out resources (internships, professional development opportunities, curricula, and events). Additionally, the Exchange is also developing and piloting the Mentor Matching Engine, which matches students with industry leaders in an unprecedented guided and meaningful way. These mentorships are “problem-oriented”, in that students are driven to find mentors based on the real-world problems they want to solve.

CompTIA, the lead entity for the **Information Technology Learning Exchange**, is focused on comprehensive community outreach to create a sustainable model for public-private engagement in the Information Technology sector. CompTIA has also successfully participated in several IT grant opportunities, including the Gates Foundation Scales Models for Certificate Delivery, which is aligned with its goal and strategy for long-term sustainability. The Exchange is focused heavily on working with industry partners to create online model lesson plans aligned with the Illinois IT Programs of Study, providing resources for in-service teacher training, and creating a comprehensive and continuously updated library of career development/exploration and outreach resources. The Exchange is meaningfully engaged in **29 schools** across the State, which include **5 STEM Academies** in the City of Chicago, and an **additional 31 CPS Schools**.

The **Health Science Learning Exchange**, led by the University of Illinois at Chicago, has been focused deeply on building membership networks and technical support, as well as expanding physical resources with education and industry partners. The Exchange has engaged with **20 high schools** and also engaged with industry partners to create a “Speaker’s Bureau”, which allows students live, virtual access to experts in the field, both in the classroom and as part of their personal career exploration. The Exchange is working with schools to consolidate and add to the existing library on career exploration and to ensure that access to this technology is broad enough that all students are able to utilize this resource. The Exchange has established a relationship with the IJAS, and for the 2013-2014 school year, the Exchange is seeking to pilot this partnership through the Aurora and Chicago Public Schools. The Exchange is working with IJAS to support collaborative scientific research, improve high school faculty mentorship, and provide better access to labs and equipment, qualified judges from employers, and facilities for student use. Finally, the Exchange has worked to develop foundational and up-to-date curriculum that is informed by educators at the University level as well as individuals from industry, as well as providing funding for a curriculum designer/manager to work with respective

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schools to improve their existing curricula and lesson plans. This improved curriculum will be shared openly through the Illinois Shared Learning Environment (www.ilsharedlearning.org).

Collectively, the STEM Learning Exchanges have engaged with over **210 schools**, and continue to work in concert to develop collective communication, fundraising, and regional engagement initiatives. The Exchanges, working with the support of the Illinois Business Roundtable and Northern Illinois University, have fostered deeper engagement with the Illinois Pathways Interagency Committee and Advisory Council, which has led to clearer coordination and role definition between the Exchanges and the Pathways Resource Center. The Exchanges are more clearly aligned with the efforts of the Illinois Shared Learning Environment, and most have moved deeply into the implementation phase.



Dr. Kemi Jona
Professor, Learning Sciences and
Computer Science
Northwestern University
Evanston, IL USA

Dr. Kemi Jona has worked at the forefront of the learning sciences and learning technologies fields for over 20 years. He is thought leader in applying insights from cognitive science to the design of learning environments, particularly in the areas of STEM education. He has worked with leading universities—including Carnegie Mellon, Cornell, Columbia, and Northwestern—on the development of innovative online programs. He was one of the founders of VOISE Academy, a nationally recognized blended learning public high school in Chicago.

Dr. Jona is Professor of Learning Sciences and Computer Science at Northwestern University where he leads research and development projects in STEM curriculum and learning technologies, online science and remote labs, and web-based patient education and outreach. He is founder and Director of Northwestern's Office of STEM Education Partnerships (osep.northwestern.edu), an organization that connects the university to the K-12 community to advance STEM education.

In addition to his work at Northwestern University, Dr. Jona acts as advisor and consultant to industry, non-profits, school districts, and state and local governments on strategic process and learning-related issues, curriculum redesign, teacher professional development, and the design of online and blended learning initiatives. He is on the board of the International Association of K-12 Online Learning.

The author of numerous book chapters, articles, and conference papers on the topics of online and blended learning, curriculum design, intelligent tutoring systems, and Goal-Based Scenarios, he holds a Ph.D. in Computer Science from Northwestern University and a BS with Honors in Computer Science and Psychology from the University of Wisconsin-Madison.

Chairman BUCSHON. Thank you very much.
I now recognize Dr. Cornwell for five minutes for his testimony.

**TESTIMONY OF DR. PHILLIP CORNWELL,
VICE PRESIDENT FOR ACADEMIC AFFAIRS,
PROFESSOR OF MECHANICAL ENGINEERING,
ROSE-HULMAN INSTITUTE OF TECHNOLOGY**

Dr. CORNWELL. Chairman Bucshon, Chairman Smith, Ranking Members Lipinski and Johnson, thank you so much for inviting me to be here today.

As you were told, my name is Phil Cornwell. I am Vice President for Academic Affairs and a Professor of Mechanical Engineering at Rose-Hulman Institute of Technology. Rose-Hulman is a university focused entirely on math, science and engineering education. For the last 15 years, U.S. News and World Reports has ranked us as number one in our category, which is basically engineering programs at schools that don't offer a Ph.D. We have about 2,200 students, which makes us a small school but a midsized college of engineering. Our placement rate last year was about 99 percent and is always 99 percent. Our average starting salary is about \$67,000.

The mission of Rose-Hulman is to provide our students with the world's best undergraduate science, engineering and mathematics education in an environment of individual attention and support. What that means is that we hire faculty members who have a passion for their technical field but also a passion for students in undergraduate education. Our goal is to graduate technically outstanding, well-rounded, liberally educated STEM professionals; and even though our primary focus is undergraduates, we do have a number of outreach activities I wanted to share with you.

One of our most successful is called Operation Catapult, which is a three-week summer program. Students come to campus, they live on campus, and they participate in lots of activities; but most important, they work on a technical project that has a faculty member as the mentor. About 30 percent of the students that attend Catapult end up coming to Rose-Hulman. The other 70 percent study STEM at other universities. So, it is a great way of solidifying their interest in STEM.

We also have a program called Homework Hotline, which has been around since 1991. That is a math and science tutoring program for students in grades 6 through 12. If a student has problems with math and science homework and they can't get help at home, they can call Rose-Hulman where Rose-Hulman students are available as tutors to help the students not just get the answer, but understand the material.

We also do a lot with industry, and I will just mention one unique program that is called Rose-Hulman Ventures. Rose-Hulman Ventures is basically an engineering consulting business that operates on the Rose-Hulman campus. Students that work with Rose-Hulman Ventures are student interns that work under the supervision of a professional project manager with client companies on projects that are important to the company. It could be working on a coding project, it could be developing a prototype, it could be developing a product. It is just something that is important to the client, and the clients typically pay time and materials.

Companies range from small startups like Fast BioMedical or NICO to large companies like Alcoa, Cummins or Dow Agro.

One of the reasons for this Committee hearing, I believe, is the recognition that we need more STEM professionals in the United States; and for me, there are two key things that we need to accomplish that. One is to increase the pipeline and increase the number of students interested in STEM, which is largely what we are talking about today; but, secondly, we also need to, once those students enter college, graduate more of them and help them be successful. As far as the pipeline, I think programs like FIRST Robotics, curriculum like Project Lead the Way, and many other programs do a fantastic job of energizing students and helping students see engineering or computer science as a possible career option, which I think is absolutely critical. But I also think it is equally important to strengthen our math, science and, I would add, computer science curriculum in the high schools, so when they get to college, they are prepared to be successful in the very rigorous curricula that are required for all of those majors.

As far as retention and graduation rates, if we forget the pipeline issue and look at the students that currently enter college with an interest in studying engineering, which is my area of expertise—less than 50 percent graduate. At Rose-Hulman, it is 80 percent. It varies widely from school to school. But if we could increase that number by just ten percent, if I did my calculations correctly, that means within six years we could graduate 100,000 additional engineers without doing anything to the pipeline. We are just helping more of our students graduate.

How do we do that? There is actually a lot of research on the topic. Some things that I think are important include an early connection of students to the discipline; and, again, FIRST Robotics does a great job of that. Most freshman design programs do that. It is very frustrating to have a really smart student drop out of engineering and they say “well, it is because I don’t like engineering,” but as a freshman, they have never had any engineering. It just drives you crazy.

Secondly, I do think having faculty members whose first priority is teaching and working with students and helping them be successful is important in terms of persistence and graduation rate. I can share some stories about that if you are interested. I also think undergraduate research and internships are important for retention and graduation rates.

So what can the federal government do? Certainly, continue to support undergraduate research—I think that is critical. Perhaps incentivize companies to offer early internships. Most companies offer internships for juniors and possibly sophomores because they consider that a critical part of their recruitment, but it is much harder for students to get a meaningful internship as freshmen. You could also incentivize students who study STEM through perhaps lower interest rates for student loans or perhaps loan forgiveness. There are lots of ways to possibly incentivize this.

I tell prospective students at Rose-Hulman all the time that a STEM education is great no matter what they want to do. If they want to go to industry, if they want to go to graduate school, if they want to go to medical school or business school, if they want to be-

come a politician, engineering STEM is great; and I applaud this Committee for taking the leadership role in promoting STEM research as well as STEM education.

So again, thank you so much for giving me the opportunity to testify.

[The prepared statement of Dr. Cornwell follows:]

**Testimony
Committee on Science, Space and Technology
Subcommittee on Research and Technology
Of the U.S. House of Representatives**

January 9, 2014

Phillip Cornwell

Vice President for Academic Affairs and Professor of Mechanical Engineering
Rose-Hulman Institute of Technology
Email: Cornwell@rose-hulman.edu

Chairman Buschon, Ranking Member Lipinski, and members of the committee, thank you for the honor of allowing me to testify before you today about private sector programs that engage students in STEM.

My name is Phil Cornwell, and I am Vice President for Academic Affairs and Professor of Mechanical Engineering at Rose-Hulman Institute of Technology. Therefore, I come to you, not as a private sector provider of such programs, but as the representative of a university that furthers the education of students benefiting from such programs.

Rose-Hulman is a private university focused exclusively on science, engineering and mathematics education. For the past 15 consecutive years we have been ranked by U.S. News & World Report as the best undergraduate engineering program among colleges whose highest degree awarded is a bachelor's or master's. We have approximately 2200 students, so we are a small school. About 80% of our students study an engineering discipline, so in terms of engineering, we would be considered a mid-sized college of engineering. In fact, we are in the top 20 – 25% of all engineering colleges in terms of the number of engineering graduates we produce each year. Our placement rate is around 99% each year, and last year our median starting salary was around \$67,000.

The mission of Rose-Hulman is to provide our students with the world's best undergraduate science, engineering, and mathematics education in an environment of individual attention and support. We hire faculty members who are experts in their fields, but who are also passionate about teaching and preparing students for success.

We are also strong believers that a Rose-Hulman education is much more than what happens in the classroom. Student life and extracurricular activities play in critical role in the education of our students and in enabling us to graduate well-rounded, liberally educated, STEM professionals. Every student group on campus has leaders who have technical majors. I love going to a football game, looking at our team, and being able to say "every Rose-Hulman student out there has had calculus and differential equations." There are not many other schools where you can say that!

We believe that retention is everybody's responsibility. We do have a retention task force, and something called the "RHIT Link Survey" to help identify at-risk students. We don't have any large classes, so faculty members know all the students in their classes and will identify and help any who are struggling. A few years ago I had a student named Betsy in three courses. In the first two, she received A's, but in the third she received a D on her first exam, which was completely out of character for her. I called her into my office to see what was going on. With tears in her eyes she said she didn't know if she wanted to be an engineer, and she didn't enjoy the material we were studying. I encouraged her to persevere, and I know her friends, who were also engineering students, encouraged her to persevere, and she did. She ended up graduating, and she is currently a Whittaker Fellow working on a Master's degree at Oxford. That is what happens when you have faculty members who care about the success of each and every student. At Rose-Hulman our 1st to 2nd year retention rate is usually between 90-93% and our 5 year graduation rate is about 80%.

One of our most successful outreach programs is called "Operation Catapult," which is a three week summer program for rising high school seniors where students live on campus and work in teams on a technical project. Every team is mentored by a faculty member with a Ph.D. There are also numerous demonstrations, lectures, and field trips. About 30% of the students who attend Catapult choose to come to Rose-Hulman.

Two other ways Rose-Hulman helps support pre-college students in their technical education is through the "Rose-Hulman Homework Hotline" and through "PRISM."

Rose-Hulman's Homework Hotline was started in 1991 as a free math and science tutoring service for Indiana students in grades 6 through 12. Tutoring is still the primary activity of the Homework Hotline, but the scope of the program has expanded to include many outreach and STEM promotional activities. Although the program was originally intended for Indiana students, calls have been received from every state in the country. Even though we target students in grades 6 through 12, we have received calls from students in the 3rd grade, college and even graduate students. The Homework Hotline has not turned down a call for homework help since its founding.

PRISM helps Indiana teachers of STEM take advantage of digital learning tools to meet the state academic standards. PRISM provides a library of teaching resources and access to Moodle, a secure platform for delivering educational content through the Internet. PRISM also fosters teacher professional development by helping instructors try out emerging digital tools that will transform their pedagogy without significantly increasing their workload.

Rose-Hulman hosts a regional FIRST Robotics competition, and we recently became an affiliate school for Project Lead the Way.

A unique way Rose-Hulman partners with industry is through Rose-Hulman Ventures (RHV). RHV operates as a successful engineering consulting business on the campus of Rose-Hulman. At Rose-Hulman Ventures, teams of student interns, under the supervision of a professional engineering project manager, work with

client companies to develop new products, services, and processes that are important to the success of the clients. RHV provides client companies access to outstanding undergraduate engineering and computer science talent while offering students real-world, hands-on learning experiences. Student interns with RHV aren't just learning about engineering; they are helping generate real business value for clients.

Rose-Hulman Ventures consults for a diverse mix of customers, from entrepreneurial start-ups, such as FAST BioMedical and NICO, to established companies with global operations, such as Dow AgroSciences, Cummins, and Alcoa. Our state-of-the-art facility in a Certified Technology Park ensures that students and clients have access to professional-level laboratories, equipment, tools and workspaces—all on the Rose-Hulman campus.

Internships are not currently a required part of the curriculum, but they are important to the education of our students. Currently, about 92% of our students have at least one paid summer internship and about 80% have two or more internships before graduation.

In my opinion, there are two aspects to increasing the number of STEM educated professionals in the United States: 1) increasing the graduation rate of the students who currently enter college with a desire to study a STEM field, and 2) increasing the number of students in K-12 interested in a career in STEM.

The average 6-year graduation rate for students who enter college with an expressed interest in studying engineering is less than 50%. Improving this number by just 10% would produce around 100,000 new engineers in 6 years. How do we do this? There has been a lot of research done on retention. Factors that make a difference include providing an early connection to the discipline; rewarding professors who have a passion for and expertise in undergraduate STEM education; and providing meaningful internships early in students' educational experiences.

I believe FIRST Robotics, Project Lead the Way, and other similar programs are great at helping make students aware of engineering as a possible career option. However, we need more than just awareness of STEM as an option – we need excellent high school mathematics and science instruction to prepare students for the rigors of an engineering education.

How could the federal government help? Here are some possible suggestions. 1. Offer incentives for companies to provide meaningful internships early in students' education, that is, after the first and second year. No such incentive should be necessary for upper level students. 2. Differentiate student loan rates based on schools' graduation rates and on student major.

In closing, I wish to thank the Committee for the opportunity to participate in today's hearing. I am happy to answer any questions.



Phillip J. Cornwell
Vice President for Academic Affairs
Rose-Hulman Institute of Technology

Phillip Cornwell is Vice President for Academic Affairs and Professor of Mechanical Engineering at Rose-Hulman Institute of Technology. He is responsible for all academic programs and provides leadership in forming an academic vision and developing short- and long-term strategies to realize that vision. Cornwell received his B.S. degree in mechanical engineering from Texas Tech University in 1985 and his M.A. and Ph.D. from Princeton University (NJ) in 1987 and 1989, respectively.

Cornwell joined the Rose-Hulman faculty in 1989. He was one of the developers of the Rose-Hulman Sophomore Curriculum, an innovative approach to teaching engineering science that was developed as part of the National Science Foundation (NSF)-funded Foundation Coalition. Cornwell is a strong advocate for the use of technology in the undergraduate engineering curriculum and was a co-principal investigator of an NSF-funded grant for a "classroom of the future" for the teaching of dynamics.

Cornwell received an SAE Ralph R. Teeter Educational Award in 1992, and he has received the two highest awards at Rose-Hulman: the Dean's Outstanding Teacher Award in 2000 and the Board of Trustee's Outstanding Scholar Award in 2001. Cornwell was one of the professors featured in The Princeton Review book *The Best 300 Professors*.

Cornwell spent many summers working at Los Alamos National Laboratory where he was a mentor in the Los Alamos Dynamics Summer School and did research in the areas of structural health monitoring, energy harvesting, vibration monitoring of femoral components, and micromotion of cementless implants. He has authored or coauthored more than 55 conference and journal publications.

In 2006, Cornwell joined the author team for one of the oldest and best-selling engineering mechanics texts of all time, *Vector Mechanics for Engineers: Dynamics* by Ferdinand P. Beer and E. Russell Johnston. Following Johnston's death in 2010, Cornwell has assumed primary responsibility for updating and improving the book.

In 2011, Cornwell became the Vice President for Academic Affairs at Rose-Hulman.

Chairman BUCSHON. You are welcome, and I would like to thank all the witnesses for their testimony, and I will remind the Members of the Committee that the rules limit questioning to five minutes. The Chair at this point will open the round of questions, so I recognize myself for five minutes.

As a cosponsor of the Computer Science Education Act, I share many of the concerns that you do, and I am quite pleased that my home State of Indiana is one that allows a rigorous computer science course to satisfy core high school graduation credit, particularly since according to the Conference Board, there are 4,864 open computing jobs in Indiana right now. That is changing by the minute, I am assuming.

According to your analytics, 264,000 Indiana students did the Hour of Code in December 2013. Mr. Partovi, what do you see as the next steps for those students if they want to pursue studying computer science?

Mr. PARTOVI. Thank you very much for that question. We were astonished to find 17 million students in this country do the Hour of Code, and we were actually prepared to offer more than one hour in terms of instruction. The one hour was enough to demystify the field for teachers, parents, students to all realize that computer science is something that anybody can learn, but we also had a follow-on curriculum that any student could learn online or any teacher could teach online. We are already within one month at the point that over 10,000 classrooms are teaching a full computer science class to almost 500,000 students.

To put this into context, in October— at any point in history there has been at most 10,000 classrooms in the country teaching computer science. In one month, we have doubled it. In terms of the number of students studying it, we have almost tripled or quadrupled it within one month because of the follow-on from the Hour of Code. It shows this is an incredibly popular topic with students, parents and teachers, and our only ask, and not for Code.org but for the field of computer science is like you have sponsored in the CSEA to remove the federal government barriers that prevent this field from spreading to our public schools. Thank you very much.

Chairman BUCSHON. Thank you.

Mr. Kamen, what differentiates your program and their offerings from other private sector STEM initiatives because you have been very successful, and why do you think it has been successful and what principles and techniques do you use in your programs that would you suggest to apply to the Federal STEM education programs?

Mr. KAMEN. I think the primary reason we have been successful, we are different, is our premise right up front was, 25 years ago, the world of parents and politicians and government leaders and corporate leaders was, we have an education crisis. My mother is a teacher, and she reminds me of that every day. We have a lot of great teachers. I am an inventor. What do inventors do? We look at the same problems everybody else looks at and see them differently. And I said, you know, my mom is probably right, she always is. We don't have an education crisis; we have a culture crisis. You get the best of what you celebrate in this country, and she

pointed out, it is not what we don't have enough of—dedicated teachers, surgeons that are willing to commit themselves to public service.

America is built on people that get together and solve a problem. Our problem is, we have such a passion in our culture because we have become rich, that we can spend time on leisure, and we have made superheroes from two places, Hollywood and sports, and particularly for women and minorities, they are sucked into spending their time until they are 18 or 19 developing skill sets that aren't likely to lead to great jobs. So I said let us get those industries that need these people, let us get these world-class tech companies together, let us them create superheroes, let us use the model that works, sports and entertainment, and let us let the private sector solve the cultural problem. You get the best of what you celebrate. Let us start celebrating science and technology.

Chairman Smith said it was a festive atmosphere in here. I would encourage everybody here to see, because you can't believe it when I say it. We started with one event at the end of our season in 1991 in a high school gym in Manchester, New Hampshire. We had 23 teams. They came to the one event and it was over. With 55 percent compound annual growth for 25 years, now we have 29,000 schools around the world, and our March madness starts the first weekend in March. We have more than 60 cities around the United States holding spectacularly large events throughout March. There is one near every one of you. Every one of you has a school in your district that is involved with FIRST. Since we get the best of what we celebrate, it wouldn't be hard to invite you to the Final Four or the Super Bowl. You would go. You would find the time.

I would ask two things. You each need to go to one of the events in your state and support these kids. First of all, it is a lot of fun. Bring your own kids and grandkids. Second of all, you will see what happens when kids develop self-confidence and become aware that they can do the kinds of things that will lead to great careers, and I will also invite you to our championship on April 25th and 26th under the Arch in St. Louis. We will fill a 76,000-seat arena.

We succeed because we have got industry behind us. They in their own self-interest want these kids to become world-class scientists and engineers and inventors. That is what they need. That is what this country needs. We have succeeded because it is the private sector. I was told 25 years ago you will never pull this off because you are going to run out of giant companies that can support all the schools, and I thought that was my biggest problem. These companies just keep delivering. They are mentors. They are scientists. They are engineers. The staggering thing to me is, the school side. All they need to do is give that math teacher or science teacher the same stipend to be the coach of the team as you give the football coach for that extra effort after school, and believe it or not, the schools have 100-year history of figuring out how to fund those other programs. That relatively small commitment, the appropriate public side commitment to make sure particularly the underserved schools can take advantage of FIRST is what you guys need to do, and then we will be in every school in this country.

Chairman BUCSHON. Thank you very much.

I now recognize the Ranking Member, Mr. Lipinski, five minutes.
Mr. LIPINSKI. Thank you, Mr. Chairman. I want to thank all the witnesses for their testimony. It is exciting to hear a lot of these things that are going on. I know that more needs to be done.

I want to ask Dr. Jona a little bit about what you have done at Northwestern. It is very impressive what you have done from what you have shown us here, what you have in your written testimony. I want to ask, because we always face, especially with this issue, we have people come and talk about great things that they are doing and it is always, okay, how do we expand this, how do we replicate it, especially what you have done at Northwestern in the Chicago area, is how do we replicate it. So what were some of the challenges that you faced in establishing and growing the Office of STEM Education Partnerships and what lessons can be taken by other institutions who want to establish something similar?

Dr. JONA. Thank you for that question. The work that we do with our faculty and would be similarly done at other institutions is largely funded by NSF's broader impact requirement, and while this is an incredibly helpful requirement and stream of funding, there really is never enough of those funds to go around. We are sort of living on the margins, if you will. And what I guess I would like to see is NIH and perhaps other STEM mission agencies adopting similar requirements or similar funding streams to broaden out that pool. My written testimony includes a number of recommendations for strengthening and expanding NSF's broader impact work, but I would say that a key—that is a key source for other new offices like mine to get up and running and off the ground.

Mr. LIPINSKI. Are there any other things the federal government can do? Obviously Northwestern is in a unique position. It is in a large urban area. It is a private university. Are there things that maybe the federal government could do to help or any suggestions you would have other schools that might be looking at doing this and may not be in the position Northwestern is in?

Dr. JONA. Yeah, I feel very strongly that the federal government could play an important role in providing seed funding, for example, for offices like mine, especially at smaller institutions or rural institutions to help them kind of get jump-started and off the ground. Another important role would be to support a national network of these offices so that we could begin to support each other and share the best practices that we have developed over time with these smaller and newer offices. In addition, this network could then serve as sort of a national distribution network for facilitating the broader dissemination of federally funded STEM resources that are developed at any of our institutions.

Mr. LIPINSKI. Thank you. I have so many other questions that I can ask.

Let me go to this. I know, Mr. Partovi, the Chairman had asked some questions, talked to you about what you had done with the Hour of Code. I know there are about 830,000 students in the State of Illinois who took part in the Hour of Code. What you put up there is very stark how many jobs there will be and how few students will be coming out of college for those jobs. Is this something that is—how do we make that better understood? It seems like at

least when I was in college, maybe because I was an engineer, I was always looking, okay, where are the jobs supposed to be in maybe directing, giving us a sense of where to go. Why is that not happening? Is it because of the lack of background and students just saying I can't—that is not something I can do or not something I am interested in? Why do you think it is that there isn't a response to this job demand that we know is out there and will continue to be out there?

Mr. PARTOVI. Thank you very much. This is a great question. In fact, one thing I have trouble getting people to realize is that, you know, there is a common thread that there is a crisis of not having enough STEM professionals in the country. If you look at the actual data, most STEM fields have too many graduates, whether—there are more math graduates than math jobs, there are actually more engineering graduates than engineering jobs, more life sciences graduates than life sciences jobs, and then way more computer science jobs than computer science graduates, and if you look at student decisions, by the time they get to college, many students have decided their passion, and if they are in one of the 90 percent of schools that doesn't even teach computer science, they never have any background to think I could do this. So the way to solve the problem isn't just building awareness. They know that oh, if I could be the next Mark Zuckerberg, that is an amazing future. That already is the new American dream. The problem is, they think I can't do it because high school never exposed them to it.

Mr. LIPINSKI. Okay. I see my time is up, so I thank everyone for their testimony.

Chairman BUCSHON. I now recognize Chairman Smith for five minutes.

Chairman SMITH. Thank you, Mr. Chairman.

We have gotten a lot of good advice today that I think we ought to take to heart. Dr. Cornwell mentioned the corporate component, the need to strengthen our curriculum and increase the percentage of majors in engineering and I assume other STEM subjects as well. Dr. Jona talked about supporting our STEM students outside the classroom. Mr. Partovi mentioned the barrier that we face with some regulations, and I want to come back to that in a minute, and the fact that a lot of schools don't even teach computer science and the big gap between what is taught and what is needed in the STEM-type jobs, and Mr. Kamen has talked about encouraging STEM students through robotics.

And Mr. Kamen, let me direct my first question to you. You mentioned at the very last part of your testimony, part of this came from your mother, who is a teacher, the need to change our culture and celebrate some of these subjects. Let me ask you to expound a little bit on that as to how we might do that in a practical way.

Mr. KAMEN. As I said, one of the things that makes America great and we all brag about it is, it is the land of opportunity, but if you are not searching for the right opportunity, you are not going to find it, and we have celebrated almost to obsession the kinds of activities, particularly for kids that don't have professional parents and people around them, so that they not only aren't aware of or don't have access to learning computer science but I am afraid that many of them, the women and the minorities, if they did have ac-

cess wouldn't do it. They are convinced at a very young age it is too difficult, it is too hard, it is not for them. They want to go and become good at things for which we all know realistically they are no jobs. So we said we are going to convince kids through celebrating science and technology all kids will realize they can do this, and as I said before, we succeeded, and I really encourage you all to go to one of our events and celebrate with these kids. We have 89.6 percent of the kids that have come through our program either go on to college to study some technology or go directly into fields to learn technology and get great jobs.

The frustration to us is industry, everybody is behind it but the school systems, as you know, are a little bit—they lack the resources.

Chairman SMITH. Right. Let me follow up on that in a minute. Just a minute. Thank you, Mr. Kamen.

Mr. Partovi, I think you mentioned a few minutes ago about the regulatory burdens. I checked, and I think I know the problem, and that is that in the definition of core academic subjects, there is no mention of computer science. Clearly, that definition of core academic subjects is out of date. A bill has been introduced by a colleague of ours, Susan Brooks, to change that definition, and in fact, that bill has been cosponsored by our Chairman, by Mr. Lipinski, Ms. Esty and I think Derek Kilmer as well. I certainly will be adding my name but if Members of the Committee want to know what they can do about it to, to bring a greater focus on computer science and to make sure it is part of the core curriculum, one answer is to support that particular piece of legislation. So thank you for calling that to our attention.

Let me ask all the panelists, a couple of you all have taught for many years. We all know what we need to teach. What should we be doing differently as to how we teach these subjects? And maybe start with Dr. Cornwell and work back down the panelists.

Dr. CORNWELL. Well, for me, one of the keys to teaching engineering and computer science is engagement in the material. So one—

Chairman SMITH. And I will have to ask you all, because of limited time, maybe 30 seconds—

Dr. CORNWELL. Right. So what I see exciting in terms of pedagogy and education is flipped classrooms. If there is a passive portion of a class where I am just lecturing and students are listening, that is a waste of time, put that online and then redesign the in-class portion to be much more active, much more engaging, and much more project-based. That has worked fantastic in courses like mechatronics and design courses; but engaging students in the material is really critical, even though you still need that lecture material; use effectively—effective use of technology and increased active engagement to me is a key.

Chairman SMITH. Thank you, Dr. Cornwell.

Dr. Jona?

Dr. JONA. I guess I would take a little bit of issue with Mr. Kamen's assertion that one of the big challenges is that STEM is too difficult. I actually think that the problem is that it is too risky for kids to do in school. If you took his exact program and tried to put it in school, kids would be failing all the time because the only

way to succeed is to try and learn from your mistakes, but that is not an environment in school where assessment is so predominant now. So kids are more worried about their GPA than about taking risks and trying hard things and so a lot of them tend to shy away from the STEM fields for that very reason.

Chairman SMITH. Okay. Thank you.

Mr. Partovi?

Mr. PARTOVI. I have a really quick answer, which is making it more fun, and we actually built tutorials. You saw that little girl's reaction. Our tutorials feature Angry Birds, lectures by Mark Zuckerberg or Chris Bosh and literally feel like a game. The kids don't even know that they are learning. They feel like they are playing when they use these tutorials.

Chairman SMITH. Okay. Thank you.

And Mr. Kamen?

Mr. KAMEN. I entirely agree. You have to make it fun. You have to make it rewarding. You have to show them superstars that they can aspire to be like because that is what drives kids to put passion into things in this country, and we have got to get kids passionate about science and technology and make them believe it is available, it is accessible, it is fun, it is rewarding and it is a great career.

Mr. SMITH. Okay. Great. I might add one other idea that is not original. I heard it yesterday from the CEO of a tech company but it might address some of the concerns about the subjects being either too difficult or not interesting enough or whatever, and that is, allow students to basically progress at their own pace so they are not keeping up with the class, they are not discouraged from taking those subjects, so that might be another consideration as well.

Thank you, Mr. Chairman. Yield back.

Chairman BUCSHON. Thank you.

I now recognize Mr. Kilmer, five minutes.

Mr. KILMER. Thank you, Mr. Chairman, and thank you all for being here.

I think this is a very important conversation. I have got 24,002 reasons to care about this, 24,000 open computing jobs in Washington State right now, and two little Kilmer girls. I have got a 4-year-old named Tess and a 7-year-old named Sophie, and Sophie's newest passion is the codable and hopscotch apps on the iPad, which teach coding concepts, and she totally geeks out on it.

Let me start on the 24,000. I just invite you, and maybe I will start with Mr. Partovi and invite others to chime in. Be more directive to us. I mean, outside of CSEA, and Dr. Jona, you mentioned the potential of trying to have the government promote distribution platforms for some of these things. Are there other things that Congress ought to do to step up not just to fill the 24,000 jobs in my state but to ensure that we have a workforce for the next generation?

Mr. PARTOVI. Sure, absolutely. You know, I looked at this. The core issue in computer science which is driving these jobs is the high school pipeline, and the reason the CSEA bill is—you know, it is a no-brainer. It only removes barriers, doesn't increase funding. It does what constitutionally the federal government should be

doing, which is giving more control to the states, but if you want to go beyond that, I wouldn't say to increase funding but look at the existing \$3 billion in STEM funding or the existing \$1.5 billion in K-12 STEM funding, how much of that is going to computer science? I would say today almost none of it because in a high school when they get STEM funding, STEM means biology, chemistry, physics, environmental sciences and calculus, and I have nothing against those things but they don't even think of computer science as a STEM topic. We all think of STEM as robotics, engineering, computer science, coding. That is not what our schools think, so the STEM funding you are providing, billions of it, goes where the jobs aren't actually.

Mr. KILMER. I would invite others to chime in if there are other suggestions for Congress.

Mr. KAMEN. I will give you a suggestion. I know that the two sides of Congress seem to be polarized on a lot of issues. I can tell you from my day job, I have 500 engineers who work on a lot of projects for a lot of big companies, most of which heard about our members of FIRST as well. But in my day job, I now have 30 openings. We have been hiring as fast as we can. We can't find tech people just like the rest of these people. I have people here on H-1B visas. It costs me a lot of time and a lot of money to acquire these people and to get them in. We are happy to pay the money because they are so valuable, but of course, I would rather give the jobs to homegrown people.

We know that you have a bill going through that is going to increase the H-1B fees to tech companies. You know, what would make that a lot easier for these tech companies to swallow is to know that some of that money is being used to solve their long-term problem. If you could say whichever said, hey, it is not even a new tax, it is not even new money, take that H-1B fee money, put some of it aside to solve the problem so that down the road we don't have to keep doing it this way, and I would suggest that if you could take some of that money and make it available to these schools so that they can internally leverage all the things you have just heard about, the amount of time and money it would take to internally build a robotics program to bring in world-class scientists and engineers to be in classrooms, you can't do it, you don't need to do it. They are there. They are free. Let the schools leverage these programs by just giving them the stipend for the coach, the ability to pay the fee to get to the event and figure out how to focus that money on the schools that need it most and that way you are solving multiple problems. I hope you get consensus. I know industry would be way more supportive of paying higher H-1B visa fees if they thought it is solving their problem.

Mr. KILMER. Thank you. With the minute I have left, let me ask—let me focus on the two, and that is, Mr. Partovi, you mentioned the failure to see adequate representation of women and minorities in the STEM fields. Again, how do you think the federal government is doing in terms of some of its programs to broaden diversity in the STEM fields and can you give direction whether it be through NSF programs or others to what we ought to do to raise our game?

Mr. PARTOVI. Sure. First of all, what I showed was not about STEM, it was just about computer science, because that is my focus. The two issues are slightly different. The female participation is a cultural one, girls being—just the culture all around them making them think this is not for me, whereas the African American and the Hispanic American issue is much more just availability. There is equal or even greater interest level among African Americans or Hispanic Americans in computer science but the schools don't teach it, and that is the bigger problem that I would suggest that you guys focus on. The cultural issue, I think efforts like FIRST and efforts like Code.org will actually change the culture. The fact that we got 10 million girls learning an hour of code last month, that is going to start to have a trickle effect, and we are going to do that year after year.

Chairman BUCSHON. Thank you very much. I now recognize Mr. Massie, five minutes.

Mr. MASSIE. Mr. Kamen, that idea of taking the H-1B visa fees and using it solve our problems makes way too much common sense for Washington, D.C. I love that idea.

As a participant when I was in grade school and high school of science fairs, I was always frustrated that the science fairs wanted a hypothesis, and there was just one iteration of the scientific process. So what really encourages me about what you have done with the FIRST program is to teach failure, that it is okay, in fact, you are going to fail multiple times in an hour. Even if you write code, you run the code and it is going to fail and you find the bugs but the same thing mechanically, so I think that is great that it also teaches that failure is okay, and it motivates those classroom topics like trigonometry. We want those kids to care about trigonometry. Why would you care about it unless you could see where you could use it?

But I want to ask you about something I know you are passionate about. You are trying to promote the superstars as engineers. I would think the equivalent of an Emmy or Grammy would be a patent. You know, kids in your programs I am sure would love someday to get a patent, because to use sort of an engineering analogy, you are trying to push a string uphill if you are trying to encourage these kids and the parents to get excited about a degree or an education in STEM unless there is something pulling the string, and what is pulling the string should be that incentive, that Emmy, that Grammy, that professional achievement. But isn't it a little counterproductive for Congress as we have recently done to advance this narrative of trolls, that if you invent something and then you go—and then a big company takes your idea and you try and live the American dream and use the justice system and get your rights asserted in court that you might be a big hairy troll? I would argue maybe we should talk about patent hobbits instead of patent trolls. They are a lot more cuddly. But I would like to hear your views on Congress's recent decision to change the patent system.

Mr. KAMEN. So sadly, that is a big topic and it is hard in a few seconds—

Mr. MASSIE. You can have the rest of my time.

Mr. KAMEN. I would violently agree with you that A, as an incentive and as a prize, as an Emmy, it has got to stay there. It has been very valuable. It is what has led the United States for the last couple hundred years to be clearly the global leader in innovation. It is not a coincidence that you name it, the Wright Brothers or Edison or the Google boys are here. It is not a coincidence. It is the lifeblood of America is innovation and the freedom to do it, and we had a patent system that supported it, and by the way, we have students that do have patents. It is fantastic. We have middle school students that have applied for patents through robotics and we are—we work with the Patent Office. We have had their director as a key person in our organization over the years. They come to our championship.

But back to the current issue of patents, I think the intersection of bad actors, people that are being called trolls, they are conflating to the general public the bad actors with the incredible importance of the patent system, and I think mostly because of misguided understanding. You know, my guess is most people in Congress understand certain other kinds of intellectual property. Dollar bills are an intellectual property. You can't run your car on them. You can't buy—you can't eat them. You can buy food or fuel. A deed to your home is intellectual property. A credit card is intellectual property. We have a society that depends on them. We know that there is a lot of credit card fraud in this country but I haven't heard Congress say let us stop letting people use credit cards. I know that there are counterfeiters out there, there are bad actors, and we should go after them and put them in jail but I haven't heard anybody say let us close the Mint and the Treasury. But because of bad actors that have made, frankly, small levels of outrage and inconvenience to people, they have—because there isn't a broader understanding of the power and importance of patents for small companies to raise money, for companies to protect themselves internationally.

I was at the CDS yesterday in Las Vegas watching all sorts of Chinese companies parade their little Segway copies around, and I am not sure what we can do about it anymore because the United States that used to be the pillar of we don't make compulsory licensing, it was the country that believed in, you can own private ideas and private property, suddenly even the debate about how we are so drastically undermining the importance and value of patents and being able to keep it is, I think, emboldening the rest of the world to do what they are doing and this country's major economic future is depending on intellectual property and innovation. This is the wrong time to be weakening it.

Mr. MASSIE. My time is expired, but before we touch the patent system again, I would love to have you come back. Would you be willing to testify on that subject? Because I think it is important. Otherwise we are pushing the string uphill to get these kids to become inventors.

Mr. KAMEN. My whole company depends on the—I have 500 people. We don't make or sell a product. We work for these giant companies giving them better solutions for their next products. I would go anywhere to testify on this because my company's future and I

think this country's future depends on a strong patent system, and calling this a reform is a euphemism.

Mr. MASSIE. Thank you very much, Mr. Kamen.

Chairman BUCSHON. Thank you very much.

I now recognize Ms. Esty for her questions.

Ms. ESTY. Thank you, Mr. Chairman, and thank you, Ranking Member, and thank all of you for joining us here today. As a parent of a child who did FIRST, I went to those competitions well before being in Congress and I had a chance to go back last year, and I would recommend it to all my colleagues. It is very exciting and it really gets you—gets your juices flowing about what is possible, and for those who haven't done it, I would also say bring an astronaut to your schools, which I did in December, and I took them into a pilot program in one of my underserved communities into a middle school where half the students were girls, and it was incredibly exciting. These astronauts were treated like rock stars, and they told stories, and NASA is very good at this, and I would—this is the sort of thing we can do because I really want to drill down a little bit of what more we can do about the specifics for the under-represented.

If you look in a state like mine like Connecticut, I had a caller this week from Newtown, Connecticut. He is looking for five programmers right now and he can't find them, and we have students who are graduating and are going to graduate with huge amounts of debt and they won't have jobs and they will be baristas.

So we really have to think about what we can do and how far back do we need to go. Certainly, we need to do it in high schools and we need to have those computer science programs, but should we be looking even further back? Should we be looking at elementary schools? What are we doing in elementary schools? I have got bills out there to try to support teaching in elementary schools because I do think that idea, I am not competent at this, I am not good at that, often starts because I have seen it with my kids. I saw it in classrooms, and disproportionately, I have to say, minority students and girls were led to believe they weren't good at these fields.

So I would like you to think about that, and think about the role that competition plays, interactive actions where you fail, you try again, you fail, you try again, but you keep doing it because it is like Angry Birds and it is not like a test. So whoever wants to chime in on driving it even before high school the use competition and, again, what constructively the federal government's role be in that?

Mr. PARTOVI. Thank you very much. Well, I talked about the Hour of Code, how we got 17 million kids to do that. There are not 17 million high school kids in this country, so a huge number of those, millions, literally, were in elementary school and middle school, and we showed them that you don't even need to be 13 or 14. There is eight-year-olds, nine-year-olds doing the Hour of Code. In terms of diversity standpoint, we had more girls try computer science and coding in U.S. schools in December than all kids in the history of the United States. We have very much flipped this idea that I can't do it completely on its head, and if we just continue

to do that, people—as long as they make it fun, which computer programming is, we can show kids that they can do it.

The biggest issue I believe actually is not the cultural one. I think the biggest issue is the access and especially among the underrepresented minorities, the fact that computer science, the schools that do teach it are suburban schools. They are not urban schools, they are not rural schools, so the underprivileged kids don't even have access.

Ms. ESTY. Mr. Kamen?

Mr. KAMEN. So again, we are in violent agreement that you have got to get their attitudes adjusted at a much earlier age. Otherwise they can't get on the train. It is moving too fast when they get to high school, and again, our sports model has been incredibly effective. We started it in high school but the proof that it works and it is a ground-up effort is the popular demand was, we need to have the equivalent of Little League because there is a World Series, there is college and then there is high school and junior varsity. Within five years of starting FIRST, which is now 20 years ago, there was such demand among the parents, "What am I going to do for the younger brothers and sisters that come and watch this thing." So we didn't form a Little League, we formed Lego League, and the Lego company has a huge operation in Connecticut. The Chairman of Lego flew over from Bilund, saw what we were doing and said I will give you your Little League. We now have tens of thousands of teams, and we not only have Little League now, to your point, we have junior FIRST Lego League for the kindergarten on up, and it is a continuum now driven by the demand created by the superstar mentality of this whole thing.

And one more comment about NASA. You talked about bringing astronauts. Just so that you all know, NASA—yes, I have Boeing with hundreds of teams and every aerospace giant and every pharmaceutical giant and every semiconductor industry company, they are all there, hundreds and hundreds of them, but the largest single source of teams for FIRST is NASA because all their facilities around the country supply mentors, they supply grants to underserved schools. Their Administrator, Charlie Bolden, came and was our guest speaker at our championship, and the kids love NASA and space and technology. They love it all if you don't make it intimidating. So NASA has been a great partner. If you could find a way to get other government agencies that have technology people to get involved, it would be great.

Ms. ESTY. Thank you very much, and I am out of time. Thanks.

Chairman BUCSHON. All right. Thank you.

I recognize Mr. Schweikert.

Mr. SCHWEIKERT. Thank you, Mr. Chairman, and forgive the buzzers. It is just one of those things that goes on around here.

And forgive me if I am—Mr. Partovi? You just said you don't believe it is cultural, but Mr. Kamen about 20 minutes ago said it was, so I want to see the two of you debate each other.

Sorry. Some of us have sort of perverse senses of entertainment.

But I really would like to back up a theme that both the right and the left here have touched on and then backed away from. Is there something cultural in our sense of expectation? We all—let us face it, most of us in this room, particularly those with gray

hair, think back to when we took our calc and trig and those things and it hurt. It was painful. Now, when I couldn't do the homework, I didn't want to go to school the next day because there was always that freaky smart kid that made fun of us. Sorry for anyone in the room, MIT with a bunch of patents.

And yet I am told today that the United States, the only thing we score the top of the world in is self-esteem. Have we done something perverse to our next generation and the generation after that culturally and saying it is not always warm, fuzzy and teddy bears and puppies. It is hard—it is hard work. It is going to be painful, and guess what? That is how you get there. And that is why I am looking for consistency in thought where someone says it is cultural, it is built into our expectations of each other and avoidance of pain, and it isn't. What is it?

Mr. PARTOVI. I would like to clarify what I said. I actually completely agree with you. The country has a cultural sort of impediment. People don't think I should work hard and get an A plus, it is geeky to be an A student, you would rather make it onto the football field than be the kid with lots of books and you know, the smartest kid in the room. What I was trying to say is that with computer science, there has been an additional cultural impediment of just oh, my God, it is all ones and zeros, I will never, ever be able to touch that thing, and people place in their minds computer science and programming as this thing that is harder than trigonometry, harder than calculus, way out there, and what I think we can easily prove when you see that 8-year-olds can do it, and not just one 8-year-old but millions of 8-year-olds, at least that one piece, which is disconnected from reality, gets more grounded. But we still need to have a culture that celebrates the successes, treats, I guess, engineers and scientists as rock stars and teaches Americans that you have to get A's to be cool.

Mr. SCHWEIKERT. Well, speaking of rock stars, the gentleman to your right, I mean, Mr. Kamen, you're touching and working with a lot of these young people. It is my vision of sort of cynicism that our avoidance of what is difficult, our constant concern about people's self-esteem is an impediment to the understanding of this is reality. Reality sometimes is hard.

Mr. KAMEN. So once again, I am in violent agreement with you including the guy next to me.

Mr. SCHWEIKERT. Could we avoid the word "violent"?

Mr. KAMEN. I am in substantial agreement with you, Congressman, and I would tell you, first of all, one of our taglines at FIRST is always, it is the hardest fun you will ever have, and we then go on to point out to these kids, you are going to fail, we have given you a job that you can't possibly do with the limited resources and limited time we have given you to have to work in complex groups, you are going to fail, but that is a microcosm of the real world for people that eventually succeed, and we literally then go on to tell them all that stuff as you pointed out, we say, you know, why do you learn trigonometry, why do you learn all these things, you have never had a place to use them. You are going to quickly find yourself trying to do something that without understanding arithmetic and algebra and trigonometry and some calculus, you are not going to have the tools to do well, so we make it relevant but we

make it fun, and as another place I substantially agree with you, we allow them to fail, to learn from those failures, and we say to them, you know, in sports you go out and you started with tee ball, the ball didn't move but you had to see a path. And then we say to them, in sports, if you didn't get it, you have a chance tomorrow. You don't get a grade, you don't get a D, you get a coach that nurtures you, and we are going to put you in teams where you can be failing and failing and failing but learning and learning and learning.

Mr. SCHWEIKERT. I was trying to go to something that is much more cultural, and I know, Mr. Chairman, we are up against time, and for Mr. Cornwell [inaudible]—down the food chain of education in our society, and so I know we are out of time, Mr. Chairman, but I don't know if we will get another round. Thank you for your patience.

Chairman BUCSHON. Thank you very much.

I now recognize Dr. Bera.

Mr. BERA. Thank you, Mr. Chairman, thank you, Ranking Member Lipinski, and thanks to the witnesses.

Mr. Kamen, I enjoyed the video as well as the sports analogy. You know, as somebody who grew up with a pretty good outside jump shot, I think it became evident in about 8th grade that I wasn't going to be Jerry West or Wilt Chamberlain. Fortunately, though, in the public schools I went to, I had teachers that believed in me and pushed me and, you know, I excelled in science and the life sciences and went on to medical school and a doctor.

But they were allowed to meet me where I was and they were allowed to push us and encourage us to imagine and dream and think, and as I toured—you know, being a professor at a medical school, associate dean of a medical school, I spent a lot of time looking at what we are doing in K-12 as well as undergrad and grad school, and much of what we are doing in the STEM fields is memorization and regurgitation, and we really need to expand and get back to imagination, you know, to encouraging folks to solve problems and teaching our kids at an early stage not just to memorize and regurgitate but to think. Coding allows you to do that, right? I mean, coding and, you know, the innovation labs. You know, in my district, Intel has a major presence and, you know, what they are doing. When I talk to the Project Lead the Way kids, they are allowing them to imagine. It doesn't have to cost a lot of money. It has to, you know, allow us to change a curriculum, though, that is very much testing-based. And it's not that easy to test computer science or test on a multiple choice test imagination. You know, I had wood shop, metal shop, auto shop, you know, and you had to do mathematics in a very different way in those, and you had to dream of a project, put it on paper and make it happen.

You know, I am glad that Mr. Partovi is here. You know, last month I visited Toby Johnson Elementary School in my hometown of Bell Grove in my district and watched these kids, 7th and 8th graders, doing their Hour of Code using your curriculum. Again, not a lot of money, not a lot of investment, just a desire and a recognition that this was important.

I guess my question to any of you on the panel is, how do we start changing the curriculum to allow that imagination cur-

riculum, that innovation curriculum to take place at an earlier stage? Because we have got to do it in the elementary schools and, you know, we have got to push imaginations.

Dr. JONA. Well, I think we have seen a number of questions around this theme. I think if the science and math classrooms in our country look like FIRST Robotics, we wouldn't have to have this conversation because we would see how much fun kids have. Unfortunately, if you look at most math and science classrooms, it is a very sort of punitive, assessment-driven, risk-averse environment for kids, and that is not an environment where science and engineering thinking, or even CS thinking, can really happen. And so, you know, it is very antithetical to the spirit of engineering, as we have heard Mr. Kamen say over and over, you have to try, you have to fail. But kids when they come home from school and, you know, my four kids are the same way, failure is a bad thing and failure is something that you avoid at all costs because once it hits your GPA, it is all over and then your, you know, college career is over and whatnot. So it is a systemic issue that, you know, has to do with the culture of assessment and sort of the punitive nature of school, and it turns a lot of kids off to harder subjects, quote, unquote, because they are afraid to try because it is hard and they are going to fail.

Dr. CORNWELL. May I make one other comment on that? I think it is critical to have teachers who are content experts who have the ability to let the class go in different directions. If the teacher doesn't feel comfortable with the material, they are probably going to be very rigid on how they do that. And the current pay structure doesn't allow necessarily for different pay for computer scientists who could, with a bachelor's degree, get a job for \$100,000. Why would they go into teaching? It is a very challenging value proposition, but I think we need teachers who are content experts that can truly get students excited because teachers can have such an incredible impact on students.

Mr. KAMEN. And to be somewhat of an optimist here, I am not sure you have to change the whole curriculum, and that is sort of our point as to why FIRST works. Kids are not going to bounce the ball for three hours a day because you put it in the curriculum and tell them to do it. They will do it 45 minutes once a week and some—but they will go out after school and do it seven days a week because they are inspired to do it.

We don't claim that the NBA is part of curriculum but we have a culture that says to these kids, "do it." And as you pointed out, you can do it after school and fail a lot and fail a lot and get a few of those shots in and keep going because you didn't get a quiz; you didn't get a test. It is a perfect environment to encourage people to fail and get better.

So using the same analogy, we say—and we have heard people up there say—kids don't want to learn trigonometry because it seems really hard and, more importantly, it has no value. In the curriculum, leave it alone. The schools will do a great job. That gym teacher will do a great job of teaching kids the basics. They will go out and become experts because of their passion. You still need those analytic skills. You need to learn arithmetic and geometry and trigonometry, but you are only going to really learn them

well if you have some motivation to use them after school when you really develop the skills.

So by that same now-tired sports analogy, I will tell you let the curriculum do what the curriculum is supposed to do: give them the basic tools, not by memory, but give them the basic tools. That is analysis. But synthesis is taking all those tools and doing things with it. Bouncing a ball is work. Playing basketball is fun. You do one because of the other. They don't have a "because of the other." Particularly kids in underserved communities don't have a "why am I doing this" answer. If you let them have FIRST in and around their culture and their community, they are going to need to learn to code because their robot won't move without it. They are going to need to learn algebra or they can't figure out voltage and current.

If we can meld the fact that schools ought to have a curriculum that is analysis-based, teach them everything that came before us, but then give them opportunity to use synthesis to create new imagination, all of that stuff should be working hand-in-hand, not one or the other.

Chairman BUCSHON. Thank you very much, Dr. Bera.

I now recognize Mr. Collins.

Mr. COLLINS. Thank you, Mr. Chairman.

I want to thank all of you. And I am intrigued with a couple of thoughts here, and I am going to maybe direct these more to Mr. Partovi and Mr. Kamen because it is obvious to me that both FIRST and Code.org are existing without federal funding. This is the private sector and entrepreneurs and those that really care about the future of our country doing what you are doing, and thank you for that.

So my comment is, as a new Member of Congress, I came here with a core philosophy that big government generally doesn't have the answers. And in Congress, all too often, especially when you look at the debate on the right and the left, there are those who think government can solve all the problems.

We are here in Congress—and some of the questions have been directed to you, what can we do in Congress? Part of my philosophy is nothing, that education starts with parents. And especially as we talk about feeding the pipeline, the K–12, parents care about their kids' future. It is the parents' job to make sure—go to the local school board. The local school board is hiring the teachers and setting a curriculum that works. And that school board answers to the taxpayers and ultimately you go to the state. Last, you go to the federal government. I don't think we should be involved in this education debate. What you are doing doesn't have any Federal involvement. I would say the answer is the parents motivating the school board.

And I am someone that has lived this. My son went to a high school that did not have Regents Diplomas. As a result, they didn't teach to the test. And by not teaching to the test, they could exceed everything the public high school was doing. So when it came time to graduate, he is now an electrical engineering student at Villanova with a minor in mechatronics. He won the physics competition, he won the SumoBot competition and came in second in the Trebuchet pumpkin-throwing competition. It was all about

fun—throwing pumpkins, SumoBots crashing together—but it didn't come from the federal government. I don't think it can come from the federal government. I think it comes from parents pushing a school board and perhaps at the state level. And I just would love to hear a few comments from Mr. Partovi and Mr. Kamen. This philosophy of mine is we are here asking. I don't think it is our job.

Mr. PARTOVI. So I would agree with you in terms of the philosophy, and it is—you know, constitutionally I would say, you know, the federal government doesn't have that many strings it can pull to mandate things at schools or parents. But I have one thing I would suggest that I have a slight disagreement with my colleague in that computer science currently isn't even in the curriculum and—

Mr. COLLINS. Well, excuse me. What if we didn't have a core curriculum?

Mr. PARTOVI. So that would be one way of achieving it, but the issue we have right now is that the federal government—

Mr. COLLINS. And I agree with you.

Mr. PARTOVI. Yes. The federal government does decide—right now, it does specify in the ESEA this is the curriculum in a way that actually excludes computer science.

Mr. COLLINS. Right. And that is why we shouldn't have it.

Mr. PARTOVI. If you could abolish the ESEA you might get to a certain place, but whatever it takes to allow the schools—we have had one million parents petition via us. One million parents have signed a petition saying we want this in every school. They go to their school board and then their school board says, well, you know, we have this federal government funding that comes this way but it defines the curriculum this way.

Mr. COLLINS. Unintended consequences.

Mr. PARTOVI. Yes, but either way, we need to at least remove what I consider federal government barriers to schools actually responding to the parental pressure that they are receiving today.

Mr. COLLINS. It is the least we could do.

Mr. Kamen?

Mr. KAMEN. So I will say I don't think we are in disagreement. I believe that schools need to have way more access to computer technology in general, and kids through those schools need to get their earlier taste of it at a much lower age. So I think we are in agreement there. And I think he is in substantial agreement with you that creating systems—government by definition is high inertia. It is big. It takes a long time to change. That is generally good because organized societies don't like chaos and they are afraid of change. So the things that you want to be big and stable, government is okay.

Nothing is changing faster than the world of tech, and within the world of tech, nothing is changing faster than code. So they are not keeping up, to his point, and they should get out of the way of trying to mandate at the micro level for sure.

I only have then two comments for you. One is I need your son's resume because we are desperate for more good mechatronics guys. Send him my way. He sounds like interesting young man. But I think another place where government should come in is to make

sure there is a fair playing field. I mean that is what I think governments are really about. And these days, you can't expect a kid to compete in a fair way if he gets into—or out of high school or drops out of high school without certain kinds of skills. It is pretty clear your son was not at risk of not developing—

Mr. COLLINS. Right.

Mr. KAMEN. —those skills, but there are plenty of families in this country or communities in this country that don't have the resource or even awareness or good judgment to go demand changes—

Mr. COLLINS. Right.

Mr. KAMEN. —in schools, so there is some place for the government, which is, as I keep saying, don't run this program. We don't want you to run this program. The last thing we need is you to help us make FIRST part of curriculum. But make sure the schools that have that teacher or that principal that is ready to say we have got to leverage this incredible program—

Mr. COLLINS. Um-hum.

Mr. KAMEN. —make sure they are encouraged to do it and have the resources to do it.

Mr. COLLINS. No, thank you. Just to add, you know, because you do brag about your kids, my son is going to do his junior year internship in Tel Aviv working for the Israeli Space Program.

Mr. KAMEN. And I will tell you I will be over in Tel Aviv on March 2 where we are having a massive FIRST event. It is their ten-year anniversary. Shimon Peres is presiding over it. FIRST has a higher percentage of the schools in Israel involved than we have in the United States.

Chairman BUCSHON. Thank you very much.

I now recognize Ms. Kelly.

Ms. KELLY. Thank you, Mr. Chair, and thank you, witnesses.

As I have sat here, my questions have changed over and over and over listening to all of my colleagues, and I will admit that I fall right into that stereotype. I ran away from science and math, and it was scary to me. But I think you hit the nail on the head as far as access and opportunity.

I represent the Chicagoland area starting, you know, if you know Chicago, 53rd by U of C going south, so most of my district is suburban and rural and they don't have the opportunities, they are shaky.

In some of my area's school boards. We have worked to bring updated computers to the high schools and to the elementary schools so the kids even have, you know, something to work on. So that is where I see government being the safety net, and it is not fair and equal at all, not even in the Chicagoland area if you compare the south suburbs to the northern suburbs and—because of how we fund schools and property taxes and on and on and on. And if we don't do something about that, I don't think we will ever be fair and equitable.

We started—I came in in April, special election, a STEM council and a STEM academy, so I have tech people and different people around the table with community colleges to see what we could do as far as changing the curriculum and what jobs are out there and what training people need. And then I go to different areas in my district and actually expose the kids. I took them to the Museum

of Science and Industry, had them meet different people, had people come to them, tech people come to them, but, you know, we service 750,000 people and it is—you know, so I go to one school, then another school, then another school, and what did the kids say? Are you coming back next Saturday? Or, can we do this? And, no, I can't. I have to keep, you know, taking turns. So we are trying to get our businesses involved in even adopting schools so they have some, you know, steadiness or some constant, you know, in their lives to keep them interested. And—so I say that.

And also the other thing is, you know, I have a doctorate so I definitely believe in education, but many of my manufacturing companies and advanced manufacturing companies, they say part of the issue is we go to school and we major in psychology like I did and then we can't find a job, and they feel that if kids graduate with the tools they need and get two-year certifications, they can get really good jobs, too. And I just wanted to know how you felt about that.

Dr. CORNWELL. I would just say I strongly agree with you. Not everyone needs a college education. We hear the same thing in Indiana as far as advanced manufacturing. For students who get a great technical education, there are wonderful jobs. So, I don't think everyone needs to go to college. I do think college is more than just job training, however. It really is a life-growing experience, but I do think it also should end with a job and meaningful employment. But I agree with—

Ms. KELLY. And not \$80,000 in loans you can't pay back.

Dr. CORNWELL. Well, that is right, or even \$5,000 if it doesn't lead to a job. To me, our students at Rose-Hulman may have a higher debt, but they all get very good-paying jobs; so it is a good investment.

Ms. KELLY. Um-hum.

Mr. KAMEN. They are all looking at me, but I think I am having a disproportionate time here.

I would tell you that you say you, you know, ran away from it. Obviously, you have a Ph.D. You didn't run away from education.

Ms. KELLY. Right.

Mr. KAMEN. I think, and I will just keep saying it, and it is not a disagreement, I think our culture certainly takes kids, particularly women and minorities and—at a very young age and puts in front of them people they can relate to from the world of sports and the world of entertainment. And the reason I think we agree is I think we have got to get to them very young and have them as passionate about developing skill sets that will lead to great jobs whether it is out of college or a tech job. But once you get them passionate, you have got to deliver the tools they need, and it isn't putting pins into frogs anymore. Everything he is saying is the skill sets—once we can turn them on to say I can do this stuff, whatever this tech stuff is, the tools you have got to give them have got to be 21st century tools to do the right stuff.

And again, I will say it is not an either/or. The schools have to have curriculum. They have to have all the things that—you guys have to solve that problem of where the money comes from and where it goes and property taxes. But more than that, you could give the schools everything they want. And when I first started

FIRST, I wanted our tagline to be, you know, “you can lead a horse to water but you can’t make him drink.” I wanted it to be “you can lead a kid to knowledge but you can’t make him think.” And what I wanted to do was say get the schools as good as they can be, and that is your collective problem. I don’t know how you do that. But it wouldn’t matter if you had the best schools in the world if it is a 50 percent dropout rate because the kids would rather do something else.

So let’s get the schools to have the right tools and let’s let the culture of America, the companies of America, the people that need these kids give them the right kind of inspiration to work hard at developing the muscle hanging between their ears. It is the only one that has unlimited potential. And the kids that need to know that most culturally are the kids you are talking about, and you should find ways to get the schools that you have been visiting to get some teacher to be a coach, to get on a team. We have the companies that will connect them. You need to get the superintendents to know that having afterschool passion-based activities that matter to the future of these kids and to this country are as important as the other activities, and that is an appropriate role of leadership.

Ms. KELLY. Thank you.

Chairman BUCSHON. Thank you very much.

I now recognize Mr. Hultgren.

Mr. HULTGREN. Thank you, Mr. Chairman. Thank you all for being here. This has been a very interesting, very helpful hearing.

One of my biggest frustrations with this place, Congress, is the busyness of it, and here we are talking about what I think is one of the most important subjects we could possibly be talking about and there is just a lot of other things going on. You hear beeps and buzzes and things, and that references the other activities, votes, committees, whatever, that we are being called to. I am so frustrated by that. I wish we could have this hearing in front of the entire Science Committee but also in front of the entire Congress. I think it is so important.

If you talk to Members of Congress, every single one would say one of our top priorities has to be STEM education, that if we are going to be an innovative nation, we have got to be a nation that is committed to STEM education. But how do we make that happen? And I think that is where we struggle. You hear it up here is what is our role? And finding that right balance of what is the best way to motivate, mentor, and educate our students, specifically in STEM education, so that we can have a bright future as a nation. We are struggling with that. We need your input. We need your help.

I also am—have enjoyed this so much but really am looking forward to the next panel of young people, which is really, I think, the—where the excitement is of seeing that from them. I talk to scientists. I represent Fermilab and have some wonderful physicists and they get so excited talking to other people about science.

That challenge we have is, again, what is our role as government? And I think it is telling the story and taking away impediments, you know, of things that will allow young people to get excited and to be able to make the most of these opportunities. That

is what we have got to do and finding every possible way to get rid of unfunded mandates that aren't doing anything to excite our kids but are taking away opportunities from them to pursue their real passions and real opportunities there.

I want to thank Dr. Jona from Northwestern. You all have done a great job working with my staff and great job in Illinois working to bring STEM resources to local districts. I also want to just, you know, give a thanks and a shout out to Mr. Partovi and also to Mr. Kamen on a couple different fronts. One: last month, I went with my 12-year-old and 9-year-old and—to do an hour of coding in Elgin. We went to Elgin Technology Center, and I did the Angry Birds Hour of Code and was successful. I was able to maneuver and code my way through an hour and loved it and was really encouraged. And the lesson for me out of that was if I can learn how to do this, anybody can learn how to do this.

I am serving on this Committee but don't have the pedigree that some of my colleagues have in these areas, but I really did see an excitement there, and what I was most excited about was my kids who were with me and how excited they got, my 9-year-old and my 12-year-old, of doing this. And also my mentor in this process was a 13-year-old, who is on the robotics team in Elgin. "Got Robot?" is the robotics team that went to St. Louis last year, great team. They are—this kid is—the whole team is phenomenal. I am so proud of them, but they are so excited. And my 9- and 12-year-old also got to meet with the Got Robot? team to see their latest robot.

But with it, what I was really excited about was they brought their brothers and sisters along, little brothers and sisters, who are doing the Lego robots. And boy, my 9- and 12-year-old were kind of intimidated by the robot, but then they saw the Lego robots and they said we can do that. That wouldn't be that hard. And they could start seeing, okay, now I see how this works together, that we can do this.

So I just want to commend you for what you are doing, and we want to be helpful. A couple of things just in the minute I have left: there are some challenge in this, too, is how do we—you know, one of the things I recognize is we see a lot of people who are going to college to pursue this and then are dropping out, maybe some for right reasons to pursue a career, others because they just didn't see it as what they thought it was going to be. So I just would ask what can we be doing to encourage people who should be staying in this to stay in it? Are there more internships, mentorships, other relationships that we can be encouraging or building that will help people who really are our best and brightest staying in this? Certainly, we want to do it on the early side, and I think FIRST is doing a great job at this. Code.org is doing a great job of this. But what else can we be doing to make sure young people who should be in this, stay in this?

Mr. PARTOVI. I would like to say a few words that actually address your questions and some of the previous comments. You know, there was this conversation about kids don't like trigonometry, they don't like calculus, they don't like tests, and what we have showed and you saw with your own kids is that kids like making apps. They like making cool stuff. And, you know, with respect to the role of the federal government, without the federal gov-

ernment's help we have managed to get this into tens of thousands of schools. And in fact, even at the elementary level, even in rural schools in one month our curriculum that you saw, a 20-hour-long course is already in almost 10,000 schools at almost no cost with no funding other than what I have managed to raise.

But the most important role for you guys I believe, however you want to do it, is to remove the barriers. And the goal I would think of it is basically put the "T" into STEM. When you think of STEM, your mind goes to us, the types of things we represent, but when you talk to a school about STEM, what they think about is predominately life sciences and math and maybe physics in between and the technology part isn't even there. And I showed you on the chart that more than 50 percent of STEM jobs are in computer science. Dean talked about the H-1Bs. More than 50 percent of H-1B visas are for computer scientists, but in our K through 12 system, STEM and the funding that comes to STEM and the definition does not include computer science. That is—that should be something that the federal government can play a role in because currently it does actually provide barriers.

Mr. HULTGREN. Yes. My time is up. There is so much more that I would love to talk with you all about. I really would echo that we would love to have you come back and have some more focused testimony on this and get other committees engaged and involved in this. I am a cosponsor of the Computer Science Education Act, which is a small step in the right direction but there is so much more we can be doing there to recognize how important that is.

The last thing I will do is—will say is how important parents and teachers are. I just feel like that is the linchpin on this. So much is—I see so many parents who are intimidated by this and teachers who are intimidated by this, and anything we can be doing for them to see this is a great opportunity for your kids to have a great future and maybe change the future. And so Got Robot?, for example, this robotics team in my area, happens to be a homeschooled team, and so those parents are incredibly dedicated to their kids' education certainly, but also to that team, and it pays off such rich dividends, which I just was so inspired by and my own kids were inspired by as well.

So thank you all. I wish we had a lot more time but also looking forward to hearing from students who are engaged in this. With this, I yield back. Thanks, Chairman.

Chairman BUCSHON. Thank you.

Without objection, the Chair recognizes Ms. Edwards for five minutes.

Ms. EDWARDS. Thank you, Mr. Chairman and to the Ranking Member. I really appreciate your allowing me to sit in on this Committee. This is not my Subcommittee.

I wanted to just sort of talk to you because I come to this from a couple of different places. And, Dean Kamen, when you visited my son's school, Capitol Hill Day School, when he was in 8th grade, I know for him and all of those of students, it was very inspiring. And it wasn't that they were necessarily going into or studying those fields but it gave them a different avenue and approach to the work that they were doing.

And I was a student—when I was a student, I had a great aptitude for science and math at all of the higher order sciences and math, and I wouldn't say I was discouraged from going into those fields at higher ed, but I was not actively encouraged, and as a result, I didn't. And it wasn't until after high school, after college, and a different direction that I happened upon Lockheed Engineering. I got a job there. I ended up first doing, you know, analysis and writing and software testing and then development that I discovered that in fact I did have a very practical aptitude.

And so it worries me that sometimes we are—you know, we are in a situation now where we don't necessarily discourage students but we have to have more encouragement for students who may not think of that as their first choice because they may not have the parents at home who understand that or who are, like a lot of parents, intimidated by all of those higher order sciences and maths.

And then as a worker in the sector, we—at Lockheed we wanted—a lot of the companies that were doing business at NASA wanted a relationship with the school system but it was so incredibly difficult. When could our engineers be in the classroom? Could they only be in there for an hour or two a day? Could the students come to our facilities, all of those things, and we are still working out some of those kinks in terms of the relationship with the private sector that gives a much more practical vantage point of how to do work in and with our school systems.

And then, lastly, as a Member of Congress, every year I do a college fair. We invited—this last year, we had about 165 or so colleges and universities. And the focus of that is we bring in employers as well to do demonstration projects around STEM fields. We actually had a computer coding project that was run by one of our local companies, and, you know, each one of them participating because it helps for students to say where is it that I am going? What is the direction I am proceeding in? And then we had the National Association of Black Engineers, and so for the first time—my district is majority African-American—that these African-American students who are going to the college fair could actually see engineers who look like them, who are doing projects with them, so that they could see a direction they were going in.

And so I just share that with you because I don't think it is one thing or another thing, and I think sometimes the federal government has to set a floor but it can't be the be-all and end-all. And in our next panel we are going to hear from two students who come from counties that I represent in a State where we have said we can't just have one science or technology school; we have to have that kind of learning taking place in all of our schools. And it is a real transformation from the time that I was at Lockheed and out at Goddard to where we are now.

But I just—I applaud you for the—for what you shared with us but I also know that the private sector is going to have to step up and work with our schools and our institutions of higher learning so that we are getting a better match of people who are coming out with degrees and the kind of work that is done in the workplace because we have such a mismatch now that it is the reason that you have to struggle with those H-1B visas. And God love those

people who are coming in to our companies, but it is because we have a terrific mismatch between the students we are producing, the skills that they have, and the workforce needs, and we have to marry those up.

And I just—I close my comments because I really came here for our second panel, but I applaud what you do and I hope, Mr. Chairman and to the Ranking Member, that in Congress we can see across the aisle to begin to get this right from a policy perspective in the Congress. And I thank you for being here.

Chairman BUCSHON. Thank you very much.

Now, without objection, the Chair recognizes Mr. Kennedy for five minutes.

Mr. KENNEDY. I will be quick. I promise. Thank you, Mr. Chair. I appreciate that. I appreciate the opportunity.

To the witnesses, thank you for indulging yet another Member that is not on this Subcommittee but is on this Committee and has great interest in this topic. Thank you all for being here.

I wanted to build a little bit off of my colleague Congresswoman Edwards' question or point I guess. I am very interested and actively engaged in a number of STEM initiatives in Massachusetts and through the work of this Committee. One of the challenges I have seen in Massachusetts is a bit of the mismatch that Ms. Edwards pointed to, but a demand from the private sector to provide more talented engineers and scientists, computer scientists. But as we try to structure what that actually is and looks like, our reluctance of some in the private sector to recognize that this is—to look at STEM and STEM initiatives as a long-term investment in their own business and business model rather than a short-term corporate philanthropy initiative that, given a bunch of iPads or a school field trip or something and taking a photograph and sending that out in their newsletter, that is how it is approached more so than a strategic overall development of an overall strategic plan. And I was wondering if you could give any recommendations to me or to this Committee as to how to get the private sector more involved in some of these long-term efforts? Whoever wants to take it.

Mr. KAMEN. Well, for one thing, as you have heard a number of times, I think a lot of the problem is not to do anything; it is to stop doing things that are counterproductive and get rid of hurdles and barriers that might have made sense when we were an industrial society. You needed rows of student lined up and seeds here and then they take the summer off to, you know, bring in the crops, which I am sure a lot of them are doing today.

But the idea that, for instance, a scientist, a Ph.D. in mechanical engineering, can't go into a school because they are not qualified to teach, that is fine. We don't want to create an issue there, but, for instance, let the students get credits for being on FIRST programs. Let them get college credits. We know the colleges are desperate for our graduates and our alumni. Find ways to take down the barriers that we have historically had between industry and schools, make it easier for the teachers to get credits for being involved with industry and learning how to bring coding into the school.

I mean there is so much structure which, again, makes—you know, inertia is a difficult thing to overcome, but knocking down barriers and creating the right incentives and—I will keep saying it—just showing up and cheering for kids that are doing something, it—you can't underestimate—you said you weren't actively discouraged but you look at how many other things were stealing your attention, the co-mission as opposed to the omission. I think you were actively discouraged because of so much else in our culture that was sending you to different places for different reasons. You were lucky, but there are a lot of kids in this country that are going to get past an age where they can develop the skill sets for these great jobs because they were distracted by a whole lot of nonsense. And government can help get rid of some of that nonsense.

Dr. JONA. Yes. I would just add, you know, there is a broad range of incentives that the private sector has to invest in R&D and build plants and bring in jobs. It might be worth considering some incentives to foster that long-term thinking that you are talking about, whether it be tax credits or other kinds of incentives. It could be anything from as simple as providing summer teacher internships at businesses so that they can keep current with engineering and scientific practices or coding practices. You know, a lot of the small startup companies are way too small to afford to host these internships like larger companies do except that is where all the excitement and activity is these days.

So I think there are some creative opportunities to incentivize business participation, you know, over the long haul. As you said, it is a self—partially self-interested workforce development issue, but it could benefit our STEM education.

Mr. KENNEDY. Thank you.

Mr. PARTOVI. If I may answer, you know, I agree with you that many of the efforts you may see from large companies are either trying to just hire the next engineer or trying to, you know, hire high school immigrants or do a laptop giveaway to take a photo opportunity, but we have actually built a very strong coalition of some of the top tech companies thinking long-term, and they are investing in elementary school education, which isn't going to pay them back dividends. It is paying the country dividends.

And just to give you a sense, we may be one of the only non-profits that can claim Google, Apple, Microsoft, Amazon, Facebook, LinkedIn, SalesFirst, Juniper, all collectively participating not in small levels but Google put—changed their logo for the Hour of Code. Apple put it into every single store in the United States. Microsoft and Bill Gates and Mark Zuckerberg delivered video lectures for us. Amazon hosted our infrastructure. These are all very long-term investments in changing the system, and these companies actually want to form a public-private partnership to bring computer science to all of America's schools.

Mr. KENNEDY. Thank you and I yield back my negative time.

Chairman BUCSHON. You didn't have any time left.

Well, I would like to thank all the witnesses. And also we didn't talk about it much today but I do think the retention issue of students that do initially go into STEM is a big deal, and there is some—I am a big Gladwell fan and his most recent book "David and Goliath," he talks about the fact that the mismatch between

the student and the school, which school that they choose, is important in that area. If the student chooses a school that doesn't match them either challenge-wise or otherwise, they have a tendency to drop out and feel like they are not—they can't compete. And so school mismatch is a big problem.

But I would like to thank all the witnesses. The Members of the Committee will have—may have additional questions for you and we will ask you to respond to those in writing. The witnesses are excused from this part of our hearing. We are going to take a very short break. If everyone that can stay seated, please do, because we are going to try to transition as quickly as possible to the next hearing.

Thank you very much.

[Recess.]

Chairman BUCSHON. All right. We are glad to begin our second panel. If everyone could be seated, we will proceed.

This is going to be a fascinating part of the hearing because we are actually going to hear from those for whom STEM education is most important, and that is the actual students.

Thank you for being here. I know it may not have been easy to get permission from your parents and teachers to come, but I think when you told them you were going to testify in front of Congress, maybe they gave you a little latitude, and obviously you are here.

We know that not every program gets every student excited, but we are interested in learning from your experiences and perspectives whether it is through FIRST, Code.org, VEX Robotics, Project Lead the Way, the Science Bowl, or something else.

Our first witness for our second panel is Ms. Ellana Crew. Ms. Crew is in the 12th grade at South River High School in Edgewater, Maryland. Our second witness is Mr. Brian Morris. Mr. Morris is in 12th grade at Chantilly Academy in Chantilly, Virginia. Our third witness is Mr. Daniel Nette. Mr. Nette is in the 11th grade at George Mason High School in Falls Church, Virginia. And our final witness is Mr. Vishnu Rachakonda. Mr. Rachakonda is in the 12th grade at Eleanor Roosevelt High School in Greenbelt, Maryland.

Our witnesses should know that spoken testimony is limited to five minutes after which the Members of the Committee will have five minutes each to ask you questions. Your testimony will be included in the record of the hearing.

I now recognize our first witness, Ms. Crew, for her testimony. Welcome.

**TESTIMONY OF MS. ELLANA CREW,
12TH GRADE, SOUTH RIVER HIGH SCHOOL,
EDGEWATER, MARYLAND**

Ms. CREW. Thank you, Chairman Smith, Chairman Bucshon, Ranking Member Lipinski, and Members of the Committee. I am a little different than most of the other kids here for two reasons, one being I am legally blind, not fully blind but not fully sighted, caught in the middle, also because I am actually not going into a STEM career, but it still definitely has changed a lot and encouraged lots of things for me just being a part of FIRST. I have never been able to play sports. I couldn't see well enough to do it and I

was always, you know, your immediate target for dodgeball in all my classes. They went out of their way to try and I was always the first one out. So sports were never a thing, games were hard. Lots of other activities were always difficult.

And I first heard about FIRST through a friend of mine who was on the team and her sister was as well. They had been doing it for a while. And the way she talked about it, it seemed like such a great atmosphere and it seemed like a really good opportunity, so I applied for the next year and got into it on the business side.

And once I was in, after a while, I just got adjusted and you meet all kinds of people. You see all kinds of things and progress. It is very interesting to see. And, I mean, robots are cool. But there is a place for everybody really. I didn't have to worry about being judged for anything. I didn't have to worry about whether or not I could do it. I could not work on the robot directly or anything, so I couldn't be on build because I couldn't quite see well enough to do that, but there is—you can certainly be involved. And when you watch it happen, it is really, really very cool.

That is all I have to say.

[The prepared statement of Ms. Crew follows:]

Ellana Crew – Testimony

My experience with FIRST has been very interesting. I first heard about the team from a friend of mine who was on the team, and the way she talked about it, it just seemed like a lot of fun and a good opportunity. So, the next year, (last year) I tried out for the FRC team, and got in on the business side. Unfortunately, since I can't see the robot, I couldn't be on build or programming, but business was just as important. It turned out to be every bit as fun and interesting as that friend said it would be. My favorite part about being on the team so far has been the competitions. I love the atmosphere of a robotics competition, and getting to somewhat see the robot in action. I am actually not planning to go into a STEM-related education or career, possibly teaching other blind children, but nonetheless, it's still extremely interesting to see the robot go from a doodle on a white board to a working machine right in front of you, and the amount of collaboration that goes into it is amazing. I had originally joined in hopes of finding something to keep me busy that I could actually do, and it turned out to be so much more than that.

Ellana Crew – Biography

The FIRST organization has made a world of difference in my life. Since I joined the team in 2012, I've been able to do so much and have an incredible amount of fun. It's a wonderful new atmosphere that I've grown rather attached to. The experience as a whole is great. It's a perfect combination of fun and work, and I really think I've grown from it. When I first came to the team, I was quiet and afraid to talk and give my input. Now I'm friends with a good bit of the FRC team, as well as the mentors. I feel very at home at the meetings and competitions, and I feel that I've been exposed to a whole new world.

I'm legally blind, so I could never play sports, and I never seemed to fit in with any other groups, clubs, or teams. Here, however, I feel like I belong, and nobody judges, and I've made some wonderful friends over the past year and a half. Also, before robotics I didn't want to go to college at all, and just wanted to work somewhere where I wouldn't see people. Because of the confidence that robotics gave me though, I'm now looking to go to college to become a teacher at a school for blind students. It's the best thing I've ever done for myself, and it's a decision I will never regret.

Chairman BUCSHON. Thank you very much. It is a fascinating perspective that you don't have to be interested in a STEM field to benefit from a STEM education and what it can offer students in all areas of whatever their interests are.

I now recognize our next witness, Mr. Morris.

**TESTIMONY OF MR. BRIAN MORRIS,
12TH GRADE, CHANTILLY ACADEMY,
CHANTILLY, VIRGINIA**

Mr. MORRIS. Good morning, Mr. Chairman, and Ranking Members of the Committee.

I am a veteran FIRST member with my involvement spanning seven years and several programs offered by FIRST such as FLL and FRC. FIRST has been an integral part of my development as a person, as a student, and as an aspiring engineer, and it has challenged and trained me in ways normal classroom schooling never has. And because of FIRST, I feel more prepared to face the challenges and obstacles of the real world than I ever imagined I would.

My involvement with FIRST dates back to the 7th grade when five of my friends and I decided to give robotics a try through FIRST Lego League. While I originally thought of FIRST programs only as games to play for entertainment, I soon realized they were so much more. FIRST isn't just about the competition. It is also about the life and learning experiences of being on a team, working with technology, solving problems, and inspiring others to do the same. This is really what got me hooked on FIRST: competing, learning, and having fun all at the same time.

I couldn't say what my favorite part of FIRST is. There is really so much I have enjoyed. I have had the chance to work on long-term projects, seeing them go from the drawing board to physical, finished products, which is my favorite part of engineering. I have learned invaluable technical skills, as well as how to manage and lead large groups. The FIRST community puts the program above any individual goal or interest, and it is overwhelmingly helpful and supportive thanks to the principle of gracious professionalism. The outpouring of passion and enthusiasm at FIRST events is truly refreshing, and watching the enthusiasm of so many young people for science and technology gives me hope for the future.

FIRST has helped me discover my passion for engineering, and because of FIRST, I can definitively say that I want to pursue electrical engineering and computer science as a career. I have applied to several top engineering schools in Virginia and the Nation, and I hope my experience with FIRST will give me an edge up in admissions. But no matter what university I end up at, I am sure the skills I learned with FIRST will serve me well in my studies and beyond.

[The prepared statement of Mr. Morris follows:]

Brian Morris – Testimony

I've been a veteran *FIRST*[®] member, with my involvement spanning seven years and several programs offered by the organization. *FIRST* has been an integral part of my development as a person, as a student, and as an aspiring engineer. It has challenged and trained me in ways normal classroom schooling never has, and because of *FIRST*, I feel more prepared to face the challenges and obstacles of the "real world" than I ever imagined I would.

My involvement with *FIRST* dates back to the seventh grade, when five of my friends and I decided to give robotics a try through *FIRST*® LEGO® League. While I originally thought of *FIRST* programs only as games to play for entertainment, I soon realized it was so much more. *FIRST* isn't just about the competition, it's also about the learning and life experiences of being on a team, working with technology, solving problems, and inspiring others to do the same. This is what really got me hooked on *FIRST*: competing, learning, and having fun all at the same time.

I couldn't say what my favorite part of *FIRST* is; there's really just too much I've enjoyed. I've had the chance to work on long-term projects, seeing them go from the drawing board to physical finished products, my favorite aspect of engineering. I've learned invaluable technical skills, as well as how to manage and lead large groups. The *FIRST* community puts the program first, above any individual goals or interests, and it is overwhelmingly helpful and supportive thanks to the *FIRST* principles of Gracious Professionalism. The outpouring of passion and energy at *FIRST* events is truly refreshing, and watching the enthusiasm of so many young people for science and engineering gives me hope for the future.

FIRST has helped me discover my passion for engineering, and because of *FIRST*, I can definitively say that I want to pursue Electrical Engineering and Computer Science as a career. I've applied to several top engineering schools in Virginia and the nation, and I hope my experience with *FIRST* will give me an edge in admissions. And no matter what university I end up at, I'm sure the skills I learned with *FIRST* will serve me in my studies and beyond.

Brian Morris – Biography

Hello, I am Brian Morris. I'm a senior at Chantilly High School in Chantilly, VA. I'm a 7 year FIRST veteran, and am currently the Chief Executive Officer of FIRST Robotics Competition Team 612, Chantilly Robotics. In the past, I've worked extensively on the robot's electrical systems, and I intend to pursue electrical engineering and computer science as a career. In addition to robotics, I enjoy technical theater, where I can apply my engineering knowledge and skills to an artistic project. In the future, I hope to work developing advanced robots, or leading and managing a team doing this.

Chairman BUCSHON. Thank you very much. And I am sure they will.

I now recognize Mr. Nette for his testimony.

**TESTIMONY OF MR. DANIEL NETTE,
11TH GRADE, GEORGE MASON HIGH SCHOOL,
FALLS CHURCH, VIRGINIA**

Mr. NETTE. Thank you, Members of the Committee.

I first learned about FIRST from my older brother, who was a founding member of Team 1418 at my school in 2004, making this our 10th year. He—I—he currently serves as the tournament director for a FIRST Lego League tournament held at our local middle school.

Unlike many of my science and mathematics classes, FIRST provides the opportunity to apply hands-on solutions to real challenges. As we compete—complete the challenge, we also learn valuable skills like team building, communication, leadership, and especially the four elements of STEM. Through the program, I have refined my ability to seek my own solutions to problems and develop my own desire to learn. Working with robots has helped me learn about idea development, material properties, pneumatics, metal-working, and motors by applying concepts that I learned in the classroom to a real life problem. FIRST gives us a challenge each year and then we go through the process of brainstorming, designing, prototyping, building, and of course rebuilding multiple times until a working solution is achieved. In addition to the processes, the pressure of a six week time constraint to complete the task at hand, I know I will encounter these deadlines and utilize these problem-solving skills in my future career.

Many students involved in the program experience for the first time the importance of interaction and communication with adults such as mentors and judges. While that was not a problem as so much for me because of my experiences in becoming an Eagle Scout, I discovered the power to spread the ideas of FIRST at a dinner conversation last year with a family friend who became very interested in the program. She invested in a Lego robotics kit and took it on a mission trip to a school in Rwanda so that the students there could begin to learn about robotics. She then went on to serve as a judge at a recent FLL tournament and hopes to become a mentor in the near future.

As a student, I have always had an interest in mathematics and science but it wasn't until the last few years, through my experience with FIRST, I realized that I would like to pursue a career in STEM. I plan to apply to Virginia Tech and hope if accepted to be able to work with robots to solve real-life challenges.

[The prepared statement of Mr. Nette follows:]

5 January 2014

Daniel Nette
FRC robotics Team 1418
George Mason High School
Falls Church, Virginia

My name is Daniel Nette, and I'm a junior at George Mason High School in Falls Church Virginia and am currently serving as the robo-coach, chassis/drive train subsystem leader, and coordinator of the physical components and robot building. I learned about FIRST from my older brother who was a founding member of team 1418 at my school in 2004, and currently serves as Tournament Director for a FIRST Lego League tournament held at our local middle school.

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Working with robots has helped me learn about idea development, material properties, pneumatics, metalworking, and motors by applying concepts that I learned in the classroom to a real life problem. FIRST gives us a challenge each year, and then we go through the process of brainstorming, designing, prototyping, building, and rebuilding until a working solution is achieved. In addition to the process is the pressure of a six week time constraint to achieve the task at hand. I know I will encounter these deadlines and utilize these problem solving skills in my future career.

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As a student, I've always had an interest in mathematics and science, but it wasn't until the last few years, through my experience with FIRST, I realized that I would like to pursue a career in STEM. I plan to apply to Virginia Tech and hope, if accepted, to be able to work with robots to solve real-life challenges.

Daniel Nette Bio

My name is Daniel Nette, and I'm a junior at George Mason High School in Falls Church Virginia. I was awarded my Eagle Scout award last year. I participate on the George Mason H.S. Swim Team. I am currently serving as the robo-coach, chassis/drive train subsystem leader, and coordinator of the physical components and robot building. I learned about FIRST from my older brother who was a founding member of team 1418 at my school in 2004. I realized through my experience with FIRST that I would like to pursue a career in STEM. I plan to apply to Virginia Tech and hope, if accepted, to be able to work with robots to solve real-life challenges.

I have provided outreach for FIRST at both the local and international levels. I have marched with our robot in the annual Falls Church City Memorial Day Parade which attracts people from all over the DC metro area. I volunteered for set-up and field support at the FLL Tournaments hosted the last 2 years at Mary Ellen Henderson Middle School in Falls Church. I discovered the power to spread the ideas of FIRST last year with a family friend. She invested in a Lego robotics kit and took it on a mission trip to a school in Rwanda so that the students could begin to learn about robotics.

Chairman BUCSHON. Excellent. Thank you very much. I now recognize our final witness, Mr. Rachakonda.

**TESTIMONY OF MR. VISHNU RACHAKONDA,
12TH GRADE, ELEANOR ROOSEVELT HIGH SCHOOL,
GREENBELT, MARYLAND**

Mr. RACHAKONDA. Thank you, Chairman Bucshon, Ranking Member Lipinski, and other Members for being here and listening to my testimony.

My name is Vishnu Rachakonda. I attend Eleanor Roosevelt High School. I am in the 12th grade. Actually, we have a significant number of students from Ms. Edwards' district herself. My experience with FIRST is that I started with FLL in the 7th grade just like Brian, and I spent four years in FRC now. And I just have to say my fellow students touched a lot—very well on the educational aspects and values of FIRST, and I would just like to talk a little bit about my personal story.

I think with FRC, especially FIRST in general, I described it in three ways: spirited, challenging, and fun. I am a basketball fan, I am a football fan, I am a tennis fan, so I love, you know, hearing everyone talk about basketball here and seeing Chris Bosh on the screen. But for me FRC has been so spirited, so different from every other educational activity I have been to. There is a subculture behind it. There is, Dean Kamen—Mr. Kamen, he is my James Naismith. Woodie Flowers, the guy who comes up with the challenges behind it, all the mentors who do it, they are my Lebron, they are my Kobe. They are the people who are my role models with respect to engineering, and I think that is very unique to FIRST and in general to these kind of STEM activities.

I think that FIRST—the challenges that are before me have pushed me to engage these fields—these STEM fields differently and more thoroughly than anything I have ever done in class. I took AP Physics B, I took AP Physics C, I have done all these AP classes, and I have gotten the grades, but being in FIRST, I can't say I am the best engineer in my club because I am not. I have gotten higher grades than the best engineer but Kyle beats me at being an engineer. So I think that in challenging me, it has been very unique and more different, and I think that is very valuable.

And finally, it has been fun. I think we have all alluded to how being fun, I think, is critical in engaging students in STEM and whatever—in STEM and these fields. And FRC has certainly done that and FIRST programs have certainly done that. I think importantly the fact that we get to interact with these professional mentors has made a huge difference in my own life. You know, I work with Mr. Healy, who is here, you know, with me today, and I think that these people have become role models, you know, in pursuing an engineering career and then also giving back to the community. I think that FRC has made a personal change in me on that level.

I would just like to tell a short story about how I have come to appreciate FIRST more. Recently, I went to Japan on a trip to present some original research, which I hope to come back to, but original research. And at that conference for high school students it was—you know, there is something called World Premier Research Institutes in Japan. They are modeled off American univer-

sities and how we have phenomenal research institutions. They are doing the same thing in Japan to try and replicate what we do. And when I was there, they were asking me what do you guys do in school? What do you guys—you know, what is it that you do that allows you to do such good research? Because we are presenting unique research that Japanese high school students there were not capable of doing, not for lack of intelligence but for lack of facilities, for lack of support. And when I told them about FIRST, about what we did, about how we manage a \$25,000 budget, how students build these 120-pound robots, they were absolutely flabbergasted. I mean these were top scientists but they were saying kids can do that? Are kids smart enough to do that? What? But the point was that it allowed me to appreciate FIRST and the programs that these—you know, these unique private sector STEM programs are engaging in. You know, Code.org, all of our students on our FRC team, they learn coding through Code Academy, through Code.org, all these websites, and it is really opening up new avenues for us.

So, you know, I guess hopefully three things that I guess maybe this discussion would include would be teacher support, which I think Mr. Kamen was talking about extensively. I think it is very difficult at my school to get people—to get teachers to support programs. I had to—Science Bowl, you mentioned that. I need to find a new sponsor for my Science Bowl team this year because my old teacher said she couldn't do it this year, and it was hard I mean because teachers just said I have so much work. I have so much work in terms of testing or whatever it is that they weren't able to be, you know, sponsors or whatever. So hopefully, you know, some way teachers can be, you know, more focused on—or allowed to sponsor these kind of private sector STEM programs like FIRST because it all starts with the school, and if you don't have that school support, no team can survive.

You know, internships and stuff like that, I think real world experience, practical STEM experience like FRC, like internships are critical, and I think that, you know, up here, Dr. Jona was talking about GPA and stuff like that. I think it comes back to college admissions. I think that is an important aspect to this STEM engagement for students. And, yeah, I just—on a personal note, I plan to, because of FIRST, major in biomedical or electrical engineering when I get to college. I don't know where yet but hopefully I will learn by the end of March. Thank you.

[The prepared statement of Mr. Rachakonda follows:]

Vishnutheja Rachakonda– Testimony

My name is Vishnu Rachakonda and I am a 12th grade student at Eleanor Roosevelt High School in Greenbelt, MD. I am the president of the school's robotics club and *FIRST* Robotics Competition (FRC) Team 53 "Area 53." I became involved in *FIRST* activities in 7th grade, when I tinkered with LEGO MINDSTORMS robots and the competition field designed by *FIRST* as a member of a local STEM club. When I moved to high school, I continued my existing interest in the STEM fields by joining my school's FRC team. Since then, I have spent five more years involved in *FIRST* programs such as *FIRST* LEGO League (FLL) and *FIRST* Robotics Competition.

I have found my *FIRST* involvement to be among the most unique experiences of my education and lifetime. FRC, the competition I have spent the most time in, has challenged me to engage the STEM fields more thoroughly than other academic or extracurricular activity I have done. Due in large part to FRC, I plan to major in biomedical engineering in college. In addition, it has been thoroughly enjoyable. The spirited nature of the teams reminds me, as an extremely avid sports fan, of the atmosphere of a college football game, only with a much more friendly spin. Building within teams themselves, as well, has been very fun.

Perhaps the most enjoyable and useful aspect of being a member in *FIRST* programs has been the sense of appreciation I feel as a student for having been given this wonderful opportunity. Mentors and adults regularly tell me how they were not able to access such inspirational, competitive, and educational activities. Furthermore, *FIRST* has allowed me to appreciate being an American. Recently, I went to Japan to present original research at a conference for other high school students. There, I described my experience in *FIRST* programs to students, world-renowned researchers, and Education Ministry officials. Their amazement with the *FIRST* programs allowed me to appreciate them even more.

Vishnuthēja RachakondaBiography

My name is Vishnuthēja Rachakonda. I am a 12th grader at Eleanor Roosevelt HS¹ in Greenbelt, Maryland and the student president for the Eleanor Roosevelt High School Robotics Club and FRC Team 53, "Area 53". I have been involved with FIRST programs since the 7th grade. I participated in FLL programs in my middle school and in local STEM clubs. I have been a member of FRC Team 53 from the 9th grade onwards. I held the positions of team treasurer (10th grade) and club president (11th and 12th grade). I have assisted in the development of the Prince George's Area Robotics Alliance and the Western Alliance of Maryland, regional organizations created to support FIRST programs, and presented at an event in support of FRC with UMD Engineering Dean Darryll Pines.

Additionally, in the 11th grade, I personally mentored a local FLL team, the C.T. Reed ES Roadrunners (Team 15893).

FIRST programs have made a major impact on me and have driven me to engage the STEM fields more thoroughly than any other activity, in-school or extracurricular. My performance in the classroom and in research positions at NIH and UMD has been impacted tremendously from the personal and professional skills I have gained. Recently, I went to Japan to present original research at a conference for other high school students. There, I described my experience in FIRST programs to students, world-renowned researchers, and Education Ministry officials. Their amazement with the FIRST programs allowed me to appreciate them far more.

¹ Eleanor Roosevelt High School and FRC Team 53 have a significant number of students from the 4th Congressional District of Maryland represented by Rep. Donna Edwards.

Chairman BUCSHON. Thank you for—all of you for your testimony. I am not sure at your age that I could have testified that well in front of Congress. Truly—and I still can't. Thank you, Mr. Massie, for pointing that out.

Fascinating to hear from the students, and I want to remind the Committee Members the rules limit questioning to five minutes.

And at this point I will recognize myself for five minutes to ask some questions.

Ms. Crew, in your testimony you noted that your—the focus on the business side of FIRST. Can you tell me about what the business side entails as part of an FRC team?

Ms. CREW. The business side kind of—they do a lot of work. There is all kinds of sub teams. We do—we manage all of the—like the awards that we enter, Chairman and—everything. The graphics especially is a huge part of the business side. I am on community service personally, which we—you know, we reach out. We donate; we do whatever we can to help. But there are multiple sub teams and they all have a really big part in it. I don't know where we would be without graphics. I don't know. We probably wouldn't have won anything without the awards team. It is a very large, intricate, complicated thing. I don't know if all teams are run like that, but at least mine is. It is a very good system.

Chairman BUCSHON. And, Mr. Morris, do you want to have a comment about that?

Mr. MORRIS. Yes. I would just like to elaborate on the less technical aspect of the team. A lot of these teams, mine in particular, are run like a corporation. There is a leadership structure and there is a product that the team produces that is a robot, but there is also all the support that goes into running an organization. So you have funding people. All of these teams are self-funded. They don't get funding through the school, so we have people who have to go out. They have to seek corporate sponsorship. They have to find mentors if there is no infrastructure in place to help get the mentors. And all of this is done by students. So even non-STEM people—I—as the executive of my team, I have not just engineers, I have marketers, I have business people, I have graphics design and website people. And these are all people that you need to run a FIRST team, so it is not just about the engineers even though that is obviously the focus, but we say this to people when we are recruiting for the team. There is a place for anyone no matter what your skill set. If it is public speaking or writing or anything, there is a place for you. And that is kind of the—what the business side is about.

Chairman BUCSHON. That is fascinating.

And I will start with Mr. Rachakonda on this next one. Have the activities you participated in during the robotics club, the FIRST competitions, changed your approach to your other schoolwork? And as a follow-up, have the activities changed how you think about problems or challenges outside of school?

Mr. RACHAKONDA. Yes. I definitely think that, you know, that these challenges have really—Mr. Kamen talked about how synthesis—analysis and synthesis. I think that I have taken stuff from FRC where I have learned about certain robot parts or have learned about certain technologies and—or, you know, coding or

whatever it is and I am able to understand that and cross-apply it to whatever I am doing in school. So, you know, we have technology classes in school. I am cross-applying what I learned in FIRST, what I learned in FRC to what I am learning in technology.

And, you know, the—being in FIRST has allowed me to be in multiple internships, research-focused internships. From those research-focused internships I am now cross-applying that to in class, you know, we have to produce a research paper by the end of the year as part of the program that I am in. You know, you are in an internship and then from there you produce a scientific paper. And so some of the skills that I have learned from FRC in terms of time management, whatever it is, technical skills, I am able to apply that in that respect. So, yes, there definitely is a mixing between those two.

Chairman BUCSHON. Mr. Nette?

Mr. NETTE. From what I have experienced with FIRST, I have been mostly kind of a nuts-and-bolts guy if you will doing most of the physical work on the robot, and that was what inspired me to get into the computer science classes that we have at our school was because I wanted to learn more about how you make those things do what they are designed to do. And so definitely what FIRST has planted the seed for me to learn more about what it is all about, how you make things work. So it got me started and now I am seeking my own route outside of FIRST through my classes to learn more about the rest of things, and hopefully, I can come back to FIRST with my new knowledge and help possibly with the programming. Thank you.

Chairman BUCSHON. Excellent.

Mr. MORRIS, how has—the things that you were learning in FIRST, has that changed your perspective on your other schoolwork or your activities outside of school?

Mr. MORRIS. It hasn't so much changed the perspective I would say but it did—what I have learned in FIRST I have definitely been able to apply outside of school as with what my fellow witnesses were saying. FIRST takes up a lot of your time and you have to learn how to manage that time. You have to learn how to prioritize, and as well from being the leader of the team, I have learned how to lead people. These FIRST teams, they are volunteers. You can't fire them if they are not doing their job. So how do you motivate these people and engage them? And that is something that is not just—I can't just apply to FIRST but I can apply to science fair or any other group project where students—how do I get these people motivated? That is a big part of it.

Chairman BUCSHON. Ms. Crew, do you have comments on that subject?

Ms. CREW. It definitely does affect your time management I think most of all since you are there—once the season starts, you are usually there pretty much almost every day of the week. So you have to figure out when you do your homework and all the other things. That is about all I have to take from it though since I am not quite involved with the computer science aspect of it so—

Chairman BUCSHON. Okay. Thank you, everyone.

I now recognize the Ranking Member, Mr. Lipinski, for his questions.

Mr. LIPINSKI. Thank you, Mr. Chairman. I just want to say that all of you, your testimony has been extremely impressive. I sit here and I think that when—well, now that Mr. Massie is gone, I can say this. You have probably put all of us—we all sitting up here probably look and say if only I were that good when I was that age. I can certainly say that for myself. But obviously, you all have great opportunities ahead of you for whatever you want to do. And I am sure if there are any parents out there, teachers out there, you have to be extremely proud of your child here. And I am sure Mr. Kamen sitting there is—has to be extremely proud.

I taught college before I was elected to Congress, but it is just very impressive what you have been able to do, and I just encourage you to keep it up. Obviously, you have put in a lot of hard work.

Mr. Morris, you talked about the hours. How many hours do you spend—did you spend on FIRST?

Mr. MORRIS. FIRST—the FIRST season is structured a lot like a sports season, so, first of all, we have our off-season and so that is we are preparing for our season. It is—that is—it is hard to kind of estimate how much but I would say at least three hours a week at least, and sometimes there will be big spates of work where we would be off at an outreach event, we will be volunteering for, you know, eight to ten hours a day.

And then we get to the build season, which is when we construct our bot, and that is—at least on my team that is four to six hours every day after school as well as eight hours on Saturday, and that increases over the duration of the build, over the duration of the six weeks. And after the build, a few months later we go kind of back into preparation mode, and then we have got our competition and competitions are three days of very intense 24/7 work basically but also they are a lot of fun. So that is just kind of the summary of the hours. I don't know if some of these other teams work differently, but that is how my team works.

Mr. LIPINSKI. Anyone else want to comment on—Mr. Rachakonda?

Mr. RACHAKONDA. Yes. On average I would say I probably spend 10 hours a week on FIRST-related activities, on robotics club-related activities. And the work never stops. You know, they say, you know, like football never stops or whatever. You are still working on an off-season. You are still working on an off-season for FIRST. We have a team calendar the entire year. Every month we have to have something done. You know, June through August we have to manage—that is when we really try and set up our plan for the next year. That is when we want to get our corporate sponsorships, and that is ideally when we want to get everything rolling in because January through March we have to build our robot. And, trust me, nothing else is happening until the robot is done. So, you know, November through December we have to train our new members, we have to teach them programming, teach them how to use the skills. Safety training has to be done because we are working with power tools.

So, yes, there are a lot of different aspects to it which I think is one of the most unique things about FRC. It is not just about the robot but you really are running—you know, I like to call it the

world's toughest corporation because all your talent is gone in four years, everyone is volunteer, and the people who are leading it are all volunteer. And so it is very unique and that is what I think is very important about it. I guess my other students can also talk about that.

Mr. LIPINSKI. Anyone else want to—Mr. Nette?

Mr. NETTE. I would violently agree with everything that has been said here. It certainly takes—

Mr. LIPINSKI. Didn't you learn not to use that word here?

Mr. NETTE. It certainly takes a substantial amount of time, but yes, in the off-season you definitely have lots more time to go into the outreach aspect of FIRST, which is just as much a part of it as the build season is. It is about helping other people, gracious professionalism. Even during the build season we will help with other teams. We take a few under our wing and sometimes help them get started. So, yes, it is definitely a great experience and it doesn't end at the end of build season, but it definitely picks back up.

Mr. LIPINSKI. Is there anything that—what can be done? Is there anything we could do, anything you could do what—in terms of encouraging more students to get involved? And I want to start with Ms. Crew because you obviously—you are coming at this—we are talking about all this technical, you know, stuff about the robotics and you are involved in a different part of FIRST. So is there anything that can be done to encourage more people—more kids to get involved?

Ms. CREW. I think it definitely needs to be in more schools and it needs to be more—there needs to be more awareness about it. There is not nearly enough, you know, information on it. You know, at school they will always do announcements about what your sports teams did and reminding you to come out to the game and all that, and robotics is kind of—it is like an accidental secret. Nobody really has heard of it unless you have—you know somebody in it most of the time or we do something really incredible and it is on the announcements. So I think it definitely needs to be more—the word needs to be spread.

Mr. MORRIS. Yes, I don't think that is really the fault of the teams. I think you have heard people mention outreach a lot. Spreading the message of FIRST is something that Dean is big on and the entire organization is big on, but like just trying to get access to the gym to use our robot to get like—not to demean the sports teams at all, but to have the same kind of formality with the school is certainly something that would help you because we certainly think that this is just as important.

Mr. LIPINSKI. Mr. Rachakonda?

Mr. RACHAKONDA. I am sorry, just briefly. I think unknowingly or like whatever, it used to be that STEM and these kind of things were niche activities. They were just something that, you know, maybe in the '70s people would build train tracks, but that is not what it is anymore, you know, sample, model train tracks. But now it has become an athletic activity at least in the model of FRC. We have 50 students on our team. That is not your usual club. We run a budget of \$25,000. That is not your usual club.

And so that is where I think that if there was more awareness in terms of how to deal with these kind of STEM activities and recognizing this is not just another academic activity, this is not just Quiz Bowl, which I am also a participant in and it is great, but it is not just Quiz Bowl. It is something different and we need to recognize that and how we treat it. And, you know, Mr. Partovi was talking about how we treat computer science and everything, but in terms of activities, too, when you do realize that, that it is quite different.

Mr. LIPINSKI. All right. Thank you very much.

Chairman BUCSHON. I now recognize Mr. Hultgren for five minutes.

Mr. HULTGREN. Thank you, Mr. Chairman.

Thank you all for being here. And I just want to commend you for really going above and beyond. That—to me, that is really kind of the story of your work is this is above and beyond, an incredible commitment but also an incredible opportunity. And I really sense that, that you recognize what a great opportunity you have been given.

A couple questions I have, one is I wonder if you could just talk briefly about how your parents first responded when you mentioned that you were interested in doing this and when you started talking about I guess some of the responsibilities, maybe driving or whatever that would be involved for them. How did they respond? We can just kind of go down the line or whoever wants to speak up.

Mr. RACHAKONDA. Well, my mike is already on, but, yes, I think—well, for me at least, even from getting started in engineering and getting started in STEM, my entire family is, you know, in a STEM field. My dad is an engineer, my grandfather was an engineer. All of them went to West Virginia University actually, interesting, but I think that my parents were definitely very supportive of how I have approached this. And my dad, you know, he also—he is involved in a tech company or whatever and he has given me advice on how to approach running—because I am the president of my club, how to approach running, you know, whatever I do in FRC, whatever I do in FIRST. And so my parents have definitely been very supportive of it and I think that is what makes the difference for successful FIRST teams, successful FRC teams. You always see parent engagement, and I think that is something that is very important for, you know, the success of STEM programs especially because they can be very expensive and they can be very time-consuming.

Mr. NETTE. Of course my parents were very excited that I was ready to join the robotics team. At the time, our high school started in the eighth grade, which it does no longer. But—so I started on our FRC team in the eighth grade. That was the year where the game was Logo Motion, and at the end of the game there was a challenge to have a mini robot that would climb a pole at the end of the match as fast as it could, and so we kind of—the rest of the team graciously let us—let the eighth and ninth graders, who were trying to get into the swing of things, handle the mini bot challenge, and so that was kind of our own undertaking and we worked through that problem on our own.

So, yes, I just kind of jumped right into it and hopefully in the near future we are trying to start a FTC team in our school district so that the student at the middle school don't necessarily have to wait until high school because there is that gap between FLL and FRC.

Mr. MORRIS. All right. There is a philosophy among FIRST—some FIRST teams that adults are only there to sign the checks, but in my experience you can't run an organization like this without parents. They not only have to be supportive—my parents are very supportive—but they also have to be involved and they have to—I think the biggest part of that is having them understand the advantages FIRST has for these kids because when these kids are spending four hours a day, six hours a day, eight hours on weekends working at the school and their parents are just like, what? What are you guys doing? What are you getting out of this? So the teams can—we can talk at the parents about, you know, what are the advantages of this? Why do you want your kids doing this? But I think it gives more credence to the—it gives more kind of weight to the argument when other adults are telling the other adults this is why this is important, this is why you should be not only happy but supportive of your kid for doing this because there are people on the team whose parents don't want them to be in FIRST, and I think that is really quite sad.

Ms. CREW. My family had some kind of mixed emotions for a while. My mom was not happy about it taking up so much time during the build season because you are there basically every single day. We have Wednesdays off at my team but every other day you are there and longer on weekends than the other days. So she wasn't exactly happy about that and it is very time-consuming and she didn't know how I was going to get there. My dad, though, he was pretty interested in it. He thought it was really cool so he kind of helped convince her of it. And he actually got involved in it, too, as a mentor. He is now the documentation mentor at our team, so he just drives my sister and I—my sister is now on the team, too—to it every day and it generally kind of works.

Mr. HULTGREN. That is great. If I could, any parents who are here, if you don't mind just raising your hand, any parents?

Thank you. I know it is a huge commitment and I just want to commend you for your involvement and engagement.

I would love to get into more talking about mentors as well. Certainly, parents are part of that but also some of the other mentors that you have mentioned, certainly some who are in the room, some who have joined with you today. But I saw that so clearly with my team Got Robot? back in my area that relationships and the commitment of mentors, giving so much of their time and not getting paid, if they are paid, really not much at all, but seeing this vision of pouring into you the opportunity that they wish they would have had when they were your age, and that is really, really cool.

So I would ask are they any mentors in the room as well?

So thank you all so much for your commitment as well of being mentors. That is amazing.

One of my fears is that we see with challenges we are facing in Congress some of the cuts that are coming are to the Department

of Energy, to STEM education mentorship programs, and we have got to do everything we can to fight against that. That is exactly what we need more of is more mentorship. And when—especially when we see teachers being so stretched or maybe not even having the passion or the desire to put in this time commitment, yet a mentor is willing to do that, some teachers certainly willing to be mentors as well, but this is something I want to continue to focus on and make sure that the funding is there for that and we do everything we can to encourage this.

So thank you. I just am inspired by the work that you are doing. Thank you, parents. Thank you, mentors. And anything you all can be doing and that we can be doing as Members of Congress just to be spreading the word of how important this is and how much this makes sense.

I will wrap up if I can, Mr. Chairman, just by talking about Mr. Rachakonda—is that right—talked about going to Japan. It sounds like an incredible experience—but how they are modeling what we have done, my fear is that we are going to lose that cutting-edge that we are really the place that is—the rest of the world looks to as the innovative nation. And there are so many other nations that are ready to do that, and I think STEM education and programs like FIRST are absolutely key for us of what type of nation are we going to be in the next 5, 10, 20 years. I want to make sure that we are continuing on that forefront, that we are the nation that every other nation is looking to to see how does America do it and then let's follow what they are doing rather than falling behind, and that is my fear.

Thanks, Mr. Chairman, for your indulgence.

Chairman BUCSHON. Thank you. Without objection, the Chair now recognizes Ms. Edwards for five minutes.

Ms. EDWARDS. Thank you, Mr. Chairman, and to the Ranking Member. And again, I really do appreciate your enabling me to sit in today.

I am here today principally because two of the students are from the counties that I represent, and I feel very proud of the work that we are trying to do in our school systems to enable this kind of learning. But I am curious from each of you what aspects of your academic curricula during the school day contribute and how does it contribute to what you are doing in your club activities?

Mr. RACHAKONDA. Well, I think that definitely—that, you know—I mean it is a STEM activity at heart, right, and I think that definitely my physics curriculum, everything I do in chemistry, all these different things are definitely—have helped me in understanding what goes on. I think that, you know, some of the advanced classes that I have taken have helped me understand what goes on at the heart of these robotics very clearly, and I feel that, you know, they were talking about the curriculum earlier, and I am not well versed enough to say anything to pass judgment on those curriculum, but I feel that I have learned a lot in school that has been useful in FIRST, and I felt the same way vice versa. So, you know, the subject matter is the subject matter and maybe in different schools it is being taught differently, taught worse, taught better, whatever it is, but I think that at heart for me that the aca-

demographic subjects are very applicable in FIRST and all these STEM activities.

Ms. EDWARDS. Thank you.

Ellana, I wonder if you could share with us—because you are in a different part of the aspect of the program—the parts of your academic work that facilitates what you are doing with FIRST or not?

Ms. CREW. Mine doesn't actually have a whole lot of contribution. I am in just standard classes. I was never in STEM. I was hardly ever allowed to really be in honors because like the special ed department was worried that I wouldn't be able to handle the workload and before like tenth grade they were kind of right. I didn't have the greatest work ethic. But I do sometimes need a lot of people work, so I guess the way they have you work together does kind of help.

Ms. EDWARDS. Thank you. Either of you—of our other two panelists?

Mr. MORRIS. A lot—the—I will have to—actually have to say that a lot of like the physics and the calculus we learn in school, you don't get a chance to like—what you are doing in FIRST is—it is more hands-on, so sometimes you have trouble like kind of rectifying the—reconciling the—what you have learned in school, what you have learned in FIRST, but it is like—I don't see any—there is—I don't think there is like a better way of doing it than FIRST because FIRST—what you have in school is you have your curriculum. What you have in FIRST is you are hands-on, and those things aren't mutually exclusive but FIRST teaches the hands-on I think better than, you know, school ever possibly could.

Mr. NETTE. The math and science classes of course prepare us somewhat for what you are going to do on FIRST, but in math when you take a test or something, they tell you what equation you have to use to solve the problem, but when you are doing this in the real world, you have to figure that part out yourself also. You have to figure out what equation to use, then which numbers to put where and all that. Being a junior I haven't gone into some of the more advanced math and science classes yet, but on another note, one of the things that our team is trying to do this year is to engage some of the students from aspects outside of STEM like the English students and the history students, too, because there is of course functions that they can do on our team. There are awards that you have to write essays for and all accounting and all that, so economics classes and everything play into it. So we are trying to reach out beyond STEM and have some position for everyone in all the classes on our team.

Ms. EDWARDS. Thank you. I want to just get to one thing. Our earlier panel talked about this idea of failure, and it is a thing that I have been kind of wrapped up in since I have been in Congress because I think sometimes we don't put resources into things because something fails and then you experiment with it. Can you all share with us what you have done that failed that you learned from and the value of that?

Mr. MORRIS. I will actually—I will start on this. The first game—the competition—you are designed to fail. They give you way too many requirements with way too little time, and so you are going to mess up. I am sure every team here has had, you know, robots

that maybe didn't have—you know, didn't perform as awesomely as they had hoped because—but it is really—the core of the engineering challenge of FIRST is not just building the robot, it is prioritizing to say, all right, what aspects of this are we going to concentrate on and how are we going to concentrate on that? And if you fail, then—I mean you just—it is not like—this is FIRST. This isn't a—real life and so you—this is a place where you can fail and learn from your failures without the consequences being too heavy.

Chairman BUCSHON. Thank you very much.

Thank you for all of our witnesses. Again, as Mr. Massie pointed out, you have probably done a better job testifying in front of Congress than maybe I would. I have four kids and I have found this to be one of the most fascinating hearings I have ever attended. I mean that sincerely. So I would like to thank all the witnesses for your very valuable testimony.

And the Members of the Committee may have additional questions for you and we will ask you to respond to those in writing. The record will remain open for two weeks for additional comments and written questions from the Members.

At this point, the witnesses are excused and the hearing is adjourned.

[Whereupon, at 12:55 p.m., the Subcommittee was adjourned.]

Appendix I

ANSWERS TO POST-HEARING QUESTIONS

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Responses by Mr. Dean Kamen

Responses to the Questions from the House Committee on Science, Space, and Technology
Subcommittee on Research and Technology – “Private Sector Programs that Engage
Students in STEM”

Questions for the Record, Mr. Dean Kamen, Founder and President, DEKA Research &
Development Corporation, Founder, *FIRST*

Question submitted by Rep. Larry Bucshon, Chairman, Subcommittee on Research and
Technology

We work to effect STEM education to prepare a workforce that covers the breadth of STEM fields and jobs. What is your perspective on what “STEM education” is and should be and how it connects to preparing young people for success in these diverse professions?

“STEM education” is more than textbook or classroom teaching. It also includes providing opportunities for students to develop 21st century work and life skills such as team work, problem solving, conflict resolution, persistence, time management, presentation skills, leadership and self-confidence to prepare them to work in a STEM career. STEM education is also providing real-world hands-on experiences which put into practice what students learn in the classroom, engaging them and making learning relevant. It is inspiring youth to see themselves doing more than they thought they could – taking risks, participating in new experiences and developing skills that they cannot get from coursework or a traditional education system. *FIRST* complements the learning that occurs during the school day and fills in the gaps of “STEM” education.

In the real world, the answers to tough questions are not found in the back of a textbook. Students must be engaged by proposing complex tasks within an exciting, collaborative framework. Participating on a *FIRST* team provides the opportunity for youth to apply academic learning to real life situations, and develop new and important STEM and 21st century work skills that will have direct application in their future careers. The mission of *FIRST* is to inspire young people to become science and technology leaders – this cannot be accomplished by the traditional education system alone. Programs like *FIRST* are necessary to provide the inspiration and engagement that gets students excited and interested in STEM, preparing them to be successful in the STEM fields.

There is a growing resurgence of manufacturing in this country. But it is not your grandfather’s manufacturing returning to America. It requires a vastly different skill set. Unfortunately, classroom work alone cannot prepare our students for this resurgence. Indeed, the US is importing some 130,000 foreign STEM workers each year, because we cannot find enough STEM-skilled workers in this country. As noted above, *FIRST* is inspiring our students to pursue STEM careers and providing them needed skills that cannot be taught in a classroom. Our survey shows that almost 90 percent of our *FIRST* alumni are either pursuing a STEM degree or are already employed in a *STEM* profession (see below regarding studies).

Questions submitted by Rep. Dan Lipinski, Ranking Member, Subcommittee on Research and Technology

You testified about student engagement and the development of important life skills (teamwork, learning from failure, etc). Do you believe that engagement programs such as FIRST should have explicit STEM learning outcome goals? Why/why not? If yes, what have you learned about how to go about measuring those outcomes in formal settings? What ideally would you like to be able to measure?

It is important to measure STEM learning outcomes. But those measurements need to encompass a wider range of outcomes and goals. Outcomes need to measure more than how well students do on tests or their grades in a math or science class. They should also include measuring students' ability to apply knowledge in the real world as well as skills, such as teamwork, communication and problem solving, which are critical to future career success. The recent Programme for International Student Assessment (PISA) test (which assesses the application of knowledge in math, science and reading to real life contexts of 15 year olds in 65 education systems world-wide, indicated that among the 34 OECD countries) the United States performed below average in mathematics in 2012 and ranked 26th. PISA identified areas of weakness for US students including: formulating a real-world problem into mathematics, interpretation of real world aspects, and the application of mathematical literacy. For the US to do better, we need more programs like *FIRST*. *FIRST* programs are designed to actively engage students in hands on activities that apply math and science concepts in real-world challenges.

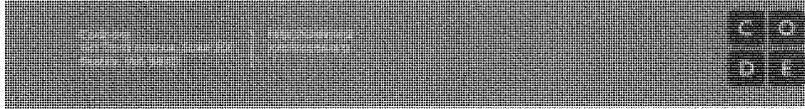
In real-world STEM failure is an inevitable hurdle along the path to innovation. Learning how to overcome challenges and find solutions to complicated problems are valuable life lessons that go beyond the confines of the classroom. These should be considered outcomes by which successful engagement programs are measured.

Programs like *FIRST* are complementary to in-classroom learning. They require students to take the content they have learned in their math and science classes and apply those principles to real life situations. Learning outcomes for students who participate in *FIRST* include a greater awareness of STEM activities in the world, the ability to apply principles from the classroom to real life and the development of 21st century work-life skills. Students also engage in enriching STEM experiences such as designing, building and programming robots, conducting research, developing strategy and applying engineering principles. Outcomes also include the change in students' educational and career outlook, evident in an increased motivation and intent to pursue STEM focused post-secondary training, education and professions.

FIRST has measured STEM learning outcomes through quantitative and qualitative data collection from mentors, students and parents. Using mixed methods and data collection from multiple sources has provided *FIRST* with a more complete understanding of how our programs are working and the impact on student participants. Finally, as noted above, our survey shows that near 90 percent of our alumni are pursuing a STEM degree or are working in a STEM profession.

How do you differentiate correlation from causation in measuring the impact of your programs? For example, when looking at graduation rates of students who participated in FIRST, how do you control for other factors, such as education level of the parents and other self-selection indicators?

FIRST cannot claim causation, only correlation, from any of its evaluation data. Our data comes from surveys, interviews and observations conducted externally through formal evaluation studies as well as ongoing program evaluation efforts conducted internally. Consistently our data shows that students who participate in our programs experience an increase in STEM awareness, skills and knowledge. Evidence also indicates that students are increasingly likely to enroll in challenging math and science electives, attend college and major in a STEM field. We have found positive STEM outcomes across various groups who participate in *FIRST* – girls, under-represented racial minorities and those from rural and inner city communities. Despite these consistent and positive findings, we realize that we need stronger evidence of the success of our programs. Two years ago we started a longitudinal study to track new students in our programs and a similar group of students not in our programs over five years to understand how *FIRST* works to inspire students in STEM.

Responses by Mr. Hadi Partovi

February 18, 2014

Chairman Larry Bucshon
Subcommittee on Research and Technology
Committee on Science, Space and Technology
2321 Rayburn House Office Building
Washington, DC 20515

Dear Chairman Bucshon:

Thank you again for the opportunity to testify at the January 9, 2014 hearing titled, "Private Sector Programs that Engage Students in STEM." I enjoyed sharing with you and your colleagues the work of Code.org, the success of the "Hour of Code" and the many reasons that computer science should be available to all students in all K-12 schools.

Per your letter dated February 4, 2014, I submit the following responses to the Questions for the Record and edits to the hearing transcript.

Question posed by Subcommittee Chairman Larry Bucshon:

We work to effect STEM education to prepare a workforce that covers the breadth of STEM fields and jobs. What is your perspective on what "STEM education" is and should be and how it connects to preparing young people for success in these diverse professions?

There has been an unyielding call for improved STEM education in the United States since the "Nation At Risk" report of the 1980s. And yet, our country's education policies do not support a robust STEM education curriculum in its K-12 classrooms. Business and industry are clamoring for talent in computer science, engineering, information technology, mathematics and the sciences and yet, STEM education and the disciplines it encompasses are not broadly supported by federal policies like the Elementary and Secondary Education Act, the Higher Education Act and the America COMPETES Act.

A key part of the problem is a confusion about the acronym "STEM". Within K-12 education, STEM often means "math and science", which translates to the traditional, century-old academic subjects: algebra, calculus, chemistry, biology, and physics. But when we talk about the "STEM" crisis in our economy and schools, we are really talking about a crisis in *computer science education*. According to the Bureau of Labor Statistics, more than 50% of all STEM-category jobs in the next decade will be computing jobs. In fact, according to the Conference Board, demand for computing professionals is roughly four times higher than the average demand for all other occupations, with more than 580,000 jobs in computing open as of December 2013. What is less well known is that almost every job -- medicine, law, business, government and banking -- increasingly requires foundational familiarity with computer science. A 21st-century doctor, lawyer, or banker may not need to know how to



write complex code, but he or she increasingly needs to understand the inner workings of an app, a website, cookies, software security, and other technology basics.

Despite these facts, most K-12 schools do not offer computer science, and students are not expected to be exposed to it at any level. In fact, last year, less than 1 percent of Advanced Placement (AP) exams taken were in computer science. And only a tiny fraction of that 1 percent are women and underrepresented minorities. Computer science is simply not part of what we call the "core" curriculum in our schools, or "STEM" education. It is an afterthought. As a result, cohort after cohort of students are being denied the knowledge and skills they need in our increasingly digital world. Our K-12 schools teach students how to dissect a frog, or how electricity works -- it's time they also taught them how to "dissect an app", or how the Internet works.

A limited list of federally-defined "core academic subjects" and a flawed and narrow definition of "STEM education" marginalize the teaching and learning of computer science. The definition of core academic subjects does not include computer science, which diminishes support for this field among state and local policymakers who decide what is taught and which educators get limited professional development support. The definition of "STEM" is clarified throughout many statutes as "science, technology, engineering and mathematics", which similarly makes it difficult for computer science advocates to win attention and resources for the discipline that accounts for half of all STEM jobs. It's not easy to add a new, rapidly-evolving field to the K-12 curriculum, but it's a challenge our schools must meet. The UK has already put in place a plan to bring computer science to every school, nationwide, starting in September of this year. But in the US, when we talk about STEM, when STEM policies are translated to action, "STEM" means the same fields we've taught for decades: biology, chemistry, physics, and calculus. These are important, foundational topics. But we need to focus the STEM conversation on a new field, a field that is driving 50% of new STEM jobs, a field that is increasingly foundational across all careers in science, business, government and law, a field that is *not even taught* in the majority of our schools. Today when we say "STEM", computer science is ignored. We need to change that conversation.

Federal laws governing elementary and secondary education are revised, generally speaking, once every ten years. This requires lawmakers to be forward-thinking in defining what is or could be taught in K-12 classrooms. For computer science instruction to expand and be available to more students, it must be explicitly included in the definition of "STEM" and "core academic subjects". This policy change would help Code.org and countless other non-profit organizations that work with schools to meet the demand for computer science courses - a demand so clearly voiced by the 25 million students who took part in the Hour of Code campaign. Education policy must reflect the diversity of all STEM fields, the more traditional and emerging. This will provide states and localities the encouragement and the ability to invest in the subjects their students demand and that employers look for in the workforce.

"STEM education" is a term born in Washington, DC that now pervades conversations about what education is or should be. I believe that STEM education and all education should prepare young people to be successful in the workforce. I cannot see how any educational program that sets out to do that can do so without offering students the opportunity to learn computer science.

Question posed by Subcommittee Ranking Member Daniel Lipinski:

Our Committee held a hearing a few years ago looking at a National Academies report on learning STEM in informal environments. In that hearing, we heard a lot about the challenges to properly assessing and evaluating the effectiveness of STEM engagement programs, such as competitions. We heard some compelling numbers from you about participation in Hour of Code. Recognizing that Hour of Code was just a first step for Code.org, I'd like to learn more about how you plan to approach assessment as you continue to develop your programs.

Hour of Code was arguably an "engagement" program but you are also working to get formal learning modules and curricula into classrooms. How do you distinguish the goals of engagement programs from the goals of formal learning programs? How will you approach developing appropriate metrics for each? What ideally would you like to be able to measure?

The goals of an engagement program are mainly based on participation, while the goals of a formal learning program add on student performance, student attitudinal change, and teacher metrics related to the professional development experience. The goals of the Hour of Code were total participation, participation from traditionally underrepresented groups, and involvement from the community and industry. To date, over 25 million students have participated and we estimate that 48% of participants were girls. That means more girls participated in computer science in US schools during the December campaign than have in the last seventy years. We had the support of hundreds of partners--from the largest technology companies, like Microsoft, Apple, Amazon and Zappos to local schools, afterschool programs and Boys & Girls Clubs. Every one of us was surprised and overwhelmed by the level of participation.

The success of "Hour of Code" highlighted the demand for computer science from young people in our schools. Code.org is now working with school districts across the country to meet that demand by offering curriculum and the associated teacher supports--at no charge--so that districts can offer students rigorous computer science courses. We have completed district contracts in nine regions, with twenty-three districts that will reach students in 150+ high schools. Our goal is to have at least 30% female enrollment in those high school classrooms. We also offer a free online course for K-8 students - 13,000 classrooms have followed-up on the Hour of Code experience by offering this course, with over 700,000 students enrolled within the first 10 weeks, and 40% of the students are female.

Code.org is currently supported solely through private funds. However, we have voluntarily elected to bring on a university-affiliated external evaluation firm to help us develop and measure our learning goals. We believe that external validation is vital to achieving our primary goal of program improvement, not as a stipulation of public funding. As a result, our formal learning program evaluation goes beyond participation to measure: student performance on standardized assessments associated with our curriculum; the teacher experience going through our professional development program (self-efficacy, content knowledge, instructional practice); and student attitudinal measures such as confidence, feelings of belonging in computer science studies and fields, and the desire to pursue computer science-related academic programs and/or careers.

How will you try to differentiate correlation from causation in measuring the impact of your programs? For example, how will you control for other factors, such as education level of the parents and other self-selection indicators?

Differentiating correlation from causation is the ultimate desire of any educational intervention evaluation. The effort hinges on identifying a control group that is similar in as many relevant ways as possible to the group that experiences the intervention--in this case, exposure to computer science. The moral hazards of double-blind studies in K-12 education have been explored and documented by many, but due to the lack of K-12 computer science opportunities in the US, there are many possibilities for identifying and observing control groups in the very districts and areas that will be adopting computer science programs for the first time.

As noted earlier, Code.org has completed district contracts in nine regions, with twenty-three districts to reach students in 150+ high schools to date. The districts and schools vary by region, resources and student demographics. Chicago Public Schools, Broward County (FL) public schools, New York City and Charles County (MD) public schools are among our partnering districts. These districts differ in countless ways.

As for measuring results, impressive participation numbers in our engagement campaign are just the first step. The school district agreements require (anonymous) data sharing for the purpose of academic evaluation by our university research partner. In consultation with our university external evaluator and school districts, we will be careful to set up studies that utilize the school data to select control groups with similar characteristics to the group of students going through our programs. All data is gathered and secured as required by the federal Family Educational Rights and Privacy Act (FERPA) and our agreements abide by all district policies. While we might not have access to the level of detailed data you specify--educational attainment levels for parents of participating students and other self-selection indicators, we will be able to compare the performance of teachers and students in various districts. We have secured agreements with suburban and urban districts, and are working on reaching rural areas. We are keenly interested in the many factors that affect educational achievement among students and success for schools and districts and will be working with our partners to ensure we are doing our very best to give teachers the support they need to provide students with the educational experiences that will serve them well--well after high school.

Edits to hearing transcript:

On page 19, line 389 reads "the Internet works, and this isn't fundamental not only to..."
It should read: "the Internet works, and this **is** fundamental not only to..."

On page 20, line 427 the first word reads "mail" and it should read: "math"

Again, thank you for the opportunity to share the importance of K-12 computer science education with you and your colleagues. As I said on January 9, the subject of computer science is crucial to the future of our country and the strength of its economy. Further, the young people who learn computer science will be better prepared for any academic or professional pursuit they choose. To prepare our students for the changing needs of the 21st century we need to teach our students computer science starting at an early age, in every elementary, middle and high school - to help our children understand the subject, be excited about the creativity it inspires, and be interested in pursuing it as a career.

There is great demand for K-12 computer science exemplified by the now over 25 million students who have tried their hand at coding via the "Hour of Code". My organization is doing what it can to help, although there must be changes to current laws to eliminate barriers that prevent computer science classes and other opportunities from being more readily available. The Computer Science Education Act (HR 2536) would be an important first step, and I was so pleased Chairman Smith voiced his support for the measure at the hearing and followed that public statement with a letter to all of the Members of the full Committee urging them to join him as a cosponsor of the bill. As an early cosponsor of that measure, I hope you can help us as we advocate for its passage and enactment before the end of the 113th Congress.

Thanks again and if you, your colleagues and staff have any questions about computer science education, Code.org or policy barriers to the teaching and learning of computer science, please do not hesitate to contact me or Cameron Wilson at Cameron@code.org.

Sincerely,



Hadi Partovi
Co-founder and CEO
Code.org

Responses by Dr. Phillip Cornwell

Response to additional questions submitted by members of the Subcommittee on Research and Technology of the U.S. House of Representatives concerning the January 9, 2014 hearing titled, "Private Sector Programs that Engage Students in STEM."

February 17, 2014

Phillip Cornwell
Vice President for Academic Affairs and Professor of Mechanical Engineering
Rose-Hulman Institute of Technology
Email: Cornwell@rose-hulman.edu

Question submitted by Rep. Larry Bucshon, Chairman, Subcommittee on Research and Technology

We hear a great deal that our K-12 pipeline isn't producing students ready for postsecondary education. I am also concerned that students are not always selecting the right match for their postsecondary education, leading to switching out of STEM majors or dropping out of school. Rose-Hulman specifically caters to students interested in pursuing STEM subjects. How does Rose-Hulman identify and recruit such a specific pool of talented STEM students? How does your institution retain those students? What advice would you give to students on how to select the best school for them to excel?

How does Rose-Hulman identify and recruit such a specific pool of talented STEM students?

As pointed out by Chairman Bucshon, Rose-Hulman Institute of Technology offers a relatively small number of possible majors, all of which are in the areas of science, engineering, and mathematics (SEM). About 80% of our students are majoring in one of the engineering disciplines and the other 20% in mathematics or one of the sciences. Our institution's focus on these majors, combined with our location and high admissions standards, creates special challenges in recruiting students. Approximately three million students graduate high school in the United States each year. Of these students, roughly two million pursue post-secondary education. Of those students who attend college, only about 120,000 will enroll with an intention of studying SEM. Finally, fewer than half of these students will have a combination of high school experiences, standardized test scores, and grades sufficient to meet admission requirements at Rose-Hulman. This means that less than 1.5% of national high school graduates will be eligible for consideration at our school. Not all of these students are interested in attending Rose-Hulman. For these reasons, recruitment is both difficult and immensely important.

To recruit students, Rose-Hulman purchases lists of student names from sources such as the PSAT to populate a mailing list of students who have expressed an interest in studying one of the majors we offer. Beyond this, our Office of Admissions is very active in visiting high schools and attending college fairs throughout the nation to tell prospective students about our school and its academic programs. We also rely on visits to our website that are often a result of web searches such as "schools that provide an excellent undergraduate engineering education." Finally, we get names of potential students through alumni referrals. Once potential applicants have been identified, we encourage the student and his/her parents to visit campus so that they can gain an appreciation for the quality of our students, faculty, and facilities. We also have a successful outreach program for rising high school seniors called "Operation

Catapult.” This is a three-week summer program where students live on campus and work in teams on a technical project. Every team is mentored by a faculty member with a Ph.D. There are also numerous demonstrations, lectures, and field trips. About 30% of the students who attend Catapult choose to come to Rose-Hulman.

How does your institution retain those students?

Once a student has applied, been admitted, and decided to join our entering first-year class, the arduous process of earning a degree can begin in earnest. We work our students very hard, and we have very high standards, but we also provide support, encouragement, and assistance to help our students succeed. This focus on student success comes directly from our mission statement, which is “to provide our students with the world’s best undergraduate science, engineering, and mathematics education in an environment of individual attention and support.” Our ability to retain over 90% of our entering students to a second year and to graduate over 80% of our students within five years is a point of pride for our institution and is particularly laudable when considering that Rose-Hulman does not offer any degrees outside of the SEM areas. None of our classes or labs are taught by graduate students. Our faculty members are not only experts in their areas of expertise, but are also passionate about teaching. Furthermore, we keep class and laboratory sizes small. Rather than having a class of 200, we will have 8 sections of 25. We do this because we believe it provides a better educational experience for students, and it also allows professors to know all of their students so they can intervene when they observe a student who is struggling. Our professors make extraordinary efforts to be available to our students, both in person during the day and electronically during evening hours. Our students know that faculty members are there to help and that they are approachable whenever difficulties may arise.

In addition to having a faculty whose primary focus is on teaching students, we also have several programs and support structures to help retain students. These include:

1. A Retention Task Force that:
 - a. meets at least biweekly throughout the academic year,
 - b. has representatives from Enrollment Management, Student Affairs, our Learning Center, and departments that teach a lot of freshman courses such as Applied Biology, Chemistry, Humanities and Social Sciences, Mathematics, and Physics,
 - c. discusses and evaluates strategies to improve retention and student success.
2. The RHIT Link Survey
 - a. This survey consists of an electronic form sent to all professors teaching freshmen and to all Resident Advisors. It asks them to identify students who appear to have:
 - i. weak academic preparedness,
 - ii. a poor work ethic,
 - iii. a poor attitude,
 - iv. persistent tardiness.
 - b. Students identified in the survey are targeted for intervention. The intervention includes
 - i. notifying academic advisors,
 - ii. strongly encouraging students to attend counseling sessions with a Retention Task Force representative,
 - iii. strongly encouraging students to use our Learning Center, meet with his/her professors, and find peer mentors.

3. The Rose-Hulman Learning Center. This Center
 - a. is staffed by student tutors who can provide tutoring in many of the classes offered at Rose-Hulman,
 - b. has files of old exams available for student use,
 - c. offers workshops and review sessions.

All of our freshmen are also assigned a Freshman Advisor. These advisors are faculty volunteers who have undergone training. In addition to providing advice during registration for classes, they are expected to meet with their advisees at least three times a year for social activities such as cookouts. All of our freshmen are also required to take a course called "College and Life Skills" to help them make the transition to college. These classes also give students a better understanding of the various majors at Rose-Hulman and require them to prepare and submit resumes to our Office of Career Services.

At Rose-Hulman, the students who leave the school usually do so in their freshman or sophomore years. To help improve sophomore retention, Rose-Hulman built a residence hall in 1999 specifically for sophomores. This residence hall has classrooms in the basement, study areas on each floor, and dedicated sophomore tutors. There was a noticeable increase in our retention of sophomores upon completion of this building.

What advice would you give to students on how to select the best school for them to excel?

I believe that the "right college" is a very personal decision for all college-bound students. Ultimately, I encourage students to visit the colleges they are interested in attending in order to get an appreciation for the student experience at the school of interest. When students visit Rose-Hulman, we encourage them to sit in on a class and to visit a student residence hall so that the visiting student, and her/his family, will leave with a realistic expectation of what a Rose-Hulman education entails. We encourage every visitor to take a student-led, individual tour of our campus. During this tour, students and their families are encouraged to ask the Rose-Hulman student guide pointed questions about the student experience, our faculty, our curriculum, and what our graduates do upon graduation.

Before choosing a college, I believe students should ask themselves the following questions:

1. Does this school offer programs of interest to me?
2. How much interaction do I want with professors?
3. What, if any, extracurricular activities would I like to pursue and will I be able to pursue them at this college?
4. Will this school help me be successful in achieving my long-term career goals?
5. Is this a school where I feel I will be accepted and will fit in with the campus community?
6. Do the benefits of attending this school justify the expense?

Ultimately, I believe that there is not necessarily a "best" school for every student, although I do believe some schools are better than others depending on a student's interests, needs, and ability. We find that Rose-Hulman is certainly not the right learning environment for every student who visits. However, for many students, we provide a learning environment, both in and out of the classroom, where they can thrive.

