STEM AND COMPUTER SCIENCE EDUCATION: PREPARING THE 21ST CENTURY WORKFORCE

HEARING

BEFORE THE

SUBCOMMITTEE ON RESEARCH AND TECHNOLOGY

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

HOUSE OF REPRESENTATIVES

ONE HUNDRED FIFTEENTH CONGRESS

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July 26, 2017

STEM AND COMPUTER SCIENCE EDUCATION: PREPARING THE 21ST CENTURY WORKFORCE

WEDNESDAY, JULY 26, 2017

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

The Subcommittee met, pursuant to call, at 10:09 a.m., in Room 2318 of the Rayburn House Office Building, Hon. Barbara Comstock [Chairwoman 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
2321 RAYBURN HOUSE OFFICE BUILDING
WASHINGTON, DC 20515-6301
(202) 225-6371
www.science.house.gov

STEM and Computer Science Education: Preparing the 21st Century Workforce

Wednesday, July 26, 2017
10:00 a.m.
2318 Rayburn House Office Building

Witnesses

Mr. James Brown, Executive Director, STEM Education Coalition

Mr. Pat Yongpradit, Chief Academic Officer, Code.org

Dr. A. Paul Alivisatos, Executive Vice Chancellor & Provost, Vice Chancellor for Research, and Professor of Chemistry Materials Science & Engineering, University of California, Berkeley

Mrs. Dee Mooney, Executive Director, Micron Technology Foundation

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

HEARING CHARTER

July 21, 2017

TO: Members, Subcommittee on Research and Technology

FROM: Majority Staff, Committee on Science, Space, and Technology

SUBJECT: Research and Technology Subcommittee Hearing:
"STEM and Computer Science Education: Preparing the 21st Century Workforce"

The Subcommittee on Research and Technology of the Committee on Science, Space, and Technology will hold a hearing titled *STEM and Computer Science Education: Preparing the 21st Century Workforce* on Wednesday, July 26, 2017 at 10:00 a.m. in Room 2318 of the Rayburn House Office Building.

Hearing Purpose:

The purpose of the hearing is to highlight the importance of STEM and computer science education to meeting a wide range of critical current and future workforce needs. In addition, the hearing will shed light on the various initiatives taking place across the nation to educate and inspire students to pursue careers in STEM and computer science related fields.

Witness List

- **Mr. James Brown**, Executive Director, STEM Education Coalition
- **Mr. Pat Yongpradit**, Chief Academic Officer, Code.org
- **Dr. A. Paul Alivisatos**, Executive Vice Chancellor & Provost, Vice Chancellor for Research, and Professor of Chemistry and Materials Science & Engineering, University of California, Berkeley
- **Mrs. Dee Mooney**, Executive Director, Micron Technology Foundation

Staff Contact

For questions related to the hearing, please contact Sarah Jorgenson of the Majority Staff at 202-225-6371.

Chairwoman COMSTOCK. The Committee on Science, Space, and Technology will come to order.

Without objection, the Chair is authorized to declare recesses of the Subcommittee at any time.

Good morning, and welcome to today's hearing titled "STEM and Computer Science Education: Preparing the 21st Century Workforce." I now recognize myself for five minutes for an opening statement.

Today we will discuss several initiatives in science, technology, engineering, and mathematics, or STEM, and computer science education, and how a variety of organizations engage students in these important fields.

A STEM-educated workforce is necessary for innovation and for ensuring U.S. economic strength, competitiveness, and national security. As demand for skilled STEM workers continues to grow, the U.S. must work to fill those employment needs, especially with the looming retirements of the baby-boomer generation.

In addition, there remains a critical cybersecurity workforce shortage as cyber-attacks are increasing in both quantity and complexity. The results from the 2017 Global Information Security Workforce Study predicts a worldwide shortage of 1.8 million cybersecurity professionals by 2022. Also, according to CyberSeek, 40,000 jobs for information security analysts go unfilled every year in the U.S., and employers are struggling to fill 200,000 other cyber-related jobs.

I know just in my district, in Virginia, we hear about thousands and thousands of cyber jobs that are going unfilled. This is one of the most competitive areas where we know we could use more employees and students, and there are a lot of innovative programs going on trying to get students into that pipeline.

It is a privilege to serve an area of Virginia where so many of my constituents are the most talented people who work on cyber issues at so many of our companies, whether it's Northrop Grumman or Capital One or small start-ups like PhishMe, and there are dozens of others. I could go on and on with the hundreds of companies that we have addressing these issues, but those are just some of the few that I have been able to visit and see a lot of their cybersecurity workforce in action.

But whenever I visit these companies and constituents who work in the technology sector, a repeated concern expressed to me is the increasing need for individuals with appropriate education, training, and knowledge of cybersecurity matters, and how important it is that we get that pipeline from grade school now. There are great examples of local companies working to fill these workforce gaps. In Ashburn, Virginia, in my district, we have Telos, which is working with our local high school, C.S. Monroe Technology Center, which provides cybersecurity certificates so kids can start working right out of high school in these much-needed jobs, and again, getting into that pipeline while having employers who will often then pay for their college degree as well as their benefits and salary while they're going through school. In addition, Telos is working with George Washington University's Science and Technology campus, which is not just here in D.C., but also in Loudoun County.

Yesterday, I attended an event right here in the Capitol with Girls Who Code. It is a program which provides young women experience in computer related fields and sets them on a path toward acquiring these important skills that will be, as we know, so much needed in 21st century workforce. We know there are not enough women in those fields, and Girls Who Code is one of those exciting programs that's capturing the imagination of these young people in high school and even earlier to get them on that path.

Capital One, as I mentioned, which is headquartered in my district, also exposes middle school students to technology by partnering with schools and community leaders to inspire the students to focus on software engineering. Since it was launched, their program has had over 2,500 participants who have created over 500 different mobile apps.

Additionally, Micron, who is here today, has a sizable facility in Manassas in my district, which, commits STEM-focused grants and partners with Virginia universities to help inspire our students. They also partnered with Discover Technology to create their new STEM Mobile Discovery Lab, a bus specifically designed with interactive science exhibits where students are able to work with robotics and explore 3D printing. I am looking forward to hearing more about the work the they are doing during this hearing. I also wanted to thank them for recently coming to my Young Women's Leadership program, where they were also promoting one of our programs. We were privileged to have a number of members from NASA promoting the STEM fields and an astronaut who came to speak to the girls, so it was one of our best-attended events, and we're happy to promote the bus there.

While these examples are encouraging, we know there is so much more we need to do to educate and train our current and future workforce. The workforce gap is especially troubling when considering the many hearings we have held in this Committee on federal cybersecurity issues. These hearings focused on cybersecurity incidents, as well as emerging risks which threaten federal agencies' computer networks and hundreds of millions of Americans who entrust their confidential personal data to these agencies but also their personal data that's in their everyday work, whether in their banks and, you know, in every part of our life.

In order to fill these jobs, we must be able to harness the talent of our Nation's young men and women. When it comes to women, it's estimated that only three percent of these jobs are filled by women. That is part of the reason why we passed the INSPIRE Women Act, which was signed into law earlier this year. This bill leverages NASA's talent pool of current and retired astronauts and other career professionals, including early career female scientists, engineers, and innovators to inform and inspire young women to pursue their dreams in STEM subjects.

Through the combination of public and private sector investments, we can help inspire our students to get into these programs early and to stay, to capture their imagination, to help them and their parents understand that this is, you know, very much needed in our workforce but also very exciting areas which can pretty much take them into any field that they may be interested in.

So with that, I look forward to hearing the testimonies of our witnesses.

The statement of Chairwoman Comstock follows:]

COMMITTEE ON
SCIENCE, SPACE, & TECHNOLOGY
Lamar Smith, Chairman

For Immediate Release
July 26, 2017

Media Contact: Kristina Baum
(202) 225-6371

Statement of Chairwoman Barbara Comstock (R-Va.)
STEM and Computer Science Education: Preparing the 21st Century Workforce

Chairwoman Comstock: Today we will discuss several initiatives in science, technology, engineering, and mathematics, or STEM, and computer science education, and how a variety of organizations engage students in these important fields.

A STEM educated workforce is necessary for innovation and for ensuring U.S. economic strength, competitiveness, and national security.

As demand for skilled STEM workers continues to grow, the U.S. must work to fill those employment needs, especially with the looming retirements of the baby-boomer generation.

In addition, there remains a critical cybersecurity workforce shortage as cyber-attacks are increasing in both quantity and complexity. The results from a 2017 Global Information Security Workforce Study predicts a worldwide shortage of 1.8 million cybersecurity professionals by 2022. Also, according to CyberSeek, 40,000 jobs for information security analysts go unfilled every year in the U.S., and employers are struggling to fill 200,000 other cyber related jobs.

It is a privilege to serve an area of Virginia in which so many of my constituents are talented people who work on cyber issues at well-established companies such as Northrop Grumman or start-ups like PhishMe that are rapidly expanding due to the cyber threat.

However, when I visit with these companies and other constituents who work in the technology sector, a repeated concern expressed to me is the increasing need for individuals with appropriate education, training, and knowledge of cybersecurity matters.

There are some great examples of local companies working to fill these workforce gaps, like Ashburn, Virginia-based cybersecurity company Telos, which is working with a local high school, C. S. Monroe Technology Center, and George Washington University's Science and Technology campus in Loudoun County.

Yesterday, I attended an event where I was able to learn about the Girls Who Code program which provides young women experience in computer related fields and sets them on a path toward acquiring the skills necessary to compete for these well-paying 21st century jobs.

Capital One, headquartered in McLean, Virginia, exposes middle school students to technology by partnering with schools and community leaders to inspire the students to focus on software engineering. Since it was launched, the program has had over 2,500 participants who have created over 500 different mobile apps.

Additionally, Micron, who has a sizable facility in Manassas, commits STEM-focused grants and partners with Virginia universities to help inspire students. They also partnered with Discover Technology to create their new STEM Mobile Discovery Lab – a bus specially designed with interactive science exhibits where students are able to work with robotics and explore 3D printing. I am looking forward to hearing more about the work that they do during this hearing.

While these examples are encouraging, we must do more to educate and train our current and future workforce.

The workforce gap is especially concerning when considering the many hearings we have held in this Committee on federal cybersecurity issues.

These hearings focused on cybersecurity incidents, as well as emerging risks which threaten federal agencies' computer networks and hundreds of millions of Americans who entrust their confidential personal data to the agencies.

In order to fill these jobs, we must be able to harness the talent of our nation's young men and women. It is estimated that only 3% of these jobs will be filled by a woman. That is why I introduced the INSPIRE Women Act, which was signed into law earlier this year.

This bill leverages NASA's talent pool of current and retired astronauts, and early career female scientists, engineers, and innovators to inform and inspire young women to pursue their dreams in STEM subjects.

Through the combination of public and private sector investments, we can help inspire students to study these subject areas and pursue careers that will help unleash technological innovation, grow our economy, increase our competitiveness, and improve our national security.

And with that, I look forward to hearing the testimonies of our witnesses.

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Chairwoman COMSTOCK. So thank you, and I now recognize the Ranking Member, the gentleman from Illinois, Mr. Lipinski, for his opening statement.

Mr. LIPINSKI. Thank you, Chairwoman Comstock, and thank you, Chairman Smith, for holding this hearing today. This is an issue that's very important to me, very close to my heart. I want to thank all the witnesses for being here today also.

For the past 8-plus years I have had the privilege of serving as first Chair and then Ranking Member of this Subcommittee, which was formerly the Research and Science Education Subcommittee before we merged with the Technology and Innovation Committee. I've also during that time been Co-Chair of the STEM Ed Caucus, and we've done a lot of work in this area, but a lot more still needs to be done. My experiences here in Congress along with my background in engineering, my wife was a math major and has taken that into her career, it's all given me a lot of insight into the importance of STEM education for the success of individuals in today's job market but also for the success of our Nation's economy. I'm not as well versed in computer science as in STEM ed, but I do know I spent much more time in the '90s as a political science grad student, a lot more time doing computer programming than I did in the 1980s as an engineering undergrad. The importance of computers, computer programming, has just over the last four decades continued to mushroom, and it's just critically important in so many jobs today, so I'm really glad that we're holding this hearing today.

Computers, we all know, are becoming more and more integral to our daily lives. With a device we carry around in our pocket, we can video chat with loved ones, order groceries, or even watch a live stream of a Congressional hearing like this one. Looking to the future, artificial intelligence, mixed reality, and the Internet of Things will undoubtedly play larger roles in our everyday lives.

Obviously none of this is possible without computer scientists and individuals with computer skills. The innovations coming out of Silicon Valley are inspiring, but industries beyond the technology sector are also integrating computer science and data analytics into their business models. With this increased reliance on computing and information technology, the workforce demand for computing and programming expertise has skyrocketed. Code.org estimates that there are over a half million open computing jobs nationwide as we talked about where are the jobs. That's the place where we have all these jobs that are unfilled. That means we are missing a lot of economic value.

This hearing is a great opportunity to discuss challenges and opportunities for producing a workforce equipped to meet the demand for computing expertise. The National Center for Education Statistics reports that a record number of computer science bachelor's degrees were awarded in 2015. Colleges and universities are straining to expand their capacity to accommodate the surge in student interest but we're obviously still not producing enough skilled computer scientists. So we want to know what we can do to address this problem?

There are also barriers at the high school level to providing access to high-quality computer science courses. According to a 2016

research study by Gallup and Google, only 40 percent of schools teach computer programming. Computer science curricula vary from school to school as only 10 states have created K–12 computer science standards. Increasing the pool of qualified teachers has also proven to be a very difficult challenge.

I'm encouraged to see that each year more schools are offering computer science courses and allowing students to count them toward credit for graduation. In fact, last year the Chicago Public School System became the first in the country to add computer science to the list of requirements for graduation. The Chicago Public Schools class of 2021 will be the first high school class in the country to graduate with every student having taken a computer science course. These are all steps in the right direction, but there is clearly more work to be done.

We need to provide opportunities for adults seeking career retraining and continuing education to have access to coding and computing skills through community colleges and employment training centers. To that end, I was pleased to see the Strengthening Career and Technical Education for the 21st Century Act pass the House unanimously last month, but as I regularly hear from employers in my district, demand for these skills still outstrips supply.

Finally, we need to work to ensure that all students no matter where they grow up, their background, their race, or their sex, have the opportunity to become educated in computer science and all STEM fields. Increasing the participation of women and underrepresented minorities in STEM fields will not only increase our global competitiveness, but also help grow the STEM workforce.

I look forward to a fruitful discussion about measures that can be taken to ensure that graduates entering the workforce and adults retraining for new careers are equipped with the necessary expertise to meet overwhelming employer demand.

Thank you again to our witnesses for being here, and I yield the balance of my time.

[The prepared statement of Mr. Lipinski follows:]

OPENING STATEMENT
Ranking Member Daniel Lipinski (D-IL)
of the Subcommittee on Research and Technology

House Committee on Science, Space, and Technology
Subcommittee on Research and Technology
"STEM and Computer Science Education: Preparing the 21st Century Workforce"
July 26, 2017

Thank you, Chairwoman Comstock, and thank you to all of the witnesses for being here today.

For the past 8 and half years I have had the privilege of serving as Chair and then Ranking Member of this subcommittee – formerly the Research and Science Education subcommittee – and co-chair of the STEM Education Caucus. These experiences, combined with my training as an engineer and my wife's training in math, have given me great insight into the importance of STEM education for the success of individuals in today's job market as well as for the success of our nation's economy. I'm not as well versed in computer science, but I do know that I spent much more time doing computer programming as a political science grad student in the 90s than I did as an engineering undergrad in the 80s. The importance of computer science and computer skills has exploded since that time. So I am glad we are having this hearing today to discuss the state of STEM and computer science education in our country.

Computers are becoming more and more integral to our daily live. With a device we carry around in our pocket, we can video chat with loved ones, order groceries, or even watch a live stream of a Congressional hearing. Looking to the future, artificial intelligence, mixed reality, and the Internet of Things will undoubtedly play larger roles in our everyday lives. Obviously none of this is possible without computer scientists and individuals with computer skills. The innovations coming out of Silicon Valley are inspiring, but industries beyond the technology sector are also integrating computer science and data analytics into their business models. With this increased reliance on computing and information technology, the workforce demand for computing and programming expertise has skyrocketed.

Code.org estimates that there are over a half million open computing jobs nationwide. These unfilled jobs amount to significant untapped economic value. This hearing is a great opportunity to discuss challenges and opportunities for producing a workforce equipped to meet the demand for computing expertise.

The National Center for Education Statistics reports that a record number of computer science bachelor's degrees were awarded in 2015. Colleges and universities are straining to expand their capacity to accommodate the surge in student interest. But we're obviously still not producing enough skilled computer scientists. What can we do to address this problem?

There are also barriers at the high school level to providing access to high-quality computer science courses. According to a 2016 research study by Gallup and Google, only 40 percent of schools teach computer programming. Computer science curricula vary from school to school as only 10 states have created K-12 computer science standards. Increasing the pool of qualified teachers has also proven to be a difficult challenge.

I am encouraged to see that each year more schools are offering computer science courses and allowing students to count them toward credit for graduation. In fact, last year the Chicago Public School system became the first in the country to add computer science to the list of requirements for graduation. The Chicago Public Schools class of 2021 will be the first high school class in the country to graduate with every student having taken a computer science course. These are all steps in the right direction, but there is more work to be done.

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Finally, we need to work to ensure that all students no matter where they grow up, their background, their race, or their sex, have the opportunity to become educated in computer science and all STEM fields. Increasing the participation of women and under-represented minorities in STEM fields will not only increase our global competitiveness, but also help grow the STEM workforce.

I look forward to a fruitful discussion about measures that can be taken to ensure that graduates entering the workforce and adults retraining for new careers are equipped with the necessary expertise to meet overwhelming employer demand. Thank you again to our witnesses for being here and I yield balance of my time.

Chairwoman COMSTOCK. Thank you, Mr. Lipinski, and I now recognize the Chairman of the full Committee for a statement, Mr. Smith.

Chairman SMITH. Thank you, Madam Chair, and also, thank you for having a hearing on a subject that I know is of special interest to both of us.

Since our founding, American innovators have played an important role in our nation's growth and prosperity. With the rise in competition from abroad, however, we must ensure that America stays a world leader in innovation. We can do this in part by better educating American students in STEM subjects.

Unfortunately, America lags behind many other nations when it comes to science, technology, engineering and math. American students ranked 19th in science and 31st in math out of 35 countries. That to me is just an incredible statistic. We are in the bottom half in science and pretty close to the bottom ten percent when it comes to math. We can and must do better to keep America globally competitive.

We have to capture and hold the desire of our nation's youth to study science and engineering so they will want to pursue these careers. More graduates with STEM degrees means more advanced technologies and a more robust economy. A well-educated and trained STEM workforce promotes our future economic prosperity.

But it is not just about the economy. These graduates have the potential to develop technologies that could save thousands of lives, jump-start a new industry, or even discover new worlds. We can work together to ensure that students continue to go into these fields so that their ideas can lead to a more innovative and prosperous America.

You may be surprised to find out that STEM originally did not include computer science in its definition. In the last Congress, I introduced the STEM Education Act of 2015, which was signed into law. This bipartisan bill expands the definition of STEM to include computer science. The bill also helps encourage students to enter STEM fields. This measure directs the National Science Foundation to continue to award competitive merit-reviewed grants to support informal STEM education programs such as afterschool science programs and in ways that formal classroom training often does not.

Thanks to Representative Esty, a member of this Committee, the bill also amends the NSF Noyce Master Teaching Fellowship program to allow teachers in pursuit of master's degrees to participate in the program. This enables more teachers to have the opportunity to compete for the grants.

Another challenge is that despite representing nearly half of the college-educated and total U.S. workforce, women account for less than 25 percent of America's STEM workforce. To address this disparity, the first two Science Committee bills signed into law by President Trump helped support women's involvement in STEM fields. The INSPIRE Women Act was led by Research and Technology Chairwoman Comstock, who is chairing us today, and the Promoting Women in Entrepreneurship Act was led by Representative Esty. I thank them both for their efforts to help inspire women to work in STEM-related fields.

Today we will hear from leaders and experts who focus on engaging students in STEM and computer science education. 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 achieve 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. A well-educated and trained STEM workforce will promote our future economic prosperity, but we must encourage our nation's youth to study science and engineering so they will want to pursue these careers.

We need to ensure that young adults have the science and math 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.

I look forward to hearing from our witnesses, but let me say at the same time, Madam Chair, and also to our expert panelists today, that I have a Judiciary Committee markup that began 23 minutes ago, so I'm going to need to go there and shuttle back and forth.

Also, before I finish, I just want to point out, and I don't think I've done this before, in regard to the Ranking Member, Mr. Lipinski, I was reminded of this during his comment, that I believe he is the only member of the Science Committee to have received an NSF grant. Is that your understanding?

Mr. LIPINSKI. I did receive one. I'm not sure I'm the only one.

Chairman SMITH. I bet you're the only one. We have to remind Dr. Foster, who also has his own niche on the Committee, that he has some competition.

Thank you, Madam Chair. I'll yield back.

[The prepared statement of Chairman Smith follows:]

COMMITTEE ON
SCIENCE, SPACE, & TECHNOLOGY
Lamar Smith, Chairman

For Immediate Release
July 26, 2017

Media Contact: Kristina Baum
(202) 225-6371

Statement of Chairman Lamar Smith (R-Texas)
STEM and Computer Science Education: Preparing the 21st Century Workforce

Chairman Smith: Since our founding, American innovators have played an important role in our nation's growth and prosperity. With the rise in competition from abroad, however, we must ensure that America stays a world leader in innovation. We can do this in part by better educating American students in STEM subjects.

Unfortunately, America lags behind many other nations when it comes to science, technology, engineering and mathematics (STEM) education. American students ranked 19th in science and 31st in mathematics out of 35 countries. We can and must do better to keep America great.

We have to capture and hold the desire of our nation's youth to study science and engineering so they will want to pursue these careers.

More graduates with STEM degrees means more advanced technologies and a more robust economy. A well-educated and trained STEM workforce promotes our future economic prosperity.

But it is not just about the economy. These graduates have the potential to develop technologies that could save thousands of lives, jump-start a new industry, or even discover new worlds.

We can work together to ensure that students continue to go into these fields so that their ideas can lead to a more innovative and prosperous America.

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The INSPIRE Women Act was led by Research and Technology Chairwoman Comstock, and the Promoting Women in Entrepreneurship Act was led by another Science Committee Member, Rep. Esty. I thank them both for their efforts to help inspire women to work in STEM-related fields.

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And we need to more effectively use taxpayers' dollars to achieve 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. A well-educated and trained STEM workforce will promote our future economic prosperity. But we must encourage our nation's youth to study science and engineering so they will want to pursue these careers.

We need to ensure that young adults have the science and math 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.

I look forward to hearing the ideas of our witnesses.

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Chairwoman COMSTOCK. Thank you, and I now recognize the Ranking Member of the full Committee for a statement, Ms. Johnson.

Ms. JOHNSON. Thank you very much, Madam Chairman. This is an exciting occasion for me.

I first became aware of what we now call STEM education when I passed my first bill in 1974 in the Texas House. I had met Dr. John Kilby, who worked for Texas Instruments, and discovered the chip, the semiconductor that carried Texas Instruments around the world as a leading company, and later met Michael Dell from Austin, Texas, who came up with the Dell computer, and I knew then that we needed everyone involved.

So Madam Chairperson Comstock, I appreciate the fact that you're having this hearing.

I was thrilled when President Obama announced his Computer Science for All initiative last year. The Computer Science for All initiative not only called attention to the need to improve computer science education, but also to the need to ensure that all students, including women and under-represented minorities, are encouraged to participate. Since President Obama's announcement, we have seen a flurry of activity, and progress has been made, but we are not there yet.

Representative Connie Morello and I and Dr. Ellis from Michigan worked on this subject for seven, eight years before we finally got America COMPETES.

You know, in high school, female students are taking the Computer Science Advanced Placement exam at rates far lower than any other AP exam. In 2016, female students accounted for just 23 percent of the AP exam takers in computer science. Under-represented minorities accounted for 15 percent of exam takers.

The number of bachelor's degrees in computer science has exploded over the last several years. However, when you break this growth down by gender, it is apparent that it is almost entirely due to an increase in male graduates. Only 18 percent of the bachelor's degrees in computer science are awarded to women. The same fraction of women were earning bachelor's degrees in computer science in the 1970s.

Structural and social barriers are preventing us from fully engaging students of both genders, students of all ethnicities, and students from all backgrounds as we attempt to increase participation in computer science. Right now, computer scientists are creating innovative products and services that will affect all of our lives. These innovations cannot meet the needs of society if they are developed without insights from women and under-represented minorities.

One encouraging advancement has been the implementation of a new AP Computer Science course, called Computer Science Principles. The National Science Foundation supported the development of this course, and it is designed with the goal of engaging more women and underrepresented minorities in computer science.

With the introduction of this new exam in 2017, participation in AP Computer Science exams increased by four percent for women and five percent for under-represented minorities. This is a great

step forward, but more can and must be done to engage women and under-represented minorities at all levels of education.

I look forward to discussing ways to foster a welcoming learning environment for all students to gain skills in computer science. This is essential if we are to ensure that the Computer Science for All initiative, launched by President Obama, lives up to its name.

Before I close, I'd like to make note of the efforts made by a valuable member of the Committee, Representative Jackie Rosen. Last week, she introduced the "Code Like a Girl Act" which seeks to engage more girls in computer science at early levels of education, just where we're supposed to start the STEM orientation. I thank her for her efforts, and I hope to see her bill receive speedy consideration.

I thank the witnesses for being here today, and I look forward to the testimony, and I yield back.

[The prepared statement of Ms. Johnson follows:]

OPENING STATEMENT
Ranking Member Eddie Bernice Johnson (D-TX)

House Committee on Science, Space, and Technology
Subcommittee on Research and Technology
"STEM and Computer Science Education: Preparing the 21st Century Workforce,"
July 26, 2017

Thank you, Chairwoman Comstock, for holding this hearing on STEM and Computer Science Education.

I was thrilled when President Obama announced his Computer Science for All initiative last year. The Computer Science for All initiative not only called attention to the need to improve computer science education, but also to the need to ensure that all students – including women and underrepresented minorities – are encouraged to participate. Since President Obama's announcement, we have seen a flurry of activity, and progress has been made, but we are not there yet.

In high school, female students are taking the Computer Science Advanced Placement exam at rates far lower than any other AP exam. In 2016, female students accounted for just 23 percent of AP exam takers in computer science. Underrepresented minorities accounted for 15 percent of exam takers.

The number of bachelor's degrees in computer science has exploded over the last several years. However, when you break this growth down by gender, it is apparent that it is almost entirely due to an increase in male graduates. Only 18 percent of bachelor's degrees in computer science are awarded to women. The same fraction of women were earning bachelor's degrees in computer science in the 1970's.

Structural and social barriers are preventing us from fully engaging students of both genders, students of all ethnicities, and students from all backgrounds as we attempt to increase participation in computer science. Right now, computer scientists are creating innovative products and services that will affect all of our lives. These innovations cannot meet the needs of society if they are developed without insights from women and underrepresented minorities.

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With the introduction of this new exam in 2017, participation in AP Computer Science exams increased by 4 percent for women and 5 percent for underrepresented minorities. This is a great step forward, but more can and must be done to engage women and underrepresented minorities at all levels of education. I look forward to discussing ways to foster a welcoming learning environment for all students to gain skills in computer science. This is essential if we are to ensure that the Computer Science for All initiative, launched by President Obama, lives up to its name.

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I thank the witnesses for being here today, and I look forward to the testimony and discussion. I yield back.

Chairwoman COMSTOCK. Thank you, Mrs. Johnson and I would really appreciate your comments on women's education.

Since I'm not a science major, I'll brag about my daughter. My daughter was a biology major and then got her master's in forensic science, works at a lab here, does DNA analysis, and I credit her preschool education when she was in Montessori where before she got out of kindergarten, she knew multiplication and knew all her math and had that concrete understanding of science and math. So maybe we need to also revisit with some of our Education Committee Members how we can get more Montessori and that kind of concrete science education into our preschools since we're obviously spending lots of money on that preschool education, but sometimes they're—not to knock finger painting or anything—the math and the science that Montessori has is awesome. So, I'm going to give my little Montessori plug since all my kids were in that, and now I'm battling to get my grandchildren in there, too, since I credit that for all their high science scores.

So before I introduce our witnesses today, I would like to ask unanimous consent to add a letter from the Computer Science Education Coalition into the record.

[The information appears in Appendix II]

Chairwoman COMSTOCK. I will now introduce our witnesses.

So first, our first witness today is Mr. James Brown, Executive Director of the STEM Education Coalition. Prior to joining the Coalition, he was Assistant Director for Advocacy at the American Chemical Society. A nuclear engineer by training, he previously worked as a Legislative Aide for Representative Doc Hastings of Washington and began his career as an engineer with Newport News Shipbuilding working on aircraft-carrier construction. Thank you. Mr. Brown received a bachelor's of science degree from the University of New Mexico and a master's of science degree from Penn State both in nuclear engineering. He also holds an MBA from George Washington University, and we look forward to hearing from him.

Next we have Mr. Pat Yongpradit. Is that—do you want to say it for us?

Mr. YONGPRADIT. Yongpradit.

Chairwoman COMSTOCK. Yongpradit. Thank you. He is the Chief Academic Officer of Code.org, a nonprofit dedicated to promoting computer science education. Prior to this role, he had a career as a high school computer science teacher—my husband also did that, so I've got to give my husband credit for the kids being great in science and math too—where Mr. Yongpradit inspired students to create mobile games and apps. He has been recognized as a Microsoft Worldwide Innovative Educator and is certified in biology, physics, math, health and technology education. He received a bachelor's of science degree from distinction in biology from McGill University and a master's degree in secondary science education from the University of Maryland.

I now recognize Mr. Lipinski to introduce our third witness.

Mr. LIPINSKI. It's my pleasure to introduce Dr. Paul Alivisatos, Executive Vice Chancellor and Provost at the University of California-Berkeley, which shows that even though I'm a Stanford guy, I'm not biased. Dr. Alivisatos is also the Samsung Distinguished

Professor of Nanoscience and Nanotechnology, the Founding Director of the Kavli Energy and Nanoscience Institute, and Director Emeritus of Lawrence Berkeley National Laboratory. In his leadership Role at UC Berkeley, he oversees the university's many programs working to increase the number and diversity of students in STEM programs, and personally played a role in growing one of them, the Division of Data Science, by chairing the search committee for its dean. In addition to his academic achievements, Dr. Alivisatos is the founder of two prominent nanotechnology companies, Nanosys and Quantum Dot Corp, the latter which now is part of Thermo Fisher Scientific, the world's large scientific instrument company. Dr. Alivisatos holds a bachelor's degree in chemistry from the University of Chicago and a Ph.D. in chemistry from U.C. Berkeley.

Chairwoman COMSTOCK. Okay. And our final witness today is Ms. Dee Mooney, who has been Executive Director of the Micron Technology Foundation since 2006. In her role, she drives the Micron Foundation's programs—you don't drive the bus—aimed at advancing science and technology education and enhancing the quality of life in Micron's manufacturing site communities. As I briefly mentioned in my opening statement, of Micron's 13 locations in the United States, the company has an important presence in my district, which we very much appreciate and in the Commonwealth of Virginia. In fact, Micron's Manassas location is the site of the company's flagship 300-millimeter water fabrication facility, deploying the world's most advanced memory technology. In addition to employing over 1,200 people on its Virginia team, Micron and the Micron Foundation have donated $7 million toward Virginia education and community organizations and partner with Virginia universities to help support and inspire students in STEM education.

So, I want to thank you for all the important work that you do, and I think, you know, we have one example here today, but I know all of us could probably provide examples from our districts where our businesses and our small businesses and startups are so engaged in our community and with our students from a very young age. We have a Children's Science Center and we have various STEM programs where our businesses are always showing. They are active and engaged in those programs because you all know better than anyone understand the need for the STEM pipeline, so it's always very exciting for me when I see that STEM pipeline starting at a local, you know, science fair with five-year-olds, and your companies are there. So, thank you.

Ms. Mooney also serves on several educational and community nonprofit boards in Boise, Idaho, and is currently the Vice Chair for Idaho's STEM Action Center. She holds a bachelor's degree in psychology from Iowa State University and a master's degree in industrial psychology from the University of New Haven.

I now recognize Mr. Brown for five minutes to begin his testimony.

TESTIMONY OF MR. JAMES BROWN, EXECUTIVE DIRECTOR, STEM EDUCATION COALITION

Mr. BROWN. Good morning, and thanks to all of you on the Committee for the invitation the opportunity to testify at today's hearing.

One of the roles our Coalition plays is to listen to and be the voice of STEM stakeholders within the policymaking process, and one of the voices that we hear from a lot are grandparents. Grandparents do their homework and they get this issue. I will get a call from a grandparent who will read me a list over the phone of the highest-paying college majors—petroleum engineering, systems engineering, actuarial science, chemical engineering, computer science and engineering, nuclear engineering. They get it. They've done their homework. They get the fact that STEM skills are important not just to their children and their grandchildren but to the society in general.

They also get some of the ironies of this issue. So 83 percent of millennials sleep with their smartphones but only 16 percent of high school graduates have an interest in pursuing careers in science and technology, and they also get that that number would be a lot higher if we did a better job of getting women and students of color into these important fields.

I'm going to talk about three trends that are at work in the policy area that have lots of implications for STEM education. The first is what's going on at the state level. So in 2015, Congress passed the Every Student Succeeds Act. It replaced the No Child Left Behind law, and amongst other things, it grants back to the states and to districts a lot of decision-making powers over accountability systems and how they spend federal resources. Twenty-five states so far have put forward plans under this new education law, and we just completed an analysis of what's in those plans, and there are some positive trends. So 17 of those 25 states have added science to their state's accountability systems. This is a huge decision with implications for STEM education because it drives resource decisions up and down the education spectrum. A similar number of states have added career and technical education indicators and measures of advanced coursework taking like AP subjects that are STEM related. About a quarter of those states have also proposed to use federal resources for teacher quality programs to hire STEM educators to invest in teacher training programs for the teachers already in the classroom and similar activities, and another quarter of those states have proposed using new federal dollars available under a new funding stream to support well-rounded educational activities to support things like STEM competitions, hands-on science activities and STEM-focused specialty schools.

However, there's a catch. The Trump Administration's budget and the bills that have been moving through the House Appropriations Committee have been sending what I say are mixed signals about whether those programs will exist or what the funding levels will be for those programs, and I go into more detail in that in my written testimony. That's the first trend.

The second trend is the changing nature of the economy and of the STEM workforce. You've highlighted this in your opening statements, and I know the other witnesses will say this as well: the economy is changing. STEM skills are becoming much more important to employment, and that's across the spectrum, so not just the rocket scientist. From the supply room to the boardroom, STEM skills are more important, and the biggest area of growth is in the so-called middle skills jobs. About half the jobs in the STEM arena don't require a four-year college degree. Those are your STEM technicians, people in advanced manufacturing. The challenge is, parents and teacher are kind of lagging in their understanding of these trends, so people's images of those jobs are very different than the realities that exist today, and the National Science Foundation, for example, plays a huge role in studying these trends, being able to translate them into how we change our practices to capture more people who will be interested in these fields, and give them the right kinds of skills.

The third trend is the nature of learning is changing. One of the biggest recognitions in the STEM education community is that a lot of learning, important learning, is happening outside the classroom. It's happening online, it's happening in after-school programs, it's happening in museums. The kids that we're talking about that are not in the STEM fields, a lot of them will get their first experience with a mentor or a hands-on learning experience, and if you talk to people in the STEM fields, those experiences are a lot of times why they chose to go the way that they did in terms of careers, and again, the National Science Foundation has an incredibly important role in supporting knowledge about how those pathways work and how people make decisions in environments outside the traditional classroom, so that's an incredibly important area.

And lastly, I'll just say there's a strong bipartisan tradition of supporting STEM education as a policy priority. A lot of that tradition originated in this room, and what I would love to say to the next grandparent that calls us up and asks for help on this subject is the Federal Government has got their back on this issue.

[The prepared statement of Mr. Brown follows:]

Written Testimony
of
James Brown, Executive Director, STEM Education Coalition
to the
Committee on Science, Space, and Technology
Research and Technology Subcommittee
on
"STEM and Computer Science: Preparing the 21st Century Workforce"
July 26, 2017

Thank you for the opportunity to testify before the Committee and to offer our Coalition's views on the current state of science, technology, engineering, and mathematics education and the best federal policies to improve student outcomes in the STEM subjects.

As an alliance of more than 700 affiliated education, business, and professional organizations, the central mission of the STEM Education Coalition is to inform and guide federal and state policymakers on the critical role of STEM education.

In today's economy every American needs to have a strong foundation in STEM in order to succeed in virtually any job – from the shop floor to the research lab to the boardroom. Further, the best, highest-paying jobs of today are nearly all in the STEM fields. These jobs demand problem-solving, teamwork, creativity, and out- of -the -box thinking – all skills that are best cultivated through high quality learning opportunities in STEM. The steps we take to prepare our children now in STEM will have an enormous impact on the future of our economy, our national security, and America's continued leadership in science and technology.

Why STEM Matters

Our complex and changing world demands an adaptable workforce that is prepared to collaboratively reason through tough problems and come up with creative solutions to the challenges of tomorrow. STEM educational opportunities cultivate students' curiosity and creativity while teaching them to work as a team, base their reasoning on evidence, and solve problems through experimentation. Our students must gain the critical thinking abilities and other transferrable skills offered by STEM to be prepared for the unknown challenges and opportunities of our future

STEM education is closely linked with our nation's social and economic prosperity, and strong STEM skills are a central element of a well-rounded education. Why?

- At all levels of educational attainment, STEM job holders earn 11 percent higher wages compared to their same-degree counterparts in other jobs.[1]
- Half of all STEM jobs are available to workers without a four-year college degree, and these jobs pay $53,000 on average—a wage 10 percent higher than jobs with similar educational requirements.[2]
- 60 percent of U.S. employers are having difficulties finding qualified workers to fill vacancies at their companies. [3]
- While the U.S. economy grapples with economic recovery, job postings in in the STEM occupations outnumber unemployed workers by nearly two to one.[4]
- The top 10 bachelor-degree majors with the highest median earnings are all in STEM fields.[5]
- Almost all of the 30 fastest-growing occupations in the next decade will require at least some background in STEM.[6]
- Over the next 10 years, more than half (57%) of all manufacturing jobs will go unfilled because workers lack the skills needed to fill the positions[7]
- Although most parents of K–12 students (93 percent) believe that STEM education should be a priority in the U.S., only half (49 percent) agreed that it actually is a top priority for this country.[8]
- Only one in five STEM college students felt that their K–12 education prepared them extremely well for their college courses in STEM[9].
- Only 45 percent of U.S. high school graduates are ready for college work in math and 30 percent are ready in science.[10]
- Only one out of five households has access to and takes advantage of STEM-related after-school programming[11].
- Fewer than 40 percent of students who enter college intending to major in a STEM field complete a STEM degree.[12]

For all these reason, Congress must elevate STEM education as national policy priority as reflected through education reforms, policies to drive innovation, and budgetary priorities. More precisely, action by policymakers on STEM education should match the commonplace rhetoric about its importance.

States Are Making Important Decisions on STEM Education

The new federal K-12 education law, the Every Student Succeeds Act (ESSA) which was passed with broad bipartisan support in 2015 represents a fundamental shift in education policy with enormous implications for STEM education. This law will go into full effect over the next year and puts an array of key decisions affecting teaching and learning back into the hands of states and districts. Under ESSA schools are explicitly permitted to use federal dollars in a wide variety of new ways to support STEM activities.

In accordance with informal guidance issued under by the U.S. Department of Education in April, state and local education leaders can now support STEM activities with federal dollars in three main ways under the new ESSA framework:

- Increase students' equitable access to STEM courses and experiences, including out-of-school programs, STEM-themed schools, and career pathways;
- Support educators' knowledge and expertise in STEM disciplines through recruitment, preparation, support, and retention strategies; and
- Increase student access to materials and equipment needed to support inquiry-based pedagogy and active learning. [13]

It's worth mentioning that the guidance issued by the Trump Administration around allowable uses of federal funding to support STEM are nearly identical to similar guidance issued in 2016 by the Obama Administration, a sign of the recognition that STEM priorities are bipartisan and broadly shared.

In addition to these direct uses of federal funding provided to states and districts, states are permitted under ESSA to include student proficiency in science and other STEM-related subject areas in their state accountability systems. Meaning that student test scores in science can "count" in state accountability systems, broadening the focus of accountability dramatically from the narrow focus on math and reading that occurred during the No Child Left Behind era. Moreover, what we learned over the last 15 years is that if science doesn't "count", too many teachers will not choose or be allowed to teach science with their limited classroom time. Therefore, including science in state accountability can ensure this practice is not repeated.

These are the things that states *can* do under the new education law. What will they do?

If the first wave of state ESSA plans submitted to the Department of Education are a good indicator, the outlook is cautiously encouraging.

Our Coalition has collaborated with Education First and the Overdeck Foundation on an analysis of the 25 state ESSA plans that have either already been submitted (17 states) to the Department or that have published advanced drafts for public comment (8 other states)[14]. This analysis was published just last week has been covered since by Politico and by Education Week. Here are some highlights of what that analysis showed:

- **17 states are proposed to add student performance state science assessments to their state accountability systems.** This is a very important measure of STEM as a policy priority, since inclusion in accountability systems will influence a large number of "downstream" factors, such as instructional time, classroom resources, teacher recruitment plans, etc.
- **17 states (not the same 17 as with science) are adding career and technical education indicators to their accountability systems.** Similar to science, the inclusion of these measures will help link CTE coursework with college and career ready standards, will promote more rigorous CTE coursework, and will shed more light on economic and racial disparities in outcomes for CTE students, many of which end up in STEM careers.
- **19 states are adding Advanced Placement or International Baccalaureate indicators to their accountability systems.** AP/IB coursework is heavily focused on STEM subjects and is a very good mechanism for measuring how advanced coursework and highly trained teachers are distributed. Students taking advanced coursework are more likely to succeed in postsecondary education.
- **10 states are integrating STEM as priority for afterschool programs.** These states are requiring or encouraging federal funding for the ESSA's 21st Century Community Learning Centers program (Title II, Part B) to be focused on STEM-related activities and programs. These programs often reach a higher proportion of at-risk youth and have measurable impacts on the uptake of "employability" skills and student interest in STEM fields.
- **5 states will prioritize STEM in teacher professional development plans.** Federal funding under Title II of ESSA is a vital source of support for in-service teacher professional development and many states are proposing to use such funds to attract and retain STEM educators and to align curricula with workforce requirements.
- **5 states will also prioritize STEM as a core component of a "well-rounded" education.** One of the new funding streams under ESSA was the Title IV, Part A Student Success and Academic Enrichment Grants program, which will provide new flexible resources, mainly at the district level that can support a wide range of activities that contribute to a "well-rounded" education, including STEM activities, along with student health and safety, and classroom technology. This program is where the largest portion of new STEM activities included in ESSA reside.

The important conclusion of this analysis is that many states are responding to the economic and social signals they are receiving from parents, students, teachers, employers, and the global economic environment with an increased focus on STEM education, which was one of the main goals of the new education law.

However, Congress and the Trump Administration are sending mixed signals back to the states that are not making it easier for states to accomplish their STEM goals. The Trump Administration has proposed to entirely eliminate funding for many of the very ESSA programs that states are now proposing to utilize to support STEM education goals, including Title II.A Teacher Quality ($2 billion), Title IV, Part A "Well-Rounded" ($400 million), and Title IV, Part B Afterschool ($1.2 billion). Further, the House Appropriations Committee just last week advanced a FY 2018 bill for education programs that would also eliminate the $2 billion Title II professional development program, while adding $100 million for well-rounded education, and trimming almost $200 million out of the afterschool appropriation. Our Coalition strongly supports full funding for of these essential programs[15].

The major point we want to convey is that state and local policymakers need to see that there will be consistent and predictable federal funding levels provided for the federal programs they will depend on to support STEM education goals. We recognize that the federal budget process is chaotic and that we are faced with a large national deficit and mounting debt. However, state and district governments deal with the same realities and if we want them to prioritize STEM activities, they need to know that the federal government will be a reliable, supportive partner in those efforts.

While we have focused so far on the major role the Department of Education plays in administering more than $30 billion in federal funding for K-12 education, it is important to note that the National Science Foundation (NSF) and other federal science agencies have critical roles in aiding school, teachers, students in accomplishing national and state STEM goals, assessing outcomes, evaluating best practices, and in supporting specific STEM disciplines. The role of NSF in particular is becoming more important as the ways we learn about and choose careers change with rapid developments in technology.

Modern Career Notions Around STEM

Being a high-schooler today and contemplating decisions about college, career, and other forms of postsecondary education is daunting.

Colleges have become very expensive, with tuition and fees at public four-year colleges and universities growing 19 times faster than the median family income since 1980[16]. Student debt has grown to over $1.3 trillion[17]. Employees entering the workforce today can also expect to have many more jobs throughout their careers than their parents.

STEM careers are changing rapidly as well. As the global economy becomes more technological, more jobs require STEM skills across the spectrum from the board room to the factory floor – and especially so-called "middle skills" jobs that are important in advanced manufacturing and the service industries. Further, as technology has become more commonplace, so has data and data-driven decision making. These trends are now being explored in depth across the American workforce and are understood by almost every modern business.

However, parents, teachers, and students – and the education system in general – are struggling to keep up.

As an example, the Brookings Institution published a great study a few years ago documenting that roughly half of the jobs in the STEM fields do not require a four-year college degree[18]. This finding is very much at odds with the perceptions of parents in public opinion surveys, where recent studies have shown that large numbers of parents do not think "science is for their kids" or that "the average American doesn't need science skills."[19]

There are similar trends at work with teachers and students, where a variety of misperceptions exist about careers in STEM fields, salaries for those STEM careers, and the prospects for people from diverse backgrounds in STEM fields.

A lot of kids and parents are not aware that STEM-skilled technicians – the people who repair airplanes, medical devices, modern cars, or maintain security for IT systems – make as much or more as many college degrees and many times enjoy greater job satisfaction and lower rates of unemployment[20].

These disturbing trends are due, at least in part, to longstanding imagery of scientists doing their work in white lab coats. And the images of scientists and engineers conjured in the minds of many are mostly white and male. These public images matter in career decision making at every level.

The National Science Foundation plays a powerful role in fueling our knowledge base around these issues. NSF programs have traditionally expanded our understanding of trends in STEM careers and in the education of students and teachers to join those careers.

NSF needs the resources to make sustained investments in understanding how to cultivate more STEM talent from communities of color and how to overcome barriers to the participation of women and minorities in STEM fields. NSF also needs to help educators understand how best to use technology in their classrooms and integrate experiential learning and student use of the internet.

NSF must also continue to focus on discovering better ways to educate new teachers with core STEM skills – and how to support those teachers in our poorest and most challenging school environments.

We certainly appreciate the Committee's support for helping to provide NSF with the legislative authority to address these challenges. The STEM Education Act of 2015 helped to expand the definition of "STEM" fields to include computer science – a needed modernization and to help improve the Noyce Scholarship program for STEM teachers by making it more accessible to prospective teachers seeking a graduate degree. We also appreciate the Committee's work earlier in the year to pass legislation signed into law by President Trump to promote NSF efforts to bring more women and girls into the STEM fields[21].

I know my other colleagues on the panel will provide more details around computer science, but we certainly share the belief that computer science has emerged as an essential skill in many, many modern career paths. Our Coalition has long-supported an inclusive definition and use of the term "STEM education" by federal and state programs that is not practically limited to only math and science, but also embraces engineering and technology and their related disciplines, including computer science, data analytics, statistics, and other related computing fields.

Afterschool, Informal Learning, and STEM Education

At the same time technology and globalism is rapidly changing the American workforce, the ways in which students learn and become familiar with their career choices are changing at an equally frenetic pace.

One significant trend is the STEM education community's enthusiastic embrace of informal education programs as a mechanism for improving educational outcomes. If we want to employ an "all hands on deck" approach to improve STEM, we must fully utilize the opportunities presented by out-school, informal, and afterschool learning environments. Emerging research is demonstrating very clearly that out-of-school STEM programs contribute to both academic and social measures of student success.

A major study published in *Science* in 2006 found that "professed interest in STEM careers by eighth grade was a more accurate predictor of getting a science-related college degree than were the math or science test scores of those same eighth-grade students."[22]

More than a decade of increasingly comprehensive studies have reinforced the notion that informal learning can make concrete, measurable contributions to student success, not only in the classroom environment, but in broader measures of youth development, maturity, and career success.

A study of the U.S. Department of Education's 21st Century Community Learning Centers program, the only federal funding source exclusively dedicated to afterschool programs, showed that participating students had fewer absences and less tardiness, higher grades, higher rates of homework completion, and increased rates of parental involvement in school[23].

After a 15-month review of the current evidence base, the National Research Council's (NRC) Board on Science Education concluded in a recent 2015 study that out-of-school programs have been shown to:

- contribute to young people's interest in and understanding of STEM,
- connect young people to caring adults who serve as role models, and
- reduce the achievement gap between young people from low-income and high income families.[24]

The beneficial aspects of informal and out-of-school STEM programming have certainly been noticed by the private sector, where a wide range of companies are increasing their philanthropic focus on STEM generally and on informal opportunities in particular, including afterschool STEM programming, STEM-related competitions, student "real world" experiences, and similar opportunities to provide young minds with high-quality meaningful experiences in STEM[25].

In this area, the STEM Education Act of 2015 is also helpful, as it reaffirmed the important role of the NSF in pioneering research into how informal and classroom-based learning methods can be most effectively integrated and best employed. Federal policies that seize on afterschool programs and their unique role in inspiring interest and success in STEM education will engage more young people in the STEM fields so important to the future of our country.

Closing

A dozen years ago, one of our Coalition's main goals was to get Congress to recognize that improvements in STEM education had to be thought of as being just as important to the future of the country as investments in basic research and development. The 2007 passage of the America COMPETES Act, other bipartisan legislation from this Committee, the initiatives of two prior Presidential administrations of different parties, and the 2015 passage of the Every Student Succeeds Act have all served to elevate STEM education as a national priority. However, the challenge has really only begun as countless school districts, principals and teachers across the country are now searching for solutions to the myriad of daily challenges inherent in making STEM a functional daily priority. We see the proper federal role in this

environment as providing our schools with the proper resources, tools, and supports – both political and financial - to successfully rise to that challenge.

We appreciate the chance to offer our views and pledge to work with the Committee and your colleagues in Congress achieve these common goals.

Thank you.

STEM Education Coalition Leadership Council Members

www.stemedcoalition.org

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Biographical Background
James Brown
Executive Director
STEM Education Coalition
July 2017

James Brown is the Executive Director of the STEM Education Coalition, an alliance of more than 700 business, professional, and education organizations, that works to raise awareness in Congress, the Administration, and other organizations about the critical role that STEM education plays in enabling the U.S. to remain the economic and technological leader of the global marketplace of the 21st century. Prior to joining the Coalition, he was Assistant Director for Advocacy at the American Chemical Society. A nuclear engineer by training, he previously worked as a Legislative Aide for Rep. Doc Hastings of Washington and began his career as an engineer with Newport News Shipbuilding, working on aircraft carrier construction. He received a B.S. from the University of New Mexico and an M.S. from Penn State, both in nuclear engineering. He also holds an MBA from George Washington University.

Chairwoman COMSTOCK. I now recognize Mr. Yongpradit for his testimony.

TESTIMONY OF MR. PAT YONGPRADIT, CHIEF ACADEMIC OFFICER, CODE.ORG

Mr. YONGPRADIT. Thank you, Ms. Comstock. That was a great job.

So Chairwoman Comstock, Ranking Member Lipinski, and members of the Subcommittee, on behalf of Code.org, thank you for this opportunity to testify about the importance of computer science education in preparing the country's 21st century workforce. My name is Pat Yongpradit. I'm the Chief Academic Officer of Code.org. But more importantly, I'm a former computer science teacher, just removed from the classroom four years ago. And being a teacher is hard. Being a computer science teacher in this Nation is even harder. You are often the only computer science teacher in a school. If you're in one of the 21 states without a clear computer science certification pathway, you may have to be certified in a different subject to teach computer science, and if you're in one of the 40 states that don't have computer science standards like Mr. Lipinski already noted, you may lack any curricular direction and have to constantly craft resources on your own. The lack of support from the state level is not surprising as there are only a handful of states that have dedicated funding for computer science or have any state position that's even responsible for K–12 computer science. All of these challenges apply to mean as a teacher in Silver Spring, Maryland, but my school at one thing going for it. At least it had a computer science teacher. As reported in a survey administered by Gallop, the problem is that the majority of schools, 60 percent, don't even offer computer science. That means thousands of students, students in your districts who want to learn computer science just can't.

So the challenge before our Nation is clear: preparing enough computer science teachers and creating policies that will install and high-quality computer science experiences for all students.

So much has been said about our Nation's STEM crisis, but when we talk about the STEM crisis in our economy and schools, we need to address the greatest area of concern: computing. The Bureau of Labor Statistics has projected that millions of new STEM jobs will be created between 2014 and 2024, but did you know that while six percent of new job growth will be in life sciences, where I got my undergrad degree? Over 70 percent of new growth will be in computing occupations. So this impact goes beyond STEM like Mr. Brown noted.

Computing occupations have become the single largest sector of new wages in the United States overall. Almost half of all professionals who use advanced computing skills like coding are in non-STEM fields, so a 21st century doctor, lawyer or even banker may not need to know how to write complex code but they at least need to understand the inner workings of an app, what's a website, security and other computing basics, and this isn't just about future jobs. It's about the 500,000 currently open jobs in our Nation. These are private and public sector jobs such as cybersecurity.

How do we strengthen our Nation's cyber defenses? Provide every American with a foundational K–12 computer science education. This will also build a pipeline for our Nation's cyber workforce.

So our crisis is that while job demand is high, only 40 percent of our schools teach any amount of computer science. Only eight percent of our STEM graduates are in computer science. There just aren't enough Americans prepared to meet the demand.

Furthermore, the existing workforce isn't diverse. The root cause is our K–12 system. For example, of the students who took the AP computer science exam in Virginia last year, only 24 percent were female. In Illinois, that percentage was 21 percent.

Code.org is a national nonprofit dedicated to expanding access to computer science, so we're working on this, we with our partners. So we're known for an annual Hour of Code, which many Members of Congress have engaged in. We call on students all over the world to engage in one hour of coding during the week of Computer Science Education Week. That's just the beginning.

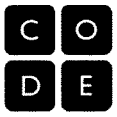
We also create free, open-source courses. We've trained more than 60,000 teachers nationwide in all of your states to teach computer science. We partnered with 120 of the largest school districts. We even have set up a Governor's Partnership for K–12 Computer Science. There are nine governors, six Republicans, three Democrats. Governor Hogan from Maryland just joined two weeks ago.

So looking forward, there is much work to do. The majority of schools in the United States don't teach computer science at a time when Canada, Ireland, New Zealand, Romania, Malaysia, Japan, Sweden and the U.K.—the U.K. has been at this for three years already instituting nationwide computer science.

So Code.org and the computer science community are grateful for the help we have here on Capitol Hill. If at any point you want to talk more about what's happening in your states, your districts around computer science, that's basically my thing. I go around to state departments of education and help drum up more work around computer science and help them with their goals as well.

So thank you for this opportunity to speak and I look forward to hearing from our other panelists.

[The prepared statement of Mr. Yongpradit follows:]



Testimony of
Pat Yongpradit
Chief Academic Officer, Code.org

Before the
US House of Representatives
Committee on Science, Space and Technology
Subcommittee on Research and Technology

STEM and Computer Science Education: Preparing the 21st Century Workforce
July 26, 2017

Chairwoman Comstock, Ranking Member Lipinski and Members of the Subcommittee, on behalf of Code.org, thank you for the opportunity to testify about the importance of computer science education in preparing the country's 21st Century Workforce. My name is Pat Yongpradit and I am the Chief Academic Officer of Code.org and a former computer science teacher.

Being a teacher is hard - being a computer science teacher is even harder. You are often the only computer science teacher in a school. If you are in one of the twenty-one states without a clear computer science certification pathway, you may have to be certified in a different subject to teach computer science. If you are in one of the 40 states that don't have computer science standards, you may lack any curricular direction and have to constantly craft resources on your own. Attendance at professional development or conferences? It probably comes out of pocket. In order to sustain your job, you may have to actively promote the program and recruit students. All of these applied to me. But Springbrook High School in Silver Spring, MD, had one thing going for it--at least it had a computer science teacher. As reported in a survey administered by Gallup, **the problem is that the majority of schools (60%) don't even offer computer science.**

The challenge before the nation is clear: Preparing enough teachers and creating policies that will install and sustain high quality computer science experiences for all students.

The STEM Crisis is a Computing Crisis

When we talk about the "STEM" crisis in our economy and schools, we are mainly talking about a computing crisis. The Bureau of Labor Statistics has projected that millions of new STEM jobs will be created between 2014 and 2024, and that the majority of STEM job growth will be in computing occupations. For comparison, 70% of new job growth in STEM fields will be in computing occupations,

while only 6% will be in life sciences. In fact, there will be more new job growth in computing occupations than all other STEM fields combined. The issue is that there aren't enough American graduates to fill the need, as only 8% of all STEM graduates are in computer science. This problem affects more than just the high tech field and traditional STEM areas. A recent report from Change the Equation uncovered that almost half of the 7.7 million professionals who use advanced computing skills, such as coding, are in non-STEM fields. Almost every job -- medicine, law, business, banking and even government -- 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 at least need to understand the inner workings of an app, a website, cookies, software security, and other computing basics.

National numbers tell the big story, but state level data shows the local crisis. In Mrs. Comstock's state of Virginia, there are 35,591 open computing jobs (4.5x the state average demand rate) but only 1,570 computer science graduates. Of the 2,856 students who took the Advanced Placement Computer Science A exam in Virginia last year, only 24% were female. In Mr. Lipinski's state of Illinois, there are 21,204 open computing jobs (3.8x the state average demand rate) and 1,768 computer science graduates. Of the 2,938 students who took the Advanced Placement Computer Science A exam in Illinois last year, only 21% were female. Nationally, the AP Computer Science A exam boasts the lowest percentage of women text-takers among all 38 AP exams. Our states aren't graduating enough students in this field and even when there are interested students, they do not represent the broader population.

The key issue here is a matter of access, rather than demand. In a survey of what subjects students like the most, computer science outranked the core subjects and was only second to the arts and performing arts. 90% of parents want their children to learn computer science, but only 40% of schools offer it.

Computer Science Education and Code.org

I know that you and your colleagues on the Science, Space and Technology Committee and in Congress have grown increasingly aware of the importance of computer science education in K-12 schools in recent years. In fact, you and your colleagues have supported pieces of legislation that have been enacted and that have produced real results in growing access to computer science in the country's schools. For example, the passage of The STEM Education Act of 2015, which added computer science specifically to the definition of STEM at federal research agencies, inspired higher education institutions in Maryland to add computer science to their STEM endorsement programs for teachers. In addition, computer science is included as part of a "well-rounded education" in the 2015 revision of the Elementary and Secondary Education Act, and computer science teachers are specifically eligible for some of the professional development programs in the law. Thank you. At Code.org, we appreciate that progress and look forward to building upon it.

Code.org is a national nonprofit dedicated to expanding access to computer science in K-12 education—especially for female students and underrepresented minority students. We were founded in 2013 and are known best for our annual Hour of Code, which encourages people all over the planet to spend just

one hour learning a few fundamentals of coding. The event reaches tens of millions in over 180 countries each year--and even a few Members of Congress have tried it. But the Hour of Code is just the beginning—only a taste of what computer science has to offer. And it's only one small part of a larger effort to expand access to essential skills that put more students on the pathway toward career-readiness.

In addition to Hour of Code, we create open-sourced courses for students and adults. We offer professional development to prepare teachers to teach computer science at all grade levels. To date, we've prepared more than 60,000 teachers to teach computer science at all grade levels. We've also partnered with more than 120 of the largest school districts to add computer science to the curriculum. These districts teach almost 10% of all U.S. students and 15% of Hispanic and African American students. We are also building capacity in local organizations through a nationwide network of 41 regional partners. We are working hard to bring about wholesale change in the K-12 education system and have so many wonderful partners in this effort.

Along with our partners in the Code.org Advocacy Coalition, Code.org engages with state boards of education, state departments of education, governors' offices, and legislators. Code.org has been involved in the adoption of policies that support computer science in more than 20 states over the last few years. Nine governors have joined the Governors' Partnership for K-12 Computer Science, with Maryland's Governor Hogan announcing his membership on July 14, 2017. To guide states and school districts, Code.org partnered with four other organizations to steer the development of the K-12 Computer Science Framework. The Framework provides guidance to states and districts around topics such as curriculum, course pathways, teacher preparation, and standards.

There has been much progress in growing access to K-12 education. In fact, this year, the broader computer science community celebrated a major milestone. In May, more than 50,000 students took a new Advanced Placement (AP) Computer Science course called AP Computer Science Principles, the largest launch for any AP course ever. Then, just recently, we learned that more than 29,700 female students took an AP computer science exam in 2017. That's a 135% increase from 2016 and a dramatic increase from the 2,600 female students that took the AP Computer Science exam 10 years ago. Furthermore, participation by black and Latino students increased by 170% since 2016, to more than 22,000. There are many factors that contributed to these gains, but we are encouraged by them and proud of the role we played in getting the nation to this point.

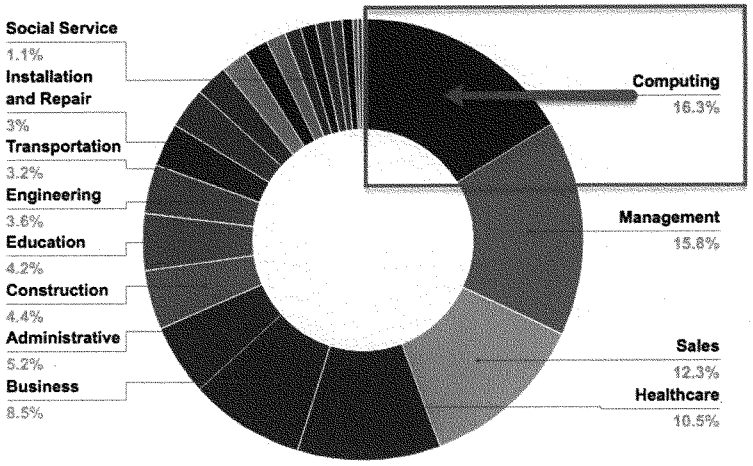
Looking forward, there is still much work to do. As I noted before, the majority of schools in the US still don't teach computer science at a time when more countries are choosing to require that computer science be taught to their students in elementary and secondary schooling. And, while 40% of schools do offer some amount of computer science, there is a challenge in expanding that to 100% rapidly since there are not enough computer science teachers right now to do so. Code.org and the computer science community continue to think about and address these issues daily. We are grateful for the help we have in that endeavor here on Capitol Hill, in the states and in local districts.

Growing Opportunities for Americans

Our working class – young and old, rural and urban, Democrat and Republican – is worried about being left behind by globalization, technological change, and a system that doesn't seem to reward hard work the way it used to. The American Dream feels broken.

Computing jobs provide individuals the most economic opportunity, and there are more than 500,000 open jobs in computing right now. This decade, computing occupations have become the single largest sector of *new* wages in the U.S. This isn't just about future jobs. It's about more than 500,000 currently open jobs. These are among the best-paying jobs in the country; they are private sector and public sector jobs. They support the country's security and is financial markets. And these job openings are growing almost twice as fast as all the other jobs in the country.

Breakdown of new wages in the U.S., by occupation category



As you know, often our solution to fill these openings is to import talent from across the globe. Given the majority of high-skilled immigration is for computer scientists, we should embrace policies that will grow talent at home.

The opportunity goes far beyond just coding and California; this isn't just about Silicon Valley. 91% of open software and computing jobs are outside Silicon Valley. For example, in Michigan there are 14,384 *currently open* jobs.[1] This isn't just about tech companies. 67% of computing jobs are in retail, banking, transportation, entertainment, agriculture, manufacturing, and government.

[1] Data on current job openings in computer science: Conference Board data compiled by Code.org

The Solution is in Education and Re-training

Every school should offer computer science. Here are three specific things the Federal government can do:

1. **Provide federal funding for K-12 schools to teach computer science.**
   Every school should teach computer science. As a nonprofit that has been addressing this problem at a national scale our analysis shows the true cost is closer to $400M, as a one-time expense that could be spread over four years.

2. **Provide incentives to universities to prepare graduates for our workforce needs.**
   As tuition and student debt skyrocket, consider rewarding colleges that adapt their curriculum and teaching capacity to fit today's workplace needs. A computer science degree, from any college, is worth much more than any other college degree[2]. Students with these degrees are able to repay their tuition loans faster, and rarely default. Consider slashing their interest rates.

3. **Expand re-training programs for adults.**
   Create programs to retrain adults in computing skills to put the underemployed back to work. Technology boot-camps for adults are already the fastest-growing sector of private education, and they're needed in more regions, urban and rural.

Exposure in K-12 Addresses Cyber Issues

Given a growing cyber threat and our country's lack of preparation to defend itself, this issue goes beyond education and economic opportunity – it is a matter of *national security*, evidenced by the Department of Defense's own challenges in hiring software and cybersecurity experts. The weakest link in our cyber defense is our own citizens and their inadequate technology education.

Cybersecurity cuts across many domains of study, but the technology itself has its roots in computer science. Because of the unique role cybersecurity specialists play in our country's security, the most sensitive jobs in this field must be filled by US citizens. And it's clear we are not producing enough highly skilled security specialists to address our growing cybersecurity needs. A report from the Center for Strategic and International Studies stated, "There are only about 1,000 security specialists in the United States who have the specialized skills to operate effectively in cyberspace; however, the United States needs about 10,000 to 30,000 such individuals."[3]

Expanding access to K-12 computer science will help meet the specialized needs of the cybersecurity workforce needs in the long run. As our overall pipeline of diverse students in the US interested in and willing to study computer science in higher education expands, so will the potential pool of students specializing in the technical aspects of cybersecurity.

Beyond just giving students access to the foundational aspects of computer science, we can also expose students to specific cybersecurity concepts within K-12. For example, students can understand how

[2] Comparison of the lifetime value of college degrees: the Hamilton Project.

[3] http://csis.org/publication/prepublication-a-human-capital-crisis-in-cybersecurity

technology impacts their lives (e.g., social networking, cyber-bullying, mobile computing). In a high school introductory course, all students can develop a broad understanding of computer science that exposes them to basic principles of security such as cryptography, threats, and authentication, which will increase interest in taking more specialized courses in cybersecurity. Cybersecurity education has a natural home within computer science courses, and as these courses expand in K-12, we can also expand exposure to and the depth of cybersecurity-specific instruction.

Policy and Expanding K-12 Computer Science Access

Decisions about education funding, standards, and policies are often local ones. But we've never had an urgent need to add an entire new field of study to our K-12 system. The Reagan Administration first sounded the alarm for teaching computer science in high school. 30 years later, less than half of our schools even offer it, we struggle to fill open computing jobs, and our national security is at risk. U.S. governors -- all of whom support more local control of education -- recognize this issue goes beyond any one state. Last year, 27 bipartisan Governors came together to ask Congress for targeted funding to address this issue.

History has shown local programs alone won't address this problem. How many state departments of education have even a *single* employee in charge of K-12 computer science? Only eight. If there's not even a single person running a computer science department at the state or district level, the local budget will be divided among the departments that already exist, leaving nothing for the computer science department that hasn't even been formed yet.

Everybody agrees we should do this. Support for computer science is gratifyingly strong. It has the bipartisan support of Governors, Members of Congress, and Mayors from both sides of the aisle. Surveys show that 90% of American parents want their children to study computer science in school, and 88% want this to have federally funding support. Last year, a coalition of Fortune 500 CEOs, governors, educators, and nonprofit leaders signed an open letter asking the Federal government to fund computer science education. This issue has the support of not just every major *tech* CEO, but also the CEOs of America's top airlines, hotel chains, banks, manufacturers, entertainment companies, you name it.

Conclusion

Despite the divisions in America, we can find common ground on issues like this, that everybody agrees on. I am proud of Code.org and its allies in the computer science community that have made so much progress in recent years. I look forward to building on it.

Thank you again and I'm happy to answer any questions you have.

Code.org
1501 4th Ave, Suite 900
Seattle WA 98101
www.code.org

Biography

Pat Yongpradit is the Chief Academic Officer for Code.org, a nonprofit organization dedicated to promoting computer science education. As a national voice on K-12 computer science education, his passion is to bring computer science opportunities to every school and student in the United States. During his career as a high school computer science teacher, he inspired students to create mobile games and apps for social causes and implemented initiatives to broaden participation in computer science among underrepresented groups. He has been featured in the book, "American Teacher: Heroes in the Classroom", has been recognized as a Microsoft Worldwide Innovative Educator, and is certified in biology, physics, math, health, and technology education. Although Pat currently spends more time focused on computer science from a national perspective, he still finds ways to sneak into the classroom.

Chairwoman COMSTOCK. Thank you.

And now we'll hear from Doctor——

Dr. ALIVISATOS. Alivisatos.

Chairwoman COMSTOCK. Alivisatos. Thank you. Just like it reads. My sister is a Rapawano, and it reads just like that, so——

TESTIMONY OF DR. A. PAUL ALIVISATOS,
EXECUTIVE VICE CHANCELLOR & PROVOST,
VICE CHANCELLOR FOR RESEARCH,
AND PROFESSOR OF CHEMISTRY AND
MATERIALS SCIENCE & ENGINEERING,
UNIVERSITY OF CALIFORNIA, BERKELEY

Dr. ALIVISATOS. Madam Chairperson and Members of the Subcommittee, thank you. I'm very grateful for this opportunity to comment on the challenges and opportunities we are seeing in higher education for computer science and related fields.

Tragically, as was noted earlier, even as computer science and engineering and data science as well have permeated essentially every aspect of our lives and the economy, the percentage of women and under-represented groups majoring in these disciplines has at best been holding steady and in many cases is actually declining. Further, the quantity of students we are able to train can only grow significantly if we imagine new ways of both inspiring and teaching students.

I want to talk about the new approaches Berkeley is taking to better serve our community and the Nation in this area. What can we do to increase the number and diversity of students who pursue computation and data sciences as well as other sciences and engineering subjects?

First, our universities can create programs targeted to reverse this decrease of participation of women and minority students in computer science and related fields. At UC Berkeley, we have a whole group of programs, each of which differs slightly, and which we're testing to see which ones work the best. One is the CS Scholars program, the most recent cohort of 65 undergraduate scholars. It's the largest to date and has representation of 62 percent female students and 26 percent under-represented minority students. Another is a Computer Science Capacity Award funded by Google to provide special discussion, tutoring and other support.

More importantly, I would say at this point at Berkeley we are opening up the power of data science to all of our students. Two years ago, we established a course called Foundations of Data Science that is based on helping students from any major or any background to address questions that interest them using the powerful tools of data science. From linguists to chemistry and from history to economics, students from over 60 majors have responded. This is the fastest growing program in the history of Berkeley. It will serve over 1,000 students in the fall.

We are rapidly building on this success, adding follow-on classes. We just hired David Culler as our first Dean of Data Sciences. A new undergraduate major is in development but even more important, a minor in data science will be offered and completed by thousands of students a year with an unprecedented range of diversity.

How can we build on this observation that students readily excel at technical subjects of great difficulty even those that they previously shied away from when they are personally engaged in asking a question they care about? At Berkeley we are working to give every undergraduate the opportunity to engage in a hands-on discovery experience. It's amazing what happens to students' interest once you get them out of a lecture hall and into a research and discovery team. With greater inspiration and understanding of their field, we expect better student engagement and retention in their chosen majors including computer science.

To offer personal discovery experiences to thousands more undergraduates, potentially even to all 27,000 who are at Berkley at any one time, we will engage our talented graduate students and postdoctoral scholars as mentors. Discovery experiences hold promise to bring more talent to the hard problems our society faces, and to introduce a new generation of very well-prepared students into vital sectors of our economy. As we are now entering a new phase of promoting these discovery experiences in a systematic way, we are discovering that there are many paths for us to do this and that the data science major will be a crucial piece of achieving that.

I hope that any of you that are in the Bay area will take some time to come and visit Berkeley to see what's going on and to meet some of our students because it's a phenomenal transformation that's going on.

Thank you.

[The prepared statement of Dr. Alivisatos follows:]

TESTIMONY OF DR. A. PAUL ALIVISATOS
Executive Vice Chancellor and Provost
and Vice Chancellor for Research
University of California, Berkeley

"STEM and Computer Science Education: Preparing the 21st Century Workforce,"
Wednesday, July 26, 2017
Research and Technology Subcommittee
House Committee on Science, Space, and Technology

Mr. Chairman and members of the Subcommittee, thank you for this opportunity to testify before you today.

My name is Paul Alivisatos, and I'm here on behalf of the University of California, Berkeley, where I have served as Vice Chancellor for Research, and just became Provost. I am also a professor of nanoscience and technology. I meet with my students most days of the week, and together we make discoveries, like the ones that form the basis of Quantum Dot TVs and tablet devices that are now widely available in stores. I previously directed the Lawrence Berkeley National Laboratory, which provides some of the most powerful scientific computing and data networking capabilities in the world available to tens of thousands of scientists from 17 national labs, hundreds of universities, and many companies large and small.

I've been invited to comment on the challenges and opportunities we are seeing in higher education for computer science and related fields. Tragically, even as computer science and technology and data science have permeated every aspect of our lives and the economy, the percentage of women and under-represented groups majoring in these disciplines has at best been holding steady and in many cases is actually declining. Further, the quantity of students we are able to train using current approaches is far too limited.

Today, I want to talk about the new approaches Berkeley is taking to better serve our community and nation in this area. **What can we do to increase the number and diversity of students who pursue computation and data sciences as well as other sciences and engineering subjects?**

First, our universities can create programs to try to address under-participation of women and minority students in Computer Science and related fields. At UC Berkeley, we have a number of programs that try to address this in different ways, which I discuss in my written remarks. One is the **CS Scholars Program**. The most recent cohort of 65 undergraduate scholars is the largest to date, with a representation of 62% female students and 26% under-represented minority students. Another is a **Computer Science Capacity Award** funded by Google that provides special discussion, tutoring and other support.

Second, at Berkeley we are opening up the power of data science to **all** students. Two years ago we established a course, Foundations of Data Science, that is based on helping students from any major or any background to address questions that interest *them*, using the powerful tools of data science. From linguistics to chemistry, and from history to economics, students from over sixty majors have responded, and this is the fastest growing program in the history of Berkeley; it will serve over a thousand students in the Fall. We are rapidly building on this success, adding follow-on classes, and we just hired our first Dean of Data Sciences. A new undergraduate major is in development, but even more important, a minor in data science will be offered and completed by **thousands** of students a year with an unprecedented range of diversity.

How can we build on this observation that students readily excel at technical subjects of great difficulty, even ones that they previously shied away from, when they are personally engaged in asking questions they care about? At Berkeley we are working to give every undergraduate the opportunity to engage in a hands-on discovery experience. It's amazing what happens to students' interest once you get them out of a lecture hall and into a research and discovery team. With greater inspiration and understanding of their field, we expect better student engagement and retention in their chosen majors, including Computer Science, to improve.
To offer personal discovery experiences to thousands more undergraduates, potentially even to all 27,000 who are at Berkeley at any one time, we will engage our talented graduate students and postdoctoral scholars as mentors. Discovery experiences hold promise to bring more talent to the hard problems our society faces, and to introduce a new generation of very well prepared students into vital sectors of our economy.

We are going to learn a lot from these initiatives, and I invite you to visit Berkeley to see how we are doing. I'd be happy to answer any questions you have. Thank you.

APPENDIX

The Evolving Landscape for Computer Science

Computation has become a critical aspect of almost every sector of the economy, not just a narrow segment, an essential part of almost every aspect of our daily lives, a critical component of essentially every field of inquiry, and a hallmark of our Nation's global leadership, and yet it remains largely an afterthought in our education system. Leading research universities began providing Computer Science degrees in the '60s. With the emergence of the Personal Computer in the '80s, along with electronic information processing in many industries, Computer Science programs spread across the higher education landscape, including 4-year Colleges, Liberal Arts institutions, 2-year Community Colleges, and For-profit institutions. Today roughly 1,500 institutions offer Bachelor degrees, over 500 offer Masters, and nearly 200 offer PhDs - largely in reaction to rapidly growing student demand. In the last few years, we have begun to introduce Computer Science concepts in the K-12 education pipeline.

Indications of the sweeping change of the role of computing and information technology in our society are everywhere, we note a few here:

- In this year, we will cross the threshold where the majority (50%) of the world's population use the Internet, from less than half a percent in 1995. [http://www.internetworldstats.com/emarketing.htm#stats].
- Today, nearly two billion people are active Facebook users, over 1.5 Billion Google searches will performed, and over 1.7 Billion videos will be viewed on the Internet.
- Of the five companies with the largest market capitalization, in 2016 all of them are Information Technology (Apple, Alphabet, Microsoft, Amazon, Facebook), whereas until even five years ago, this was dominated by Energy and Financial companies (in 2011 Exxon, Apple, PetroChina, Shell, Industrial and Commercial Bank of China) [http://www.visualcapitalist.com/chart-largest-companies-market-cap-15-years/]
- From 1978 to 2015, the number of people working in computing occupations rose from 219,000 to 4,106,000, an increase of nearly 1800% over a period in which total employment rose by only 58%. [Source: Bureau of Labor Statistics, Current Population Survey]. Particularly because most jobs in computing require at least some university-level education, the dramatic increase in employment has had a significant effect on the number of students seeking computing degrees.
- As of 2014, the number of people employed in computing occupations was 3,916,100.[1] The total number of Bachelor's degrees in computer science awarded by U.S. institutions *throughout the entire history of the field* is only 1,313,034.[2] The number of employees in computing occupations is therefore approximately three times larger than the number of Bachelor's degrees in computer science ever produced in the United States. [Bureau of Labor Statistics. 2015. *Employment Projections: 2014-2024.* Washington, DC: Bureau of Labor Statistics, December 2015, Table

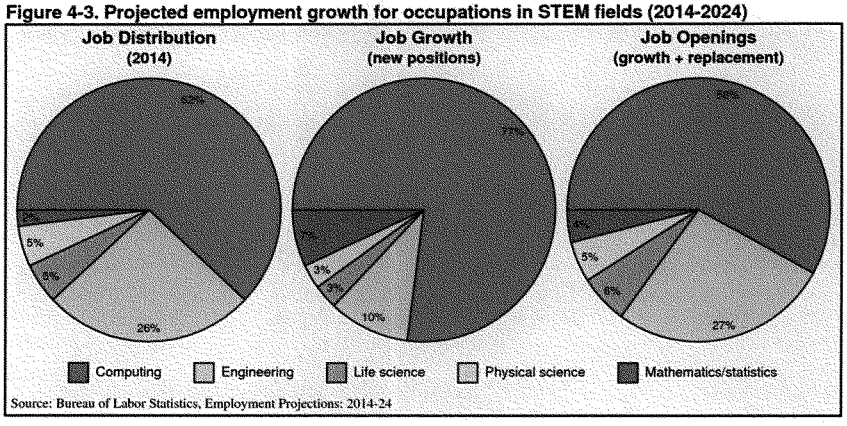
[1] Bureau of Labor Statistics. 2015. *Employment Projections: 2014-2024.* Washington, DC: Bureau of Labor Statistics, December 2015, Table 11b.
http://www.bls.gov/cps/cpsaat11b.htm

[2] National Center for Education Statistics. 2016. Integrated Postsecondary Education Data System (IPEDS).
http://ncsesdata.nsf.gov/webcaspar/

11b.] [http://www.bls.gov/cps/cpsaat11b.htm] [National Center for Education Statistics. 2016. Integrated Postsecondary Education Data System (IPEDS). http://ncsesdata.nsf.gov/webcaspar/]

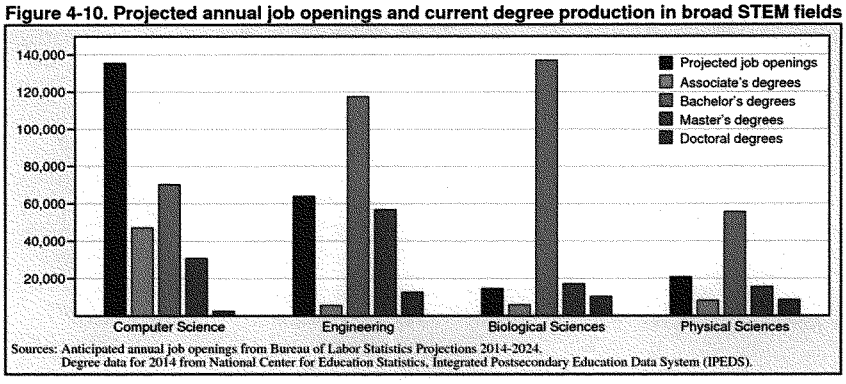
- Over the past 20 years the number of computing occupations has grown at an average rate of 143 thousand jobs per year, while computer science BA production has increased from about 20 thousand to just over 60 thousand. While this growth has placed tremendous demand in educational institutions, it still has not kept up with the demands of the economy.
- [In 2015] there were more than 600,000 high-paying tech jobs across the United States that were unfilled, and by 2018, 51 percent of all STEM jobs are projected to be in computer science-related fields. Computer science and data science are not only important for the tech sector, but for so many industries, including transportation, healthcare, education, and financial services. [Megan Smith. 2016. Computer Science for All. Washington, DC: Executive Office of the President, January 30, 2016. http://www.whitehouse.gov/blog/2016/01/30/computer-science-all/ (retrieved December 17, 2016)]
- BLS projections for 2014-2024 predict that 77 percent of all new STEM jobs will be computing related.

Figure 4-3. Projected employment growth for occupations in STEM fields (2014-2024)



Source: Bureau of Labor Statistics, Employment Projections: 2014-24

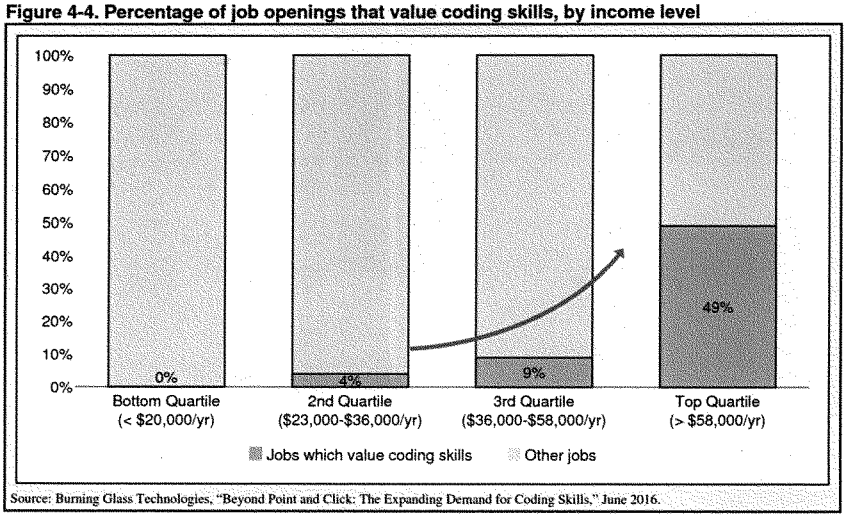
Figure 4-10. Projected annual job openings and current degree production in broad STEM fields



Sources: Anticipated annual job openings from Bureau of Labor Statistics Projections 2014-2024.
Degree data for 2014 from National Center for Education Statistics, Integrated Postsecondary Education Data System (IPEDS).

With these trends, the availability of CS education has a profound impact in shaping participation in economic prosperity. Burning Glass estimates that 49% of the jobs today in the top quartile of earnings value coding skills. Segments of society who are not provided with these skills in the course of their education are largely relegated to lower paying careers.

Figure 4-4. Percentage of job openings that value coding skills, by income level



Source: Burning Glass Technologies, "Beyond Point and Click: The Expanding Demand for Coding Skills," June 2016.

Demand and Capacity Challenges at UC Berkeley and Other Universities

The growth in production of CS degrees, while rising dramatically over the past 35 years, has also gone through fluctuations around that trend. Immense growth was experienced in the mid '80s following the emergence of Personal Computers. Another wave of huge growth was experienced during the late '90s through early 2000s with the emergence of the Web. A third wave has been experienced from 2008 and continuing, with the emergence of the smartphone and digitization of almost every aspect of daily life.

Many efforts have attempted to ascribe the fall-off of student demand from the peaks to reduction in demand for CS workers in broader economy, often using models of the lag due to the education pipeline to explain the asserted "over production."

Such explanations appear to bear little connection to evidence, as in only 3 of the last 20 years has there been any reduction computing related jobs (2001-2002 with the Internet bubble and during the great recession when occupations as a whole were reduced) and the variations in job growth bear no correlation with variations is BA degree production, even after accounting for the lag between decision to major and graduation. Today there are 80 computing jobs in the economy for every CS BA produced.

A simpler explanation of the reductions in CS degree production is simply the restrictions placed on enrollment into CS-related courses and admission into CS-related majors by Universities in order to cope with the excess demand placed on its limited resources—faculty, staff, facilities, and graduate student teaching assistants.

Application of measures to address large demand growth can easily result in a loss of student interest. Highly selective admission to courses and programs of study typically results in a highly-competitive atmosphere, placing stress on students, faculty, and staff, and may discourage segments of the student population--and thereby of the future workforce--who feel underrepresented or otherwise marginalized. Enlarged courses can result in a loss of quality and individualized treatment. Utilization of instructors untrained in the field to expand teaching capacity and thereby maintain class size can reduce quality and enthusiasm. The collective result can be a drop in production and demographic diversity.

UC Berkeley, like most universities and colleges, instituted such measures and experienced such effects. In the early '80s, when experiencing huge growth in demand for courses when instructional facilities were limited by the number of available mainframe terminals, we progressively instituted restrictions - first limiting enrollment in entry courses, then upper level courses, then set an elevated grade point average for admission to the major, and then a hard limit of a 100 students per cohort. With a GPA cut-off of 3.0 into the Letters & Science CS major, the size cap resulted in an effective cut-off about 3.8 to 3.9. And the size of the graduating class was reduced over three-fold, despite the state and nation's workforce needs. Eventually, the major lost popularity, despite continued job growth.

During the run-up to Y2K, when experiencing a similar surge to an even larger peak, we phased in restrictions far more carefully. Program scale was limited not so much by underlying facilities, given the introduction of personal computers and workstations in the instructional labs, but rather by the workload placed on the faculty, staff, and graduate student researchers. The modest reduction in workforce demand

in 2001-2002 and increase in national PhD production (which enabled faculty growth) permitted a more graceful transition to new production levels. These measures were in place as dramatic growth resumed in 2008.

Understanding this problem and the measures to address it requires understanding the academic institutional production landscape in finer detail than the overall national picture. Of the 1576 CS Bachelor degree granting institutions in the US in 2015, 100 schools (6%) produce over half of the graduates. A small number of schools, largely Research Universities, have very large programs, while a very large number of schools have quite small programs.

Not only are institutions quite heterogeneous, the growth in demand they are experiencing varies widely. While overall growth in production since 2009 is 1.5x, six hundred of these have more than doubled, three hundred have more than quadrupled, and some have increased over 10-fold. Meanwhile, programs at 400 institutions have shrunk, despite overall growth. Consolidation into large, successful programs is occurring.

The underlying question here is the size of the faculty relative to the size of the student body. According to Computing Research Association Taulbee Survey data, the number of computer science majors at the universities in the Taulbee survey increased by 241% from 2006 to 2015, while tenure-line faculty at those same institutions has grown by just 23%. Some of this gap is addressed by an increase in teaching faculty, which grew by 68%.

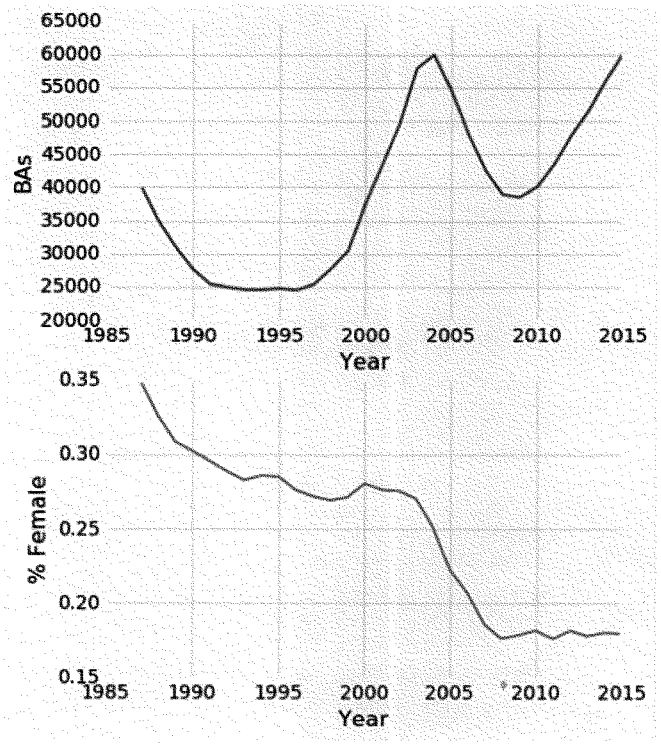
However, even if institutions are prepared to grow the faculty, given limited PhD production and strong industry demand, few will be able to do so. In 2015, 1999 Computer Science PhDs were produced nationally [IPEDS]. According to Taulbee surveys, 57% go to Industry and 3% to Government. Only 10% (200) go into Academic Tenure Track jobs and 5% (100) to Academic Teaching positions. The bulk of these go into the large Research Universities. Most smaller institutions can expect to hire a new CS faculty member only once every several years, so growth in capacity is very slow. And, for the research institutions that can grow, with NSF budgets essentially flat and NSF providing 82% of basic research support for Computer Science [https://www.nsf.gov/news/speeches/cordova/17/fc170327_aaaspolicyforum.jsp] (higher than any other area), it will be hard for to maintain healthy research programs.

Thus, acute pressure to operate Computer Science programs under excessive student demand, while sustaining active research programs, and in the presence of tremendous commercial opportunity outside the University, will persist into the foreseeable future. And issues of diversity and representation will need to be addressed in the context of these pressures.

Participation of Women in Computer Science

A strong indicator of the impacts on student climate of institutional response to periods of huge demand growth for computer science education is the participation of women in these programs. Prior to the onset of mechanism to address growth in demand in about 1983 women comprised over 35% of the Computer Science student body nationally. By 1990, after mechanisms to restrict access and to grow capacity through bringing in instructors from outside the field, participation of women dropped below 27% and

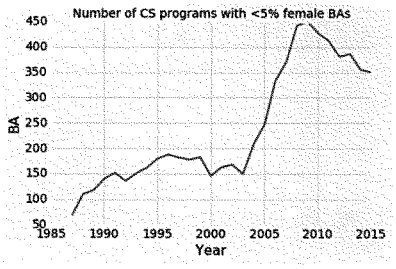
never recovered. Following the onset of measures to address the Y2K growth surge, during which the many younger programs facing the first such experience instituted measures similar to those of older ones during the '80s, participation fell further to about 17%.



While economic theory would suggests that women and men would be drawn into the field by employment opportunities and corresponding earning differentials relative to other majors, persistent gender imbalance in student production inevitably leads to disparity of representation in the workforce, which is likely to dissuade the underrepresented group from pursuing programs of study leading to to such jobs.

One conclusion is that, in order to remedy the imbalance present in a workforce that is literally serving the people of the entire planet in almost every aspect of their life, large, leading universities must take internal measures to maintain interest in computing related programs across the spectrum of the student population while they are taking measures to address huge student demand.

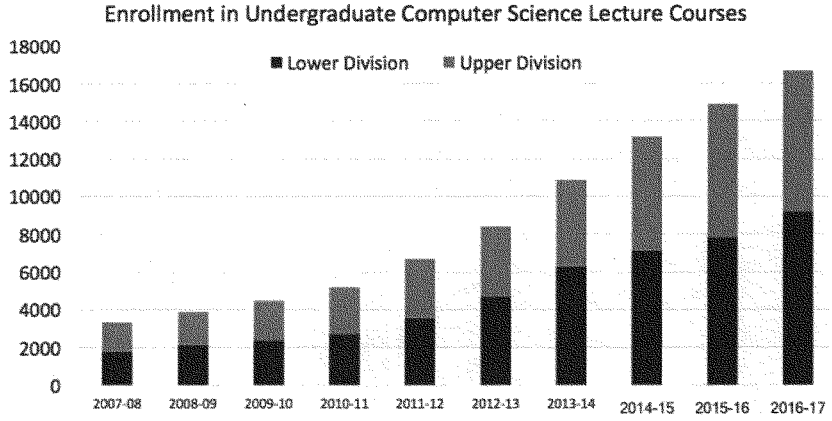
However, the large number of small programs raise a very poignant concern. In 2015, 800 of the programs had less than three women in the graduating class; 350 have less than 5% women. These observations are particularly concerning because most successful remedies rely upon building a critical mass cohort that can provide a supportive environment for the underrepresented segment.



UC Berkeley Programs to Address These Issues

UC Berkeley began to experience a rapid growth in student demand after 2006. During the recession, growth was as rapid as leading into the Internet boom. Starting in 2010 the EECS department became concerned again about the growth in enrollments and in majors. Faculty preferred taking on larger enrollments to dealing with frustrated and forlorn students. Having gained experience with the effect of previous growth waves, we began a series of measures to handle the demand while preserving climate in a manner that would restore, rather than further diminish the demographic diversity in the program. A shift had already been made toward utilizing undergraduate TAs in the lower division. This involved a fairly sophisticated development pipeline where students who performed well in a course could be employed as graders and then lab assistants, and if they did that very well they could become TAs. A culture of students teaching students developed that included substantial technical development on course technology as well as tutoring and teaching. An additional teaching professor was added. A range of novel teaching practices and several initiatives that were designed to encourage broader participation in computer science and improve the academic performance of students with limited prior programming experience.

Total course enrollments for undergraduate CS lecture courses was five times larger (+398%) in 2016 than 2007.



Placing the growth of majors in the larger context, the graduating class in 2016 was far larger than the previous peak of the Internet boom. Growth in the EECS major, in Engineering, was constrained by selective admission into the University and the requirements for declaration of Letters & Science CS major as a junior was set to match the performance of EECS students at the same stage, without an a priori cap. With these measures in place, the EECS BA production grew 1.4x compared to 2009, while the L&S CS production grew 5.3x. Importantly, production in Applied Math grew 1.8x and in Statistics 4.2x in this timeframe.

In 2009, UC Berkeley's Computer Science Department began piloting a 2-unit course called "**The Beauty and Joy of Computing**" to 20 non-major students, based on work supported by NSF. It was such a success that we decided to make this course a full 4-unit introductory course in Computer Science concepts for students who do not see themselves as interested in the major. It has grown to enroll over 500 students per year (in the two regular semesters and summer) and about a third change their direction and go on to take the introductory course for majors, CS61A. Its curriculum has been an important contribution to the NSF CS10K program throughout the nation and contributed to the new AP CS Principles exam. In the spring of 2017, **60% of its students were female,** shattering the gender diversity record at UC Berkeley for an introductory computing course. The team has been incredibly active to share the course more broadly; by the end of the summer, they will have offered professional development to over 300 high school teachers across the country. Links to more information:

- http://bjc.berkeley.edu
- http://engineering.berkeley.edu/2009/12/oh-beauty-and-joy-computing
- https://www.nytimes.com/2017/04/04/education/edlife/teaching-students-computer-code.html
- http://cs10.org/sp17/

It was not until 2011 when Code.org got its start, that this original concept was expanded more broadly. Now, this non-profit has grown with national and international recognition, and several other successful programs have replicated this model in the US with a similar mission.

At UC Berkeley, we have a number of other programs that try to address under-participation of women and minority students in Computer Science and related fields, including:

- **CS KickStart** [https://cs-kickstart.berkeley.edu] is a week-long program open to any incoming UC Berkeley students and introduces them computer science while meeting other computer science students and professionals. This program primarily targets women who are interested in the fields of science, technology, engineering, and math. Participants get hands-on experience in programming introducing them to the creativity and diversity of computer science. Participants also get the opportunity to visit tech companies in the Bay Area to see what life is like for computer scientists in industry. For several years it served 25 incoming students, but recently this doubled. It draws almost all of its support from industry and individual donors.

- **The CS Scholars Program** [https://eecs.berkeley.edu/cs-scholars] began in 2009 at UC Berkeley and has created a community in which students can learn and grow together. The EECS Center for Student Affairs (CSA) recognizes the unique challenges that students from under-resourced and low opportunity communities face at the university and in computer science, and therefore our goal is to provide a supportive network in which students can thrive. Now in its eighth cohort, the CS Scholars Program supports 350 scholars through a three uniquely designed courses. The spring 2017 cohort of sixty-five scholars is the largest cohort to date, with a representation of 62% female-identified students and 26% under-represented minority (URM) students.

- **Computer Science Education Day** [https://eecs.berkeley.edu/csedday] at UC Berkeley aims to inspire and motivate High School students to learn more about computer science, the opportunities it affords them, and exciting research and educational activities occurring on the UC Berkeley campus. Although it is only one day, it mobilizes STEM students at UCB to engage with and directly inspire high school students and has proven to have lasting impacts.

- **Summer Undergraduate Program in Engineering Research (SUPERB)** [https://www2.eecs.berkeley.edu/Diversity/SUPERB/reu.shtml] is an NSF-funded Research Experience for Undergraduates (REU) program at UCB, with a goal of preparing and motivating a group of diverse, competitive candidates for graduate study. The research focus of the REU will be collecting and using Big Data for the public good. SUPERB-Information Technology of Sustainability (ITS) participants spend nine weeks at UC Berkeley during the summer working on exciting ongoing research projects in information technology with EECS faculty mentors and graduate students. Students who participate in this research apprenticeship explore options for graduate study, gain exposure to a large research-oriented department, and are motivated to pursue graduate study. SUPERB-ITS participants receive a stipend, room and board on campus in the International House, and up to $600 for travel. 95% of the students who have participated in this program have gone on to graduate school in the STEM fields.

- **Girls In Engineering** [http://girlsinengineering.berkeley.edu/sponsors.html] is designed to grow the next generation of engineering leaders through an experience built on hallmarks of Berkeley Engineering: hands-on, team-based learning; an emphasis on leadership; and engineering in a societal context. In our College of Engineering, 24% of our engineering undergraduates are women, which is better than the national average. Encouraging diversity among students and faculty in engineering is a top strategic priority. Supported by an initial grant from NSF, the Girls in Engineering program is a week-long, non-residential summer camp for San Francisco Bay Area girls entering 6th, 7th, and 8th grades to explore different aspects of what it means to be an engineer in a fun, hands-on environment. Girls learn leadership skills such as goal setting and effective communication, and engage in activities that showcase different engineering disciplines.

Participants will also design and create engineering projects throughout the week under the guidance of Berkeley faculty, staff, and students.

- **Scaling Computer Science through Targeted Engagement** [https://research.googleblog.com/2017/02/the-cs-capacity-program-new-tools-and.html] is focused on providing access to increased and better tutoring, including weekend mastery learning sessions, increased office hours support, designated discussions section, project checkpoint deadlines, and a new office hours app that tracks student satisfaction with office hours. Google supported this program in 2015 as one of its Computer Science Capacity Awards, which address issues arising from the dramatic increase in undergraduate CS enrollments. The effect of these measures is very encouraging. The number of female L&S CS graduates grew 12-fold from 2009 to 2016, with the participation of women has grown steadily from under 12% in 2009 to over 28% in 2016, all while expanding a highly selective program.

A Broader Focus on Data Science Across Campus

Beyond computer science, at Berkeley we saw similar dynamics emerging more than half a decade ago in the new field of data science. Data science combines high-powered computing with advanced statistics to analyze massive data that push forward new industries and new scientific frontiers, from human health to galaxies, from biological systems to social behavior. At a very early stage, it was already clear that data science would go beyond revolutionizing computer science and computer technology. This impact was rightly foreseen in the Presidential Big Data Initiative of 2012. Inside UC Berkeley, our faculty saw that data science would fundamentally reshape teaching and research across many fields. When we decided in 2014 to embark on creating an undergraduate data science curriculum, we approached it from the ground up. As we saw it, this was a moment to rethink at a fundamental level what every educated person must know about quantitative reasoning: how to effectively understand, process and interpret information, to inform decisions in their professional and personal lives and as citizens of the world in the 21st century. We aimed to build our data science classes from Day 1 in a way that would be accessible and inviting to all students, beginning with a new course that a team of our leading faculty designed from scratch to define the Foundations of Data Science.

Berkeley's Data Science curriculum was launched at the entry level in fall 2015 with this innovative course, which has grown in two years to serve well more than a thousand students a year. It is the fastest-growing class in UC Berkeley's history, and it is designed to be engaging and accessible to any student who gains entry to the university, without any additional background or experience. It teaches fundamental concepts of inference and computational thinking through hands-on computing on data in Python, and picks real-world examples like jury selection, water use in California, or global population health. Starting from these examples, as well as discussions of privacy and impact, the social and ethical implications of data science are consciously addressed. Running alongside the Foundations class are a suite of so-called "connector courses" that relate the material directly to students' own areas of study. The "connectors" have seen a groundswell of student interest as well, and now range from neuroscience to civil engineering to criminal justice to history. This set of entry-level courses is designed to provide the base for later classes in a broad range of departments that will be able to leverage and extend what students have learned. The upper tiers of the program are now being developed and will provide additional depth and connect across the campus with major and integrated minor offerings.

Because of how Berkeley designed the overall program, the Foundations of Data Science class has been diverse from the start. It is accessible with basic mathematics and no previous programming experience, at the same time as it is conceptually strong. The third semester it was offered, it was just over 50% female (nearly matching the university as a whole), with a significant population of underrepresented minorities. The broad reach of the class creates a diverse pipeline of students who continue onward feeling confident that their perspectives are integral to data science. The Foundations class has drawn in students from more than 60 majors so far, from computer science, math, and statistics to the social sciences, biology, and public health.

A key aspect of the program has been creating a state-of-the-art cloud-based data science stack for education that lets students easily jump into computing with a minimum of barriers. During the class, students can write and edit code in a browser in real time, working on a laptop with the same data set and code that the professor is discussing. Learning in the class is active, and interactive: In so-called Jupyter Notebooks, students can try their own calculations, using large data sets that are available at their fingertips, and follow up with questions to the professor. All of these innovations are driven first and foremost by the goal of reducing the barriers to computing instruction, in order to broaden participation at the base, where it matters so much.

Berkeley's data science program is actively welcoming to students of many backgrounds and interests. There is a Data Scholars program on the CS Scholars model to support underrepresented, first-generation, and non-traditional students, as well a student outreach team that explains the program to other students in their own language. Another team of students and staff helps professors across the university introduce data science modules into their own classes, where students can encounter it and be drawn into the field by experiencing the power and insight of computing on data.

The tremendous workforce demand for data science and analytics has been broadly understood. In our wired, connected, and data-saturated world, data fluency will soon be essential in *many* careers. As documented in the April 2017 report "Investing in America's Data Science and Analytics Talent" (Business-Higher Education Forum and PwC), market analyses call out 2.7 million job postings for strongly data-enabled roles by 2020, and the demand is growing across industries. Leading universities such as Berkeley not only need to prepare their own graduates for this world, they have an obligation to change the national landscape. As the new field of data science grows in its impact and pervasiveness, it must be shaped by a diverse population of practitioners at the national scale.

More information: http://data.berkeley.edu/

In recognition of the transformative potential of data science—its pervasiveness, significance, and continuing evolution—a data science initiative has already been having noticeable effect on campus. The data science initiative is led by faculty and aligned with regular Academic Senate processes and campus-level strategic planning. It aims to advance Berkeley's excellence in fields around data and computing and to connect them fluidly across the campus. The initiative creates pathways for the university to move flexibly and decisively into new domains. It is charged to recommend opportunities and strategies for

research, teaching, organization, and fundraising. The reach of Berkeley's new data science education program serves as a model.

The initiative builds upon our outstanding research and graduate programs and our pathbreaking undergraduate curriculum. It draws together our wide-ranging excellence by engaging our community in its formative stages, and it integrates our intention to advance the university's public mission by engaging with the societal, humanistic, and policy ramifications of data science. The initiative is defining pathways of institutional development that can fit the world's leading public university for the 21st-century world. Starting July 1, 2017, Berkeley took a major step in appointing an Interim Dean of Data Sciences to build out a program at the same level as the Colleges and Schools in our academic structure.

Undergraduate Discovery Experiences

We have seen that students readily excel at technical subjects of great difficulty, even ones that they previously shied away from, when they are personally engaged in asking questions they care about. At Berkeley we are building on this observation in an initiative that would give every undergraduate the opportunity to engage in a hands-on discovery experience. It's amazing what happens to students' interest once you get them out of a lecture hall and into a research and discovery team. With greater inspiration and understanding of the field, we expect better student engagement and retention in their chosen majors, including Computer Science, to improve.

The Berkeley Undergraduate Discovery Experience is a campus-wide initiative to engage and support more undergraduate students in scholarly and experiential learning. Developing the capacity to inquire, discover, and create is the core purpose of an undergraduate education. It's amazing what happens to student's interest once you get them out of a lecture hall and into a research team.

The broad term "Discovery Experience" references a wide range of immersive learning projects--from substantial research experiences and artistic production to entrepreneurial initiatives and community-engaged projects. All such efforts should challenge students to question, design, implement, and iterate toward a thoughtful and creative culminating product. Many of our undergraduates already partake in such experiences. We aspire for all of them to do so.

Our intent is to create a campus-wide platform through which undergraduate creativity can be channeled, challenged, supported, and expressed. The Discovery Experience has the potential to become the defining experience of a Berkeley undergraduate education, where the popular question "What is your major?" will be complemented by "What is your discovery project?"

Some students will pursue the path of a traditional senior thesis, while others might seek the challenge of writing a novellae, directing a film, launching an entrepreneurial endeavor, or integrating community engagement with scholarship. Some experiences will be group-based while others individual. While new requirements might emerge at the departmental level, it's important to consider how some students will reach this goal outside of the major: e.g., in a minor or perhaps through a co-curricular experience. In the broadest sense, the challenge for the campus is to build upon existing programming and launch new

programming that expands pathways through which students can foster their passions and complete a discovery project.

To offer personal discovery experiences to thousands more undergraduates, potentially even to all 27,000 who are at Berkeley at any one time, we will engage our talented graduate students and postdoctoral scholars as mentors. Discovery experiences hold promise to bring more talent to the hard problems our society faces, and to introduce a new generation of very well prepared students into vital sectors of our economy.

A. Paul Alivisatos - Biography

Paul Alivisatos is the University of California, Berkeley's Executive Vice Chancellor and Provost and Samsung Distinguished Professor of Nanoscience and Nanotechnology. He is also the Founding Director of the Kavli Energy Nanoscience Institute (ENSI), Director Emeritus of Lawrence Berkeley National Laboratory where he remains a Senior Faculty Scientist, and holds professorships in UC Berkeley's departments of chemistry and materials science. In addition, he is a founder of two prominent nanotechnology companies, Nanosys and Quantum Dot Corp, now a part of Thermo Fisher.

Groundbreaking contributions to the fundamental physical chemistry of nanocrystals are the hallmarks of Dr. Alivisatos' distinguished career. His research accomplishments include studies of the scaling laws governing the optical, electrical, structural, and thermodynamic properties of nanocrystals. He developed methods to synthesize size and shape controlled nanocrystals, and developed methods for preparing branched, hollow, nested, and segmented nanocrystals. In his research, he has demonstrated key applications of nanocrystals in biological imaging and renewable energy. He played a critical role in the establishment of the Molecular Foundry, a U.S. Department of Energy's Nanoscale Science Research Center; and was the facility's founding director. He is the founding editor of Nano Letters, a leading scientific publication of the American Chemical Society in nanoscience.

Dr. Alivisatos has been recognized for his accomplishments, with awards such as the Dan David Prize, the National Medal of Science, the Spiers Memorial Award, Axion Award, Wolf Prize in Chemistry, the Von Hippel Award, the Linus Pauling Medal, Computation and Engineering's Nanoscience Prize, the Ernest Orlando Lawrence Award, the Rank Prize for Optoelectronics, the Eni Award for Energy and Environment, Colloid and Surface Chemistry Award, Coblentz Award for Molecular Spectroscopy and the Thomas Wilson Memorial Prize. He is a member of the National Academy of Sciences, the American Academy of Arts and Sciences and the American Philosophical Society.

Dr. Alivisatos received a Bachelor's degree in Chemistry in 1981 from the University of Chicago and Ph.D. in Chemistry from UC Berkeley in 1986. He began his career with UC Berkeley in 1988 and with Berkeley Lab in 1991.

Chairwoman COMSTOCK. Thank you very much.
Now we'll hear from Ms. Mooney.

STATEMENT OF MS. DEE MOONEY,
EXECUTIVE DIRECTOR,
MICRON TECHNOLOGY FOUNDATION

Ms. MOONEY. Thank you, Chairwoman Comstock, Ranking Member Johnson and Ranking Member Lipinski, and distinguished members of the Subcommittee. Thanks for the opportunity to be here today.

My name is Dee Mooney, and I work for Micron Technology, specifically, its foundation. Micron is a leading worldwide memory and storage solutions company. Our memory technician—our memory technology is in the things you use every day form smartphones to laptops to our cars. This technology is increasingly critical given the growth of data and the need to access, store and manage that information.

Our company was started by four visionaries in the basement of a dental office in Boise, Idaho, reflecting the American ideas of ingenuity, grit and innovation. Today we're nearly 39 years, 18 countries, 26,000 patents and more than 30,000 people strong.

This level of innovation requires a robust and talented workforce, especially in the STEM fields. We believe STEM education is critical to cultivating tomorrow's technology leaders, not just for our team but to advance our industry and the economy at large.

While Micron is a semiconductor manufacturer, we rely on skilled programs to develop product firmware, build software for several tools throughout our manufacturing operations. Depending on the role, you workforce needs range from technicians to Ph.D.'s. Unfortunately, we regularly see a lack of available talent to fill these skills.

The Micron Foundation was created by Micron nearly 20 years ago in part to inspire the next generation of innovators with a focus on STEM. We have given away $88 million to improve access to STEM education and invest in local communities. We are—as Chairman Comstock mentioned, we are located in Manassas, Virginia, and we do quite a few programs there with supporting robotics, our public schools for engineering camps, teacher grants. We bring the Micron bus there. We also are very—I'd like to highlight a program that we partner with at the Northern Virginia Community College called Systemic Solutions. This pipeline development program engages students in elementary school and inspires them to continue to pursue STEM throughout their school and career experience.

In Idaho, the story is similar where we support educators and students through grants and outreach. This includes hosting a free hands-on science camp for junior high students to explore robotics, virtual reality, 3D printing, and the latest technology developments. We recently expanded this program to California this year, and we are looking to expand it to other communities. We also take these lessons a step further into shaping future careers with our Girls Going Tech and Women in Technical Career speaker series.

Computer science accounts for many of the fastest-growing occupation, and we feel that too. During the 2015 Idaho legislative ses-

sion, a visionary group of stakeholders helped to create the Idaho STEM Action Center to develop unique grant training, professional development and student opportunities. This helped pave the way for a circuit initiative passed by our state legislature last year with the intent to help clarify student learning objectives within computer science and help guide districts and educators that choose to complement computer science. It helps them have a roadmap so they know how to implement that in their schools.

To us, this represents the type of collaboration and initiative needed to keep America on pace and beyond in a very global competitive environment. This starts by supporting an educated workforce that can compete tomorrow and well into the future.

I look forward to the discussion today and learning from the other panelists, and again, thank you for having me.

[The prepared statement of Ms. Mooney follows:]

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

"STEM and Computer Science Education: Preparing the 21st Century Workforce"

U.S. House of Representatives

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Written Testimony

Dee Mooney, Executive Director, Micron Technology Foundation

Chairwoman Comstock, Ranking Member Lipinski, and other distinguished members of the Subcommittee, thank you for the opportunity to participate in this important discussion today.

My name is Dee Mooney and I work for the Micron Technology Foundation. Micron is a leading, worldwide memory and semiconductor company. Our memory technology is in the things you use every day—from smartphones to laptops to connected cars. This technology is increasingly critical given the exponential growth of data worldwide and the need to access, store and manage that information.

While we compete in a global marketplace today, our company was started by four visionaries in the basement of a dental office in Boise, Idaho in 1978 – reflecting the American ideals of ingenuity, grit and innovation. Today we're nearly 39 years, 18 countries, 26,000 lifetime patents, and more than 30,000 people strong.

As you might expect, this level of innovation requires a robust and talented workforce, especially in the STEM areas of science, technology, engineering and math. This is a very passionate topic for us. I'm sure you've heard statistics about the shortage of STEM talent, unfilled current and future roles, and wages that nearly double the average of other occupations. This underscores our belief that supporting STEM education is critical to cultivating tomorrow's technology leaders – both to add to our talented team and to advance our industry and the American economy at large.

Advancing STEM education requires investment now and a persistent focus on future workforce needs as we continue to innovate and technology evolves. Today we see considerable gaps in talent within our local communities, whether it is the ability to hire either the volume or caliber of electrical and computer engineering roles needed or having to source industrial engineering candidates outside of our region.

We also struggle with finding qualified computer science candidates. While Micron is a semiconductor manufacturer, we rely on skilled programmers to develop product firmware and

build software for several tools throughout our manufacturing operations, in addition to several other needs. Depending on the role, our workforce needs range from technicians to Ph.D.s, and may require niche application or specific computer language expertise. Unfortunately, we regularly see a lack of available talent with these requisite skills and experience, which is even more pronounced when we seek to fill business intelligence, data scientist, and data engineering roles as well as most aspects of information security and cybersecurity.

This makes our collective efforts more important than ever. Understanding where the gaps are today can help us plan for the future, however we need to remain flexible. We must also keep in mind that nearly every role in the near future will benefit from a strong background in STEM education, given how quickly technology has integrated into all aspects of our lives.

The Micron Foundation was created by Micron nearly 20 years ago, in part, to inspire the next generation of innovators and address the workforce pipeline issue with a focus on STEM. Since our inception, the Micron Foundation has contributed $88 million in giving to improve access to STEM education, and to invest in the local communities where our team members live and work. My role at the Micron Foundation focuses on creating and supporting opportunities in all levels of education, especially in area schools and communities where we have a major presence, both in America and in our operations across the globe.

As a result, we work with universities, K-12 schools and nonprofits all over the world. Not far from Washington D.C. sits our Manassas, Virginia location – where we committed nearly $450 thousand dollars in grants this year to support STEM education and the community. There we work with public schools to provide for robotics programs, engineering camps, teacher grants, invention programs, scholarships and more. We also partner with Virginia universities to support student engineering projects, professor research, and state-of-the-art facilities such as the newly renovated lab space at George Mason University's Science and Tech campus.

Northern Virginia faces a critical shortage of skilled workers in STEM fields, so we have partnered with the Northern Virginia Community College's SySTEMic Solutions program. This pipeline development program engages students in elementary school and inspires them to continue to pursue STEM education in high school, college and the workforce through a collaboration with schools, businesses and community organizations.

Our investment in Virginia spans the last 14 years and has provided more than $4.5 million in funding, including nearly half a million for this year alone.

In Idaho, the story is similar, where we support educators and students through outreach and grants. This includes hosting a free, hands-on science camp for junior high students to explore robotics, VR, 3D printing and the latest technology developments each year. We recently expanded this program to one of our California locations and plan to expand it to other communities. We also take these lessons a step further into shaping future careers with our Girls Going Tech and Women in Technical Careers speaker series, or Careers in a High Tech World program. Our focus is to enable students to envision all of the potential careers, experiences and opportunities a STEM education has to offer.

Computer science plays a significant role within STEM, accounting for many of the fastest-growing occupations in this area. We are seeing this firsthand in Idaho, where a shortage of

workforce talent is bringing together our legislative, education and industry leaders to address this challenge.

During the 2015 Idaho legislative session, this visionary group of stakeholders helped create the Idaho STEM Action Center to develop unique grant, training, professional development and student opportunities aligned to Idaho's workforce needs from kindergarten through career. The Center is guided by a nine-member, Governor-appointed Board with educational leaders from the State Board of Education and the State Department and seven Idaho industry leaders including the Idaho Department of Labor, the Idaho Department of Commerce, Idaho National Laboratory (INL) and Micron.

This has paved the path for a computer science initiative passed by our state legislature last year that improves computer science awareness and access at all levels of education. Idaho subsequently became the first state to partner directly with code.org to offer its courses to teachers across the state at no charge to them or their schools.

To us, this represents the type of collaboration and initiative needed to keep America on pace and beyond in a very competitive global economy. We certainly experience this every day with our operations and competition around the globe. If we want to keep our economy strong, vibrant and competitive, we need this type of collaboration and leadership from elected officials, educators and industries. That starts by supporting an educated workforce that can compete tomorrow and well into the future.

Dee Mooney, Micron Technology Foundation

As Executive Director of the Micron Foundation since 2006, Dee Mooney drives the Micron Foundation's programs aimed at advancing science and technology education and enhancing the quality of life in Micron's manufacturing site communities. Dee collaborates with internal and external partners to develop, maintain, and improve programs as well as develop strong partnerships with community and educational organizations. The Foundation provides more than $5 million in grants annually around the world.

Mooney serves or has served on several educational and community non-profit boards in Boise, Idaho and is currently the Vice Chair for Idaho's STEM Action Center. Mooney holds a bachelor's degree in psychology from Iowa State University and a master's degree in industrial psychology from University of New Haven.

Chairwoman COMSTOCK. Thank you, and thank you for all your engagement on these issues. I know you mentioned grandparents' interest and the Children's Science Center that's in Fairfax, Micron and many other companies in the area of support. I remember being sort of a kickoff for it where Microsoft gave a large grant for them also, and they are building a longer-term museum, but right now they're in one of our local malls, and it's my granddaughter's favorite place to play. Just about any time you mention it, she's game to get there. She's 2–1/2.

So the pipeline starts young and you are all an important part there. I think there's also Family Science. I'm just going to plug all these things because I think this is something we all need to be engaged in and involved in, and I appreciate your helping with that.

So Ms. Mooney, in your testimony you talk about working with the local public schools and universities to help engage students in STEM, and I'd add preschool to that because that's certainly what the Children's Science Centers and others do. Can you speak a little bit about all this? And all of you maybe kind of—like what kind of online things can we all be promoting.

And I know Mr. Yongpradit, you talked about some of the classes that are available I think that are sort of with the internet, the democratization of education. While we're waiting to get all these things into the classroom, what can we be highlighting for people? Because the great thing, you know, in organizations like Women Who Code that we saw yesterday, I can assure you are in that group, there was at least about 100 young women there. It was very diverse. You know, this was a summer-long program and it was really exciting to see the real diversity there and how aggressive they have been, and again, a lot of our local companies are supporting that. But where can we plug people into this who may not find out about these programs or how can we make sure we're doing that, if you could all address that?

I'll start with Ms. Mooney.

Ms. MOONEY. Thank you, Chairman Comstock. We are always looking for those opportunities. Often our programs that start in junior high and high school, a lot of times those students are on their way, so we look for opportunities back at the beginning of education where we can get them excited, and this would be a good time to talk about our partnership with the STEM Bus. The STEM Bus rolls into a school and we try to target low-income schools, Title I schools that might not have a lot of resources at their fingertips, and the bus rolls in and it's a 60-foot, big bus. It's decorated with bright colors and it rolls in. There's an assembly at the school where all the kids come in and there's drones flying around, there's music. It gets a lot of excitement. And then throughout the day, students are able to come outside into the bus, which has been completely repurposed and inside there's lots of fun things. There's 3D printing, there's virtual reality, lots of hands-on activities, and we talk about what really sparks their interest. That's kind of the exciting thing that happens. Then we work with those teachers to make sure that they can continue that path to keep inspiring those students.

Chairwoman COMSTOCK. Yes?

Mr. YONGPRADIT. Mrs. Comstock, that was a great question about what online experiences can be plugged so that students who don't have access in school and still have some type of experience. There are a number of online opportunities. At Code.org, we created a number of blended opportunities. They're both online and in person. The Hour of Code itself is an online experience. They're tutorials that students can do, and that can be done outside of the Computer Science Education Week, so that was the Hour of Code, and many Members of Congress have actually participated in an Hour of Code. There are for-profits like Code HS and Code Academy. Universities like Berkeley are offering free courses through providers like EdEx and other providers like Forsair and Udacity are offering free colleges as well.

But here's the thing. Our research at the K–8 level shows that when there's a teacher in a classroom teaching these students, the classrooms are more diverse and the students go further, so that's why we put our money in the classroom and in school, making sure that these students in school can have that experience and that all students can have that experience, so that they don't have to go to an online provider outside the school to get that fundamental computer science experience.

Chairwoman COMSTOCK. Thank you.

Mr. Brown?

Mr. BROWN. One thing I'd add to this is, so 4 years ago we had 500 affiliate organizations that were part of our Coalition. Now we have a little more than 700. And when we get inquiries from people saying what do I do in my community, a lot of times what we will want to do is connect them with a growing network of STEM organizations that are in their local communities. Mayors have STEM councils now. There are regional STEM organizations. A lot of states have these entities. There are places to turn now in your local community to connect you with what's actually going on out there because these activities are blossoming across the country as the states start to prioritize these, but the answer to this is oftentimes a really local answer, figuring out who in your community is taking this on and connected people who are trying to seek help with those connector folks.

Chairwoman COMSTOCK. And I know, having served in the state house—you note a number of the schools that don't have it as mandatory. There's always a challenge when you're trying to add another class. You get a lot of pushback from the schools. It was before I had gotten in the state house but there had been a mandate for financial literacy classes, and they then delayed the implementation because it was very difficult for some of the schools to get that in there, and then it turned out. But there was an online class that you could help because some kinds wanted to be in computer science or more advanced physics than have to take a class in financial literacy for someone who already had that. So I think there is a need for some innovation here so that if you have a kid who's online, you know, doing things, how do you incorporate that? Because I know there is resistance on that state level but we need to make sure it is available, and I know in my district, the young man who won our Congressional app challenge that we have here every year did not have computer science at his school. We want

to make sure they do have that, so that's something we're going to work with them on. But he was teaching an after-school class to his colleagues. He had started this himself, a brilliant young man who had started in elementary school, but as you said, Mr. Yongpradit, we've got to make sure everyone has access to that, so what has been your experience in kind of breaking through that difficulty not wanting another mandate?

Mr. YONGPRADIT. So ultimately, schools need to be responsive to where our culture is heading, and I look at that scripture up there in the Bible where there is no vision, that people perish, and that's actually already happening right now in all these schools where they don't offer computer science, and so first off——

Chairwoman COMSTOCK. Get it offered even if it's not mandated that you take it.

Mr. YONGPRADIT. Yes, it's just an issue of priorities sometimes. I mean, there's so many electives that high schools offer. You know, sometimes things do need to go and change and evolve. So we've seen that schools all over the country, districts, principals, administrators, they all figure out new and exciting ways to fit computer science into the schedule. So in fact, it's not even a theoretical discussion. It's already happening en masse like San Francisco Unified where Berkeley is at. They're instituting computer science in K–12, every single grade, so somehow they're fitting it in into a school district that's about 56,000 students, and so whether that's integrating it into another subject or offering it as a rotation at an elementary school level with music and art, schools are figuring out a way.

Chairwoman COMSTOCK. Thank you, and thank you for your work, all of you.

Now I yield to Mr. Lipinski.

Mr. LIPINSKI. Thank you. I could sit here and ask questions all day because I have so many, so if I can quickly get answers so I can get to at least a few.

Mr. Brown, you had talked about specifically middle skill jobs where there's great need, an unfulfilled need. As I was thinking about this hearing, you know, the title is "STEM and Computer Science Education: Preparing the 21st Century Workforce," I want to know what types of skills are we talking about? Because we're talking about computers, computer science majors in college as opposed to, you know, skills learned in grades K–8. What are the skills that are necessary for the jobs that are out there? Where are we really missing—you know, where is the workforce not prepared? What types of jobs are these? Can we have some sense of how many are we missing at different levels?

Mr. BROWN. Sure. This is a really complicated challenge, this middle skill jobs question. So a good example of a new middle skill job where workers can do really good and not need a college degree is the auto mechanic. So we all have this analogy in our minds of I can't fix my care anymore because it has to be plugged into a computer at the dealer, right? Like that's the common anecdote. But if you look at what an auto mechanic's job is now versus, say, 30 years ago, an auto mechanic is now somebody who has to use a computerized interface to figure out what's wrong with the car, and then they go fix it, and that's a very different image than most

parents have of what an auto mechanic does or what somebody else that might be interested in that profession is, and for a long time the people who would go into those jobs were not treated like the STEM crowd, right? There's a societal view that those jobs are okay but they're not for my kids if my kids are going to do well in the world, and that's frankly just a wrong view because if you're really good at being an auto mechanic and you work in a high-end car dealership, you might make more money in your first or second year than a college degree person who is maybe in the middle of their class with an engineering degree. I mean, so that's a misconception that's not there. So there's a whole track of students, and a lot of these students are in the CT or the vocational-technical track that are getting trained for these jobs but a lot of times that's not where the best educators are in the school, that's not where the emphasis of the states or the districts STEM program is.

The image is, when you do person-on-the-street polling and you ask people about STEM careers, they still identify the STEM career with the rocket scientist, the Ph.D. They don't have images of these middle skill jobs to draw from, and this—so to get back to what those skills are, they're problem-solving skills. They're problem-solving skills that use technology, and the STEM field—there's lots of way to teach problem-solving. It just turns out that STEM is probably the least worst way to do that, right? You can teach people how to solve problem without being a scientist, but learning the scientific method and learning about data and evidence are the best ways to do that within the school system.

And so getting back to the point about what we really need to do is, we need to make sure the high-quality programs are also in those middle skill tracks and that we're not just focusing resources on the future rocket scientists, the people that sort of fit the description of who you expect to see when you talk about a STEM job.

Mr. LIPINSKI. Let me move on to Dr. Alivisatos. What can we do to—there's a great shortage of teachers. Any recommendations you have of what can be done so we can have more computer science or other similarly related fields get people in to be teaching at the college level?

Dr. ALIVISATOS. Well, both high school and college. You know, we have an enormous talent pool of graduate students and also undergraduates who are really learning computer science and STEM fields and who spend—spontaneously because it's their love—they spend time, for example, graduate student mentoring undergraduates or high school students, and likewise college students doing the same thing. So those people are showing that they have a deep desire to do these things. Many of them could use much more help learning how to be mentors early as part of their education. So if they're in a STEM discipline, actually having training on how to be a mentor, which is a vital part of actually being part of a science team or an engineering team, so teaching those skills in a systematic way to large numbers will open those careers to them and help them to do better.

But as you know, there are also a lot of structural reasons why the teaching careers aren't always as attractive as they could be in some of our areas, and some of those are controlled by local poli-

cies, but it's clearly a huge problem to make it more attractive to people.

Mr. LIPINSKI. Can we get—if the Chair will allow, what about programs to try to get people who are out and working to come into a university and teach or to the high school classroom and teach?

Dr. ALIVISATOS. So in our discovery experience program that we're planning, one way—we're finding many—let's say in our case, we have 27,000 students. We want them all to have a discovery experience. We need to build a network for that. So for example, a postdoctoral scholar or a graduate student would mentor. But even if we do that, there's still more personal mentorship that's needed, so we're inviting in all of our colleagues from the Bay area technology community and also from many local businesses and even from community organizations to come in and mentor our students, and also, we're putting in a requirement that every student, as they mature through the program, they themselves spend a certain amount of time mentoring in a local high school, and so we kind of see to scale this, you need to have a kind of network of people at different levels, and each time you've gone up to a next level, you should be reaching a hand down to the earlier stage to help them because that helps the numbers to work well for such a complicated large number of people problem.

Mr. YONGPRADIT. So Mr. Lipinski, I'd like to add that there's actually a great model program in the United States right now sponsored by Microsoft. It's called TEALS. I think it's Technology Education and Literacy in Schools, and basically what happens is, they take engineers from a number of companies, not just Microsoft, and these engineers go in to the classroom, sometimes three to five days a week in the morning right before they go to work and they actually teach a computer science class, and so this is in schools where they just can't find a teacher to teach computer science, and this is happening in, I believe, hundreds of schools nationwide in several dozen districts, and so that's a model program that I'd like to call out.

Mr. LIPINSKI. Thank you very much. I yield back.

Chairwoman COMSTOCK. Thank you.

And I now recognize Mr. Marshall.

Mr. MARSHALL. Thank you, Chairwoman.

Mr. Yongpradit, I missed your number. How many computer science jobs are open across the country now approximately?

Mr. YONGPRADIT. So 500,000 open computing jobs, and those include jobs that require a four-year degree, as well as the middle schools jobs that—middle-skills jobs that Mr. Brown mentioned.

Mr. MARSHALL. Okay. I want you all to write down these numbers, see if you come up with the same conclusion I come up with. I just met with Dr. Ben Carson. He told me there's six million skilled jobs open in this country right now. We're at a 16-year low for unemployment across the country. My State of Kansas has 20,000 open jobs. I think I read that Mrs. Comstock has 30,000 open computer jobs in her State. You just told us we have 500,000 open jobs across the country in computer science.

So, here's the counterintuitive things I'm learning. I'm a freshman up here. A half-million people have given up looking for a job. There are districts in our country with unemployment of 17 to 20

percent. And in those districts, 25 percent of people are on Medicaid assistance, and 50 percent of them are on food assistance. My theory—see if you disagree with me—is we don't have a job problem; we have a job skills problem in this country. Everywhere I go in my town halls, whether it's the construction industry or skills set, we don't have a skilled workforce anymore.

What's the disconnect? What are we doing to motivate people to not work or to not get that skill set to work? What has happened in our culture that we don't motivate people to get the proper skill set? I think this is a cultural problem.

Mr. Yongpradit, you've got a comment what's happened to our culture?

Mr. YONGPRADIT. Yes, I can talk about it just from my experience teaching. So, at some point we had this definition of digital literacy that was let's just learn how to use a computer, like here's a mouse, here's a keyboard, let's learn how to type and create presentations, right? And that was the thing in the '80s and '90s. Lots of us learned how to use computers in a course like that.

But what those courses missed is how to dig deeper and how to actually program the computer, how to create technologies of your own. And so, because of that, we have this huge gap between all these open computing jobs and a workforce that just isn't skilled to access those types of jobs. We have people who may be able to use a welding machine, but they're not able to program a welding machine.

So, with this level of automation that we're seeing in manufacturing jobs these days, we see people who are being automated out. Now, here's the thing. They can be automated in if they learn how to now program those machines. And in the same way we have a great opportunity ahead of us with the transportation industry with all this automation of cars. I mean, folks, in 15 years, I mean, there'll be a lot of kids who don't even think about driving. It's just nonsense to them. They'll just, you know, call up a car to drive——

Mr. MARSHALL. I need to move on.

Mr. YONGPRADIT. —for them.

Mr. MARSHALL. So we have some incredible community colleges and technical colleges in my district, and I think that they're poised to probably make the quickest adjustments.

Mr. Brown, can you give some comments? Are our community colleges responding? What are they teaching? What are they doing?

Mr. BROWN. Well, I think you used a term that's super important here, which is responsiveness. So much of this challenge—we have low unemployment, but we have also low participation in the workforce, right? The underemployment number is probably 20 percent of the population——

Mr. MARSHALL. It's scary.

Mr. BROWN. —more, right? Part of that challenge is because it's too hard to transition from one set of skills to a pretty similar related set of skills. I'll give you an example of a problem if we could solve that would get at this that community colleges probably play a role, and that's transitioning military veterans.

Mr. MARSHALL. Yes, sir.

Mr. BROWN. So, there's 100,000 people discharged from the military every year. About 60 percent of them have STEM skills, but

it's really hard for a combat medic or electrical technician to get a commercial credential because we can't manage that skills gap problem just for a highly trained population that we know their skills, and yet they don't line up with the educational institutions.

And so community colleges have a lot more flexibility than some other institutions. They're dealing with a lot more diverse population that has a lot of different skills. If we could manage that transition alone of getting more of those 60,000 military veterans into STEM careers, it would help us tell the metal technician in Indianapolis who worked for Carrier a better way to get a job.

Mr. MARSHALL. Are you seeing—who's doing it right? Who's the most successful place you've seen doing this?

Mr. BROWN. You know, the trend that I think speaks most to the innovation is the fact that companies are doing their own training for high school students——

Mr. MARSHALL. They sure are, yes.

Mr. BROWN. —now, right? I mean, that's the commercial motive. That's capitalism at work. It's probably not the ideal solution, but that's where a lot of companies are is they're doing this training in-house and skipping the education system altogether, which says we have a problem.

Mr. MARSHALL. Yes, sir. Thank you.

Chairwoman COMSTOCK. Thank you. And you're exactly right. I've seen that just in visiting whether it's a manufacturing plant—the businesses bring people in and train them on that equipment for that very reason.

But I would also mention the high schools—I think you're exactly right. The community colleges are a great place to—but our high schools are trying to do more of that, and I think making sure that they are faster and really adapt quickly like that and then move it on down into junior highs and then having these kids get some work experience, too, and being exposed to all that.

Mr. YONGPRADIT. Well, and can I just—I want to make sure this is a clear point. Companies are doing it because the education system can't keep up.

Chairwoman COMSTOCK. Right. Yes.

Mr. YONGPRADIT. That's not to say we should be giving up on fixing our educational institutions. The high schools that people really value are the ones that are preparing kids for specific career paths. That's what the grandparents are asking for——

Chairwoman COMSTOCK. Yes.

Mr. YONGPRADIT. —when they call up.

Chairwoman COMSTOCK. Great. Okay. I now—oh, Mrs. Johnson is not here. We have Ms. Esty now recognized for five minutes.

Ms. ESTY. I want to thank the Ranking Member and the Chairwoman for this important topic we're discussing today. And actually, Mr. Brown, I was going to start with lower grades in education, but as a member of the Veterans Committee and working a lot on this issue, I'd like to start with you about what we can better do because it is a crime actually that we are not providing our veterans with a better ability to transition to civilian workforce. And you're exactly right; they've got the skills.

But again, do you think stackable credentials, is this something we should be working within the VA to try to do this? How do

you—or transition from DOD? Because some of us have been looking at elements. Can we do a better job of translating? What are those Defense Department skill sets that they have, and how can we translate? And if you have suggestions for us about how we can be helpful, I can tell you there's huge commitment on this committee and across Congress to do better for our veterans.

And you just think about something like cybersecurity. We have skill sets there that are going to waste, and people are looking for jobs, so we are passionate about filling that gap and putting veterans to work. So, thoughts any of you have on what we can do on that would be welcome.

Mr. BROWN. Well, so let me first say thank you for your service on the Veterans Committee. And the Veterans Committee in the House just passed a GI bill reform, right? And one of the things that's really important sort of under the radar is that that bill contains a provision to allow veterans who are studying career fields that take more than a certain number of credits so that they're not basically aged out of their GI bill benefits. And those are the kinds of adjustments in our system we have to make to meet the unique requirements. It has laboratories. It takes longer.

The transition issue for veterans, the reason why I use it as a litmus test for this problem is part of the reason that's not happening as—it brings in all these factors we're talking about. So veteran nurses have to meet state certificate requirements in nursing, and I think there's a lot we could do to make those more portable, stackable, you know, things of that nature to make skill—because employers are looking at cross-state-lines hiring practices. There are big regional disparities on this issue, and so those are the types of things we have to take on and reform those boundaries between—it's interagency, intergovernmental type of things that are going to help us solve that problem.

It's not that the innovation's not there to do that kind of training. I mean, universities and community colleges can do it, but it's the rules of what constitutes a licensed person in a lot of those professions that are some of the barriers.

Ms. ESTY. No, I think you're right. There's siloing and there's guild mentality, and I would note a lot of us here have worked on diversity issues for women, girls, people of color. The military is much more diverse than it used to be, and so one of the ways we could rapidly change the face of what somebody who's in STEM looks like is to really aggressively look to place people with service in the military into the STEM fields. And I think it's under-attended-to, and I'd love to follow up with all of you on thoughts about how we can do that.

And, yes, we actually have a special provision on STEM skills in the GI bill, and we've made it lifelong benefits to address this issue about needing to reskill over years. So, that deals with in part the immediate problem of like how do we fill these midlevel skills right away.

I'd like to have you opine a little bit and talk about what you think we can do in elementary level. I know several of my colleagues here are working on legislation built off of things we've seen particularly for girls. If they aren't engaged by eighth grade, it doesn't matter what you have in high school; they've already self-

selected out of these fields. So, thoughts about what we can do on that? And, again, Mr. Yongpradit, that could be something we should be—not just high school students but in elementary going in and talking about science and computer fields. Thanks.

Mr. YONGPRADIT. We've been active in this area, probably the most active of all the K–12 areas that we work in, elementary, middle, and high school. So, I mentioned that we've trained 60,000-plus teachers over the last 3–1/2 years. The majority of that I'd actually estimate probably around 52,000 of that is at the K–5 level. And so what we're doing is we're taking the media specialists, the computer lab teacher, even the classroom-level teacher, and we're teaching them how to integrate computer science into their math lesson, their science lesson, or even to offer it as an elective alongside art, music, P.E. as a special or an elective in a rotation.

And you know what's wonderful about that? So, I know that a number of the members of the subcommittee are sponsoring the Code Like a Girl Act, which is wonderful. Elementary school teachers are so hungry for computer science. You would think that it'd be hard to like convince them to like, you know, bring it into their curriculum because they have so much going on already, which they do, but they are so hungry and they are so willing.

Ms. ESTY. Great, thank you. I see I'm out of my time, and I yield back. Thank you all very much.

Chairwoman COMSTOCK. And I now recognize Mr. Webster.

Mr. WEBSTER. Thank you, Madam Chair.

Yes, I was thinking about that K–5 program. I decided when I was in fourth grade I wanted to be an engineer and ended up doing that, actually planned out where I was going to go to school, started, then started praying.

So, my question is kind of around that. First of all, I know there is a need in everyday life to understand something about STEM. A couple weeks ago, my wife's washing machine broke, and I got a little manual on it off the internet. And it's self-diagnosing, so I pushed a couple buttons and up pops a binary number, and it was 12. And so I looked on this little chart, 12, bad motor control. Sure enough, that's what was wrong with it, so even in the household, it's good to know a little bit about STEM.

But we have spent a lot of money locally—I know in our area—along with K–12 funding and so forth to try to draw more people into STEM. Does that need any more coordination or is it working? Is there any empirical data that would say this works? We're really getting a lot more people, not necessarily from one particular area, just is it working? Anybody?

Ms. MOONEY. Chairwoman Comstock, Mr. Webster, thank you for your question. And you are exactly right. There is a lot of not only our foundation but a lot of company foundations, nonprofits that are working on this issue. We tend to focus very much on the schools, on the students, on the teachers, and that's fantastic to help support them, but we've noticed even with our grants that there tends to not be a parent component, and if we can educate the parents to the importance of these skills, help them to understand how to encourage their students to stay with it, that is an element that can definitely help.

We've also had focus groups where parents have come in and they've talked to us and they've said things like, "I wasn't good at math' you probably won't be either," and that really is very damaging, and that can hinder a student's progress in that area. So, we're trying to do a little bit more—in fact, actually a lot more—around the importance of parents and bringing them into the equation.

Mr. WEBSTER. So is that universal or is it in its infancy or——

Ms. MOONEY. I would say without programs and even the grant requests that come across our desk for us to fund, that element seems to be missing, so we're trying to encourage a little bit more of that. I'm sure there's lots of other areas that we could certainly be focusing on, but that is—that's something that we find missing quite a bit.

Dr. ALIVISATOS. I'd just like——

Mr. WEBSTER. Okay. Yes, go ahead.

Dr. ALIVISATOS. If I could just say a quick—I mean, I think this comment about when a young person, if they're in—often elementary school but also very much in middle school, and then it happens all the way through, when you get this kind of experience where somebody will say, you know, I wasn't good in STEM, you may not be, or math isn't for me, that kind of thing, it really closes things off for people in a way that then they internalize. And that is a cultural phenomenon that really hurts.

And so to your point that inside the home matters enormously but also inside the schools. Giving experiences where people can actually have something that they touch outside of just a test that's going to be graded but something where they can actually have a success has an enormous effect on people, and I think that many of the curricula are really evolving that way now so that people, in addition to their classroom experience, have an experience outside of the classroom where they experience a success, and that helps them to come back in. And that has to happen all through the system.

Mr. WEBSTER. Would directed scholarships, maybe enhanced scholarships for STEM, help? Yes, go ahead.

Mr. YONGPRADIT. Mr. Webster, I'll say that the number-one most effective way to spend money in computer science to actually increase the number of computer science offerings is in-service professional development. That means professional development for teachers who are already in the classroom and teaching them how to just offer computer science as an elective, as an extra course, or what have you. And it's already proven. A.P. computer science principles, which Ms. Johnson mentioned, is the largest A.P. launch of any computer science course—of any A.P. course ever. And so that was driven by in-service professional development for teachers.

Mr. BROWN. Can I just add one more——

Mr. WEBSTER. Well, I'm out of time. Chair?

Chairwoman COMSTOCK. Oh, if you—Mr. Brown, if you'd like to——

Mr. BROWN. So, two things I would add to that. I would definitely concur that the high-quality teacher component is—that's—the data show us that high-quality teachers and high-quality expe-

riences are the biggest impact on students. But I would like to say something about the scholarship question you asked. One of our experiences over the last 15 years going back to the *America COMPETES Act* and different attempts to try and incentivize students is scholarships are less effective than people think because the financial incentives alone of making it easier for a student to go to college will not necessarily overcome their lack of preparation for success in another STEM-oriented career. So, it's their degree of preparation that's more of a selector for whether they can succeed with a scholarship or with some kind of financial incentive than just doubling the amount of scholarship money that's out there.

Mr. WEBSTER. Okay. Thank you. Thank you.

Chairwoman COMSTOCK. Thank you. And I think you're so right on the teacher continuing to upgrade that because, I mean, that's why sometimes bringing the outside people in, too, helps because they're in the real world. Their skills are upgraded. My husband was teaching computer science in the early '80s. Then, he was a principal. Now, he has to go back, and there's a lot of upgrading to do there, so anything we can do to continue to upgrade those skills.

So, I now recognize Ms. Rosen for five minutes.

Ms. ROSEN. Thank you. I'd like to thank the Chairwoman, Ranking Member Mr. Lipinski, and all of our guests. And what I want to say, first of all, is I am a girl who codes, who made it to Congress, who started her career as a computer programmer in the 1970s with the card deck, learning BASIC and COBOL and Fortran and assembler, and I know what an exciting career it is, how creative it is, and how much I learned, and I use those skills every single day here. So I applaud what each and every one of you are doing. There weren't very many of us doing it in the '70s. There still aren't enough. It comes down to inspiration, education, and teaching, so I want to thank you all for that. I'm a proud sponsor of the Code Like a Girl Act, and today, we're going to introduce with Rep. Knight from this committee the Building Blocks of STEM Act, which is going to put some money into that early childhood education to let kids know that it is creative and exciting as you want to make it to have a career in technology.

So, to that end, I really want to ask you, what else can we do in Congress to help make this a reality, helping with veterans in retraining, helping with other training programs, teaching our teachers? So, how can I be helpful in Congress to make these kinds of things happen to fill these jobs and let people know that they're capable of doing it?

Mr. BROWN. I'll take a first crack at that. First off, I think you've definitely got my award for the coolest bill name I've heard, so thank you for that.

Ms. ROSEN. I'm no longer a girl, but I feel I code like that.

Mr. BROWN. One of the things I would point to that I think Congress can do is make sure that we're delivering on the promises we've made to schools to fund the programs that do in fact impact our lives. NSF does a lot of work in this area. There have been attempts in the past to narrow NSF's focus to just undergraduate or just K–12 or—I think NSF has to do it all within the realm of STEM learning because we're learning in lots of different ways.

To your point about elementary education, one of the things that we saw under No Child Left Behind is a narrowing of the curriculum to math and reading, and so I highlighted the fact that States are adding science to their accountability systems because the data show really clearly that impacted elementary science learning the most. And one of the curious things I see—I've seen this as a parent and it's in the data, too, is that elementary STEM night brings in everyone—

Ms. ROSEN. Yes.

Mr. BROWN. —right, the girls, the boys, all the different students. In middle school, there are a lot less girls.

Ms. ROSEN. Yes.

Mr. BROWN. And in high school, it's all dudes, right? So, there's definitely a phenomenon that's going on there that it's good for Congress to be aware of it because it's not just this Committee, it's the Education Committee—

Ms. ROSEN. Right.

Mr. BROWN. —it's all the other things, but you've got to work together to have a solution that addresses all of these things across all of those different policy mechanisms.

Mr. YONGPRADIT. Let's talk about two things that a lot of the members here have already done and then build on that. So, one thing is the 2015 STEM Education Act, and that included computer science as part of the Federal definition of computer science. In the State of Maryland, higher ed institutions heard about that and realized, gosh, we offer a STEM endorsement at our university. We probably need to include some computer science in it if computer science is now part of the definition of STEM. So, they actually did that on their own because of that act, so that's one positive effect from that act.

Adding computer science to the list of well-rounded education subjects in ESSA, what that has done and it continues to do is increase the priority of computer science at the state level, and so even States like Connecticut, Ms. Esty isn't here anymore, but Connecticut has included computer science as part of their ESSA plan. That wouldn't have happened if—

Ms. ROSEN. Right.

Mr. YONGPRADIT. —computer science wasn't included in ESSA.

So, I think the focus of computer science in STEM and providing guidance around computer science in STEM funding is a constant thing that Congress can continue to do.

Ms. ROSEN. Go ahead, Ms. Mooney. Thank you.

Ms. MOONEY. Thank you, Chairman Comstock.

Ms. Rosen, thank you for your inspiration words to start off with. That's great that you're a girl who codes.

Anything that you can do to continue to incentivize teachers to teach computer science and teach STEM. We have a program that we're working on at our local university where we take freshmen that are majoring in computer science or engineering and partner them with a teaching certificate so that when they graduate, they not only will have that engineering or computer science degree, but they'll also be able to teach. If there would be an incentive—I know sometimes the funding when they come out isn't equitable—but if they have an incentive to go into the classroom with that, we think

that is fantastic. And any time that we can get somebody that—especially for girls—if we can get a female teacher in the front of the room, somebody that they can aspire to, that looks like them, any of those type of programs would be very helpful.

Ms. ROSEN. Thank you. And I'd like to see that tech bus——

Ms. MOONEY. Yes.

Ms. ROSEN. —that tech-mobile—

Ms. MOONEY. Yes.

Ms. ROSEN. —in every community in America. I think that would be great. Thank you.

I yield back.

Chairwoman COMSTOCK. Thank you.

And I now recognize Mr. Hultgren for five minutes.

Mr. HULTGREN. Thank you, Chairwoman.

Thank you all so much, appreciate your work, appreciate you being here. This is such an important subject and something I'm passionate about. I think all of us are, but privileged to join with our Ranking Member of the Subcommittee. Dan Lipinski is Co-Chair of our STEM Caucus here in Congress, and just continuing to be talking about it—it really is something that brings us together. There's way too many things that divide us up here, but this is one of those things that absolutely brings us together of what can we do to prepare the next generation, our best and brightest to go into STEM fields, realizing that so much of our nation is dependent on the next explorers and discoverers and researchers who are going to have incredible breakthroughs.

I just had the privilege a couple of weeks ago to have a graduation of something that we started called our STEM scholars. In the 14th Congressional District it was 19 high schoolers, ten young women, nine young men, where it was a yearlong program. I met with them once a month, and we would go to different places around the district that I represent, seven counties just west of Chicago, north of Chicago, learning about ways for them to apply STEM education in the workforce. So, we went to Fermilab, a national lab in my district. We went to the Cain Tubular, which does tube bending for exhaust systems on rocket engines that's in St. Charles, Illinois. We went to Flavors of North America, FONA, which does chemistry of taste and smell in our foods, and many, many other things, Digital Design Manufacturing Institute, downtown Chicago, phenomenal. I mean, it was great. I learned a lot. I think the high schoolers learned a lot.

But we'd spend maybe an hour-and-a-half learning about how they could apply this, and then we'd spend maybe an hour for me to hear from them of what has worked in their lives, what sparked that interest, what sparked that passion, and how can we take that and share it with others.

The other thing we saw every place we went is the need for computer programming, that the jobs are there. Dr. Marshall, who was here a little bit earlier, talked about that, you know, I hear it so often of how we need more programmers, and it's almost like this guaranteed career path if someone is willing to dedicate themselves to doing that.

I want to just get your thoughts. What I was hearing from some of my STEM scholars and others is that they've had to kind of go

outside of school to find opportunities for programming. Many of them are part of robotics teams, which I think are phenomenal, some great programming opportunities that are a part of that. Others have done some other coding and so grateful for that.

But I guess my first question I'll address to Mr. Yongpradit, and I do appreciate Code.org. I've gone through that the last few years with different high schools and young middle schools and grade schools and had my own kids with me as we were doing that, and just a really good program that I appreciate.

I just wanted to see, you know, as a parent, I've got—my wife and I have four kids. My youngest, my 13-year-old I think really wants to go into programming or some other science field. What would you recommend that I could be doing to be helping our school do more but also looking for more opportunities as a parent to open up opportunities for my own children or other students as well?

Mr. YONGPRADIT. First off, I want to thank you for participating in the Hour of Code—

Mr. HULTGREN. Great.

Mr. YONGPRADIT. —so many times. That really helps the cause at the local level in Illinois, as well as the national level to see Members of Congress participate in that event.

One thing I wanted to note about Illinois, Mr. Lipinski, Mr. Hultgren, there actually is an Illinois State Task Force for Computer Science. They just submitted their recommendations about a week ago, so you might want to take a look at that.

Mr. HULTGREN. Good.

Mr. YONGPRADIT. In terms of increasing opportunities, you know, the Hour of Code actually has a section called Beyond an Hour of Code, and so there are all these online self-paced experiences that kids can do on their own and teachers can pick up and bring into the classroom. And these are things that don't require a whole new course. The science teacher, the math teacher can just take a little break from the standard curriculum and introduce some computer science, so that's one way of doing it and making them aware of it. And then obviously, there are a lot of afterschool activities as well like those robotics clubs, First Robotics, and things like that. So these are ways to get kids engaged when they don't have something in school, but again, I always repeat, the most important lever is getting a teacher in the school to offer that course.

Mr. HULTGREN. Yes. Just a few seconds left, but Dr. Alivisatos, if I could address this to you. According to your testimony, 100 out of 1,576 schools or about six percent, produce over half the number of graduate students in the United States with bachelor's degrees in computer science. Why is this, and what would it take to increase the number of graduates from more schools?

Dr. ALIVISATOS. Yes, I mean, look, this is an enormous challenge right now because most schools just don't have the faculty to do it. And, of course, you're competing with this enormous demand in the workforce——

Mr. HULTGREN. Right.

Dr. ALIVISATOS. —for people with those skills. Instead of teaching, they can be in the workforce and be better compensated, so, I mean, that's a huge part of it.

You know, I think that what makes it more attractive for people is when the job itself also has components to it that are outside of, sorry, just the strict classroom, and I think that that's the case for the people that you want to be teaching these classes at the level where they're going to be producing undergraduate degrees. They have to be engaged themselves also in thinking about new ideas and attacking problems that society really cares about. That motivates people. Many people will in fact be in careers that don't compensate them quite as well if they have the opportunity to do something they find greatly meaningful themselves. And so I think trying to approach how we can offer the opportunity to people who teach in those organizations, that opportunity to be thinking about cybersecurity research or things of those kinds, that gets them motivated and they'll stay.

Mr. HULTGREN. Yes. Well, thank you all. I, again, could go on for a long time. This is so important. I would love to hear a little bit more. Coding boot camps, we're hearing about some of these things that have been happening that I think have been pretty powerful and even trying to find ways to bring that to younger kids to go beyond I think could be amazing. Also, we've seen some incubators start up in some of our universities where it's that practical applied, and great relationships being built while they're still in school. But my time is long past expired. I apologize. I yield back.

Chairwoman COMSTOCK. All right. Thank you.

And we now recognize Ms. Bonamici.

Ms. BONAMICI. Thank you, Chair Comstock and Ranking Member Lipinski, and our witnesses.

I also serve on the Education Committee, had a lot of conversations about this topic. I'm the founder and Co-Chair of the Bipartisan Congressional STEAM Caucus, which now has 87 members, including the Chair and the Ranking Member, and I have invitations here for those of you who are not yet on the caucus. STEAM recognizes the importance of STEM but also the value of arts and design to teach students how to think creatively and critically and be adept at problem-solving.

We have many examples in my district in Oregon of the benefits of STEAM, for example, the Nike world headquarters where they have engineers developing state-of-the-art equipment and scientists experimenting with new materials and artists making the products unique.

We have right now scientists and engineers working with architects and designers to build new high buildings out of cross-laminated timber.

We have two nationally recognized public STEAM schools where educators are challenging students in STEM topics but also encourage them—encouraging them and inspiring them to create and imagine and make things, skills that were all—will all be really extremely useful when they reach the workforce.

But this just is not just happening in Oregon; it's happening across the country. General Motors just said this about an upcoming STEAM conference: "It's important for students to understand that not only does GM employ many engineers with STEM-related backgrounds but also requires people who excel in the artistry that designers bring to the job of designing beautiful cars."

There's a couple of researchers at Michigan State University, the Root-Bernsteins. They write and study about creativity. They found the more accomplished scientists are, the more likely they are to have an artistic hobby and be engaged in arts and crafts. Dr. Mariale Hardiman at Johns Hopkins just did a—you're nodding your head at all of this, Doctor. You know. Johns Hopkins just did a study showing that students who learn STEM classes with arts integration have better retention than students in conventional lessons.

And we've had a lot of conversations about the gender gap in STEM. Two Bit Circus, which is a Los Angeles-based engineering and entertainment company, just did a survey, hundreds of families. They confirmed the gap; it's no surprise. Boys say they're interested in technology and girls say they like art. In fact, 99 percent of the parents surveyed said their daughters did arts and crafts. So, when girls find out that they can do art and STEM, we're starting to close the gap.

So, last week, the STEAM Caucus and the CTE, Career and Technical Education Caucuses held a joint briefing. There was a representative there from the Rhode Island School of Design. They've been academic leaders in STEM. Their former President came from MIT. He was at our caucus kickoff years ago. This representative from RISD has been traveling the world. This is happening—every school in Barcelona is now going to be STEAM instead of STEM. Beijing, they're expanding STEAM instead of STEM. It is not the time now for the university to fall—or, excuse me, for the United States and our universities and our K–12 system to fall behind in being innovative.

For my colleagues on the other side of the aisle, Governor Kasich just said in his last State of the State address last year—STEAM education, I add the capital A for the arts. Any student who's going to succeed later in life, including someone choosing a technical career, is going to need creative skills and know how to apply creative thinking. These skills are best developed by exposure to the arts, science, technology, engineering, math, and arts. And Governor Kasich said this: "Arts community, did you ever think you'd see a conservative Republican ever say this? But we believe it. These are essential for success in the 21st century careers."

So—and I want to emphasize—I mean, the Chairwoman talked about Montessori. Montessori, great model, they emphasize arts and music as well, so they're adding science and STEM, but they don't cut arts and music. And we heard from one of our panelists about how, during No Child Left Behind, curriculum was narrowed.

So, thank you to all of you who mentioned the importance of funding in—under the Every Student Succeeds Act. It's so important, title 4, critical to have that funding that focuses on well-rounded education, including STEAM and computer science.

So, Mr. Brown, can you tell us how—through all of these coalitions, how can we help students become better creative problem-solvers and innovative thinkers, and what role do you see for arts and design?

Mr. BROWN. Well, one of the things the data shows us is however you get kids interested in these fields, they do better in the classroom if they're interested, and I think that's the hook of STEAM.

I mean, some kids are going to get really excited about the creativity aspects of it. That's what will bring them in. Others respond to mentorship. Others respond to doing things with their hands, right? However you can get kids interested in these fields, that's how you will give them the ability to do better in school.

Kids who are on football teams tend to be motivated to stay academically eligible so they can play football, right? I hope that same thing is happening with robotics competitions and other things where the social capital of liking something is helping them do better in school. So, it's things that get kids interested and meeting them where they are that will help us with this equation.

Ms. BONAMICI. Right.

Mr. BROWN. So, I think one of the things the National Science Foundation can do that's incredibly important is do better and more extensive studies of these phenomenon so we understand exactly how to amplify them and to take advantage of them and establish the connections between the value of inspiration and interest and performance in the classroom so that we understand that these programs are not just great because they get kids smiling but also because they contribute to the outcomes that we know are valuable and that we'll spend scarce dollars on.

Ms. BONAMICI. Well, absolutely. And the brain researchers there, the Oregon Health Sciences University Brain Institute, there have been studies that show that when students have both halves of their brain educated, they do become more creative and innovative, and it's critical thinking that is so important. And so thank you for the nodding heads.

And I do invite any of the Committee Members who are not yet on the STEAM Caucus to join and we'll get the number up past 87.

Thank you to the panel, and I yield back.

Chairwoman COMSTOCK. Thank you, Ms. Bonamici. And I do appreciate your emphasizing the arts in that since I have Wolf Trap in my district. They have a wonderful STEAM program that now is—I think Ohio is one of the States, so before Governor Kasich was celebrating that, Wolf Trap was sharing this program all around the country, and I think it's now gone beyond even this country. And it was something we started in the State House where we just gave them a grant to do that, and they have been wonderful.

And then also, since my granddaughter's favorite show is talking about grandparents, so I will talk about my granddaughter again. Her favorite TV show—usually, I'm not promoting TV shows—but Little Einstein, which is STEAM; it's not just STEM—they have music all throughout that program so it's all science and she knows all this classical music now from Little Einsteins.

And I got her—she started watching that because we had a young man who came from our district and he had gotten perfect scores on everything in math and science. And so I did ask him, "well, what did you do, what'd your"—and I said, "well, you probably didn't watch any TV or do"—and he said, "no, I watched Little Einsteins," so very well-rounded on that.

So, sorry to—and I'll plug all the members also, join the STEAM Caucus, too, because it's great.

So, I now recognize Mr. Beyer for five minutes.

Mr. BEYER. Thank you, Madam Chair, very much.

Mr. Yongpradit, what role does video game play into any of this, and how does the—all the kids—you know, right now, you hear a video game is so much bigger than the film industry and that more girls are playing than boys. So what role if any does it play in stimulating interest in computer science?

Mr. YONGPRADIT. Well, that is a great question at a great time actually since we just talked about STEAM and Mr. Brown talked about however way you get them interested, that's the way to go. So, in fact, I taught game design and game programming as a teacher, and that was my hook not just for men but for women as well. And in fact we had a special women's club just for making apps and games.

So, I'd say the role is it's a hook, number one. Number two, it's a great environment for introducing the arts, the programming aspect, as well as an entrepreneurship aspect. Video game programming is just a great medium for exercising all these different skills and areas of interest.

And it's obviously important that we teach our kids how to create these video games and not just play these video games. So all those girls who are playing video games on their smartphone these days, Candy Crush, whatever, they need to really think about how these games work at the minimum, and then hopefully also learn how to program these games.

Mr. BEYER. Great. Thank you very much.

Ms. Mooney, you know, it's sort of—it's been written greatly that Silicon Valley is an incredibly unfriendly place for women and even New Yorker cartoons about, you know—and that high-tech startups in general are fairly functionally misogynist. So how do you—there's a hard glass ceiling there, especially in these high-tech places. How do you encourage young women to study computer science when they have no hope of ever being a manager or an owner?

Ms. MOONEY. Well, thank you for the question, Chairman Comstock, Mr. Beyer. We hope that there will be inspiration along the way so they don't automatically think there's no hope for them.

We have started a Women in Technical Career luncheon series where we bring women engineers not just from Micron but from area companies to go into high schools and have lunch with the girls. And they talk about their struggles and they talk about the grit that's needed and their mentors that helped them through the way. And we feel that this conversation, it's very comfortable, it's at the girls' high school, bring in pizza. They can have a very intimate discussion with how these female engineers have progressed through their career and established relationships with the females so, as the students are going through, finishing their high school and on off into college, they have a mentor, a buddy by their side helping them every step of the way.

But it really is about making sure that females see themselves and can see the path and have some support all along the way.

Mr. BEYER. I'd also suggest we need to try to figure out what if anything we can do to help change the culture——

Ms. MOONEY. Sure.

Mr. BEYER. —in that high-tech community.

Ms. MOONEY. Sure.

Mr. BEYER. Mr. Brown, Dr. Marshall talked about reconciling the 500,000 open computer jobs with the 6 million Americans who have stopped looking or that—and everyone talks about the skills gap. How credible is it or what's the dilemma when you take a 50-year-old, 55-year-old, 60-year-old coalminer or steelworker or textile worker who's been displaced by the new economy, how readily can they adapt to computer science?

Mr. BROWN. You've hit right at the heart of the issue there. I mean, that's a difficult problem, right? You have to look somebody in the eye and say your skills are dated. If you want to get a job, you've got to have a different set of skills or maybe you've got to move to a different location, right? And one of the things our education system doesn't do very well is target that specific area within society. Our educational institutions move really slow.

Dr. Marshall also asked about community colleges, and the solution to those problems are probably going to come from the smaller, more nimble, more online places within the education system that can lower those barriers so that you can—because what you really can't say to a 50-year-old laid off electrical engineer or a coalminer is you got to go to college for four years and pay $150,000 to get a job, right? That's not viable at all. And so many of the initiatives that we focused on job retraining are not focused on the structural aspect of you have people with mismatched skills. So, we haven't really done much in that space.

And the innovators that are happening in that space are focusing on not degrees necessarily but employable credentials. And that's—when you see companies looking to hire veterans or looking to hire other displaced populations, generally what they're not looking for is a degree as the certificate for employability. It's some other form of credentialing.

And again, I go back to the fact that the National Science Foundation is doing research on all these different modalities. Teachers, people in the education system don't understand this problem either, so when that person shows up at a community college, they may not know what that 50-year-old displaced employee needs either.

Mr. BEYER. Great. Thank you very much. Thank you, Madam Chair.

Chairwoman COMSTOCK. Thank you. And I know we share a lot of constituents at George Mason University, and I want to give them a plug because they have the video game institute, which is a great place, and those are six-figure jobs that people are getting in that video game industry—they're in medicine, they're in, you know, all kinds of fields. And as you all know, I'm sure you've seen—I know when I go out to schools and I often ask the kids how many of you play video games, it's like how often do your parents get upset that you're playing video games? I said we need to change that paradigm because people are all upset about what video games they're playing and getting them engaged in understanding that there is a lot of educational component to that, as well as entrepreneurship and all of the things that you identified. So, I wanted to give George Mason a plug on that. And I know they get out there in the elementary schools, too.

I now will recognize Mr. Foster for five minutes.

Mr. FOSTER. Well, thank you very much, Chairman Comstock, and also for letting me sit in on the committee today, which I normally do not serve on, but I very much appreciate it.

I'm Bill Foster. I'm best known as being the only Ph.D. scientist in Congress and—but I'm also the only integrated circuit designer, which—in addition to that, I'm a businessman who started a tech company with my brother in our basement that now manufactures the majority of theater lighting equipment in the United States. And we just went over 1,000 employees, and we've had continual trouble hiring people with appropriate technical skills.

And one of the really important factors in that is a government commitment to high-quality education, period, which unfortunately has become a matter of some dispute. We operate in Wisconsin where the legislature and the Governor has, you know, acted in a very strong way to—and against the interests of the University of Wisconsin where I graduated from. It's resulted in a hemorrhaging of faculty from that institution and a lot of uncertainty about whether there's a commitment to high-quality education. And that has real economic implications.

I was discussing recently with my brother, who has been running the company for a long time, about whether under these circumstances he would consider developing that business in Wisconsin anymore simply because of the damage that's been done to the education system. So, it is important to preserve this, and I hope there is a bipartisan commitment to that.

I also am the Co-Chair of the New Democrats Committee on the Future of the Workforce, which is why I'm, you know, so interested in this hearing. And the question I have is within the fast-paced economy—fast-moving technical changes in our economy, how do you aim for the jobs that will actually be there five years from now? You know, there—and particularly in terms of the breadth of knowledge you shoot for. You can—you know, if you say, okay, we're going to have cell phones in our future, you can teach people about the mathematics behind, the quantum mechanics behind, the logic gate design behind the computer, logic design behind the programming, behind the—you know, the app design and on and on. There's—and you have to educate people at an appropriate level.

You know, I think—you know, I'm a big fan of Micron as a company, but the number of integrated circuit designers in our economy will never be large, okay? And so you can't—you know, that's not the job of the future for the majority of people. And I think—you know, I worry that, for example, a few years ago or a decade ago we made probably a mistake in training a whole generation of people to be web designers and learn HTML. If you're a web designer today, you don't use HTML. You use high-level tools that are comparable to maintaining your Facebook page. And so you can—and similarly, big data analytics that you talked about will probably take place a decade—and now having a conversation with Alexa and you won't even be writing the code that does this. Giant AIs will do it for you, and the cloud will do the computing.

And so trying to understand how you—you know, how you target this in terms of the altitude and particularly the danger that you train someone for a very narrow discipline that will be vanished by

the time—and so I was just wondering how you think about that problem because I know I worry about it all the time. Anyone who wants to grab it.

Mr. YONGPRADIT. So a number of States got together in 2015 to create the K–12 Computer Science Framework. And what it does is it codified the essential basics that every citizen needs to know when it comes to computer science. These are the essential concepts. These aren't things that disappear in 5 or 10 or even 15 or 20 years. These are the things that have existed over the last 50 years in computing and will continue to exist. So, basically focusing on the core foundational concepts in the computing field is the way to go educationally so that students who are in kindergarten now who are getting super excited about computer science and what they're learning—aren't ill-prepared when they get to the age of 22 and they're approaching the workforce. So, educationally, we need to focus on the core concepts.

Dr. ALIVISATOS. Maybe I can just jump in there, too, and say—I mean, for us, this is very, very core to what we do as a university, and of course you're going to get a major,in some specific subject area, but it's going to change no matter what. So we definitely have not succeeded if we haven't somehow enabled somebody to be able to have deeper skills that allow them to learn new things and to be engaged.

Having said that—and to your point about STEAM—a lot of that involves having embedded into the education the idea of creativity and of imagination. That has to be a part of it certainly.

But I will say that we're also finding that the demand on our campus for people to come back multiple times during their life for a period of time, not for four years and not for $150,000, but to come back for a period of time, the demand for that is just off-scale. We almost can't meet it right now. And so we're spending a lot of time trying to think through whether we can make a commitment to somebody that comes as an undergraduate, that they'll be able to come back to our campus a certain number of times during their life at points where their careers are transitioning and changing, and then we can help to serve them again. And I think that's probably something that we will end up doing.

Mr. FOSTER. It appears my time is expired, so I'll yield back.

Chairwoman COMSTOCK. Thank you. Okay. I guess we are at our completed time here.

Thank you so much for all the great work that you're doing out there in highlighting these issues and helping illuminate both for us and for all our companies who are engaged, all of our communities and teachers who are engaged. So as the wife of a math and computer science teacher, as the mom of a biology and forensics major, I really appreciate the work you're doing. And I think what is clear here is we all need to be lifelong learners in this field because this is going to continue to change. This needs to be incorporated everywhere from preschool through all of our lifelong training and retraining and upgrading of our skills. So, I think you've really helped illuminate this issue that will be an ongoing issue for our time.

So, I thank you and the members for their questions, and the record will remain open for two weeks for additional written comments and written questions from the Members.

And the hearing is now adjourned.

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

Appendix I

Answers to Post-Hearing Questions

ANSWERS TO POST-HEARING QUESTIONS

Responses by Mr. Pat Yongpradit

HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

"STEM and Computer Science Education: Preparing the 21st Century Workforce"

Mr. Pat Yongpradit, Chief Academic Officer, Code.org

Questions submitted by Ranking Member Daniel Lipinski, House Committee on Science, Space, and Technology

1. You point out in your written testimony that computer literacy is a matter of national security, not just economic opportunity. While it is important that K-12 students learn basic coding, it is no less important that they learn to protect themselves and to incorporate a cybersecurity mindset into their daily studies and projects. Do you know if any school systems are specifically working to introduce this topic into their classrooms, and if not what can we do to emphasize this critical subject? Do courses developed by Code.org include lessons on cybersecurity? How can cybersecurity best be integrated into computer science education at the K-12 level, rather than as an add-on?

   Answer: *Computer science* literacy is a matter of national security not just because of programming/coding, but because it also includes instruction in cybersecurity. There are three examples of how this is happening: in states that are creating K-12 CS standards, in the national AP CS Principles exam, and through the work of Code.org's partner, the National Integrated Cyber Education Research Center (NICERC).

   We see cybersecurity in state computer science standards. Currently, there are 10 states that have K-12 computer science standards and many of them were informed by the K-12 Computer Science Framework. This framework includes a strand specific to cybersecurity that covers topics such as online piracy and ethics, digital citizenship, confidentiality, authentication, encryption, viruses, phishing, and firewalls. There are 9 states that are currently creating K-12 computer science standards - all of which are using the K-12 CS Framework as a guide. Therefore, states that are making strides in computer science are also making strides in cybersecurity. By building a foundation of computer science from early grades, we are also building a pipeline of students interested in specializing in cybersecurity in later grades and in college and career.

   We see cybersecurity featured in the Advanced Placement (AP) Computer Science Principles course, which launched in the Fall of 2016 as the largest launch of any AP course ever. One of the learning objectives is to "Identify existing cybersecurity concerns and potential options to address these issues". The course includes topics such as cyberwarfare, cybercrime, and cryptography.

   How do we get cybersecurity taught in more schools? We can do it within the larger context of computer science as a discipline as well as through programs that integrate

computer science, cybersecurity, and other subjects. NICERC works with school districts and schools from across the country to introduce students to the world of cyber through integration into STEM and Liberal Arts Disciplines, and further, computer science. Concepts of cybersecurity are woven into lessons such as:

- Investigating how algorithms relate to computer graphics, robotics, and software engineering
- Analyzing computer architecture as it relates to the future, cyber security and networks
- Researching relationships between computer programming and gaming, artificial intelligence, and cloud computing

Louisiana, Arkansas, and Virginia are top state partners. Model districts include Bossier Parish Schools (Louisiana) and San Bernardino County (California).

Appendix II

Additional Material for the Record

LETTER SUBMITTED BY REPRESENTATIVE BARBARA COMSTOCK

July 24, 2017

The Honorable Barbara Comstock
Chair
Subcommittee on Research and Technology
Science, Space, and Technology Committee
United States House of Representatives
2321 Rayburn House Office Building
Washington, DC 20515

The Honorable Daniel Lipinski
Ranking Member
Subcommittee on Research and Technology
Science, Space, and Technology Committee
United States House of Representatives
394 Ford House Office Building
Washington, DC 20515

Dear Chairman Comstock and Ranking Member Lipinski:

The Computer Science Education Coalition (CSEC), a broad-based coalition of over 100 businesses and non-governmental organizations working to expand access to computer science education in K-12 classrooms across the United States, thanks the Subcommittee on Research and Technology for holding a hearing on STEM and Computer Science Education: Preparing the 21st Century Workforce. This is an important topic that has significant impacts on what our schools will teach and how competitive our economy will be for some time to come.

Computer science is a foundational skill for 21st century jobs. This skill is in high demand in the private sector and the armed forces. However, the United States is failing to take the necessary steps to equip our current and future workforce with the computer science skills needed to fill these positions. Critical jobs throughout our economy are going unfilled due to a lack of Americans qualified in computer science. The result is an economy falling short of its potential.

Last year, leading CEOs, educators, and nonprofit leaders from across the country joined 28 Republican and Democratic governors to send an open letter to Congress, asking for funding to provide every student in every school the opportunity to learn computer science. The signatories included now-Vice President Mike Pence, Fortune 100 CEOs across multiple industries, such as the nation's largest technology companies, retailers, telecom firms, airlines, investment companies, entertainment companies, hotels, and manufacturers. The signatories all have a strong interest in a domestic workforce equipped with the computer science skills our businesses need.

The CSEC looks forward to working with the subcommittee as it explores this topic. STEM and computer science education are keys to our workforce being the best and most innovative in the world. We thank the subcommittee for holding this hearing.

Sincerely,

Erin Siefring
Chair
Computer Science Education Coalition

QUALCOMM LETTER ADDRESSED TO REPRESENTATIVES COMSTOCK AND LIPINSKI

QUALCOMM Incorporated
5775 Morehouse Drive
San Diego, CA 92121-1714
www.qualcomm.com

August 9, 2017

Honorable Barbara Comstock
Member of Congress
229 Cannon House Office Building
Washington, DC 20515

Honorable Daniel Lipinski
Member of Congress
2346 Rayburn House Office Building
Washington, DC 20515

Dear Chairwoman Comstock and Ranking Member Lipinski:

Thank you for holding the July 26 hearing titled "STEM and Computer Science Education: Preparing for the 21st Century Workforce."

Qualcomm agrees with you both that "a STEM educated workforce is necessary for innovation and for ensuring U.S. economic strength, competitiveness and national security" (Rep. Comstock opening statement) and that "all students, no matter where they grow up, their background, their race, or their sex, have the opportunity to become educated in computer science and all STEM fields" (Rep. Lipinski opening statement). Qualcomm also agrees with Chairman Lamar Smith that "we must ensure that America stays a world leader in innovation" (Rep. Smith opening statement) and Ranking Member Eddie Bernice Johnson that "structural and social barriers are preventing us from fully engaging students of both genders, students of all ethnicities, and students from all backgrounds as we attempt to increase participation in computer science" (Rep. Johnson opening statement).

Qualcomm appreciates Chairman Smith's and Rep. Elizabeth Esty's leadership and the House Science, Space and Technology Committee's bipartisan work during the previous Congress on the STEM Education Act of 2015 (Public Law 114-59) as well as this year's successes with the INSPIRE Women Act led by Rep. Comstock (Public Law 115-7) and the Promoting Women in Entrepreneurship Act led by Rep. Esty (Public Law 115-6).

As the Committee continues its work on STEM, I thought it would be helpful to share Qualcomm's experiences -- with a focus on our Thinkabit Lab collaboration with Virginia Tech in nearby Northern Virginia. Our recommendation is that federal policies promoting STEM should engage students beginning at the elementary school level in hands-on, accessible programs. I welcome the opportunity for Members of this Committee to visit us so they can see our work first-hand.

The goal of Qualcomm's STEM initiatives is to help lead the next generation of great thinkers and inventors by showing them the possibilities that lay before them in areas such as robotics, connected cars, Internet of Things (IoT), and 5G.

According to the Bureau of Labor Statistics, by 2020 the U.S. will have 1.4 million computer-science related jobs available but only 400,000 computer science graduates with the necessary skills to apply for them. Filling this gap is vital to both Qualcomm's continuing success and to the broader ecosystem that technology enables, and the only way to do so is for more people who are traditionally underrepresented in the computer science and engineering fields to be brought into the equation.

Qualcomm Thinkabit Lab has exposed more than 12,000 students, teachers and parents to hands-on STEM activities at Qualcomm headquarters in San Diego, Virginia Tech's National Capital Region (NCR) campus ("VT-Thinkabit Lab"), and several other sites across the U.S.

VT-Thinkabit Lab is centrally located in Falls Church, VA near the Interstate 66-Dulles Toll Road interchange in House Science Committee Member Rep. Don Beyer's district and is easily accessible to Rep. Comstock's and Rep. Gerry Connolly's nearby districts and the greater Washington, D.C. metro area. VT-Thinkabit Lab's mission is "to serve Washington, D.C. area students, teachers, administrators, parents and collaborators in technical career exploration and hands-on electronic and programming foundations of IoT and Smart Cities sensors, actuators, and data collection and analysis" to help prepare "our future STEM workforce and our increasingly diverse, technology-driven community for jobs that may not yet exist" (www.thinkabit.tech). Although less than a year old, VT-Thinkabit Lab has already engaged more than 3,500 students and close to 2,000 parents and community and school leaders.

At VT-Thinkabit Lab, Virginia Tech students collaborate with elementary, middle-school and high-school students and their teachers on technology-driven projects. Our approach is tangible, hands-on, fun, creative and clever. As an example, a sixth-grader came up with the idea of attaching sensors to his clothes, which he said were always in a pile in his room, to help him figure out which clothes to wear (www.qualcomm.com/news/onq/2017/05/24/qualcomms-susie-armstrong-talks-thinkabit-labs-stem-and-inspiring-next). VT-Thinkabit Lab is an important component of the university's professional development of current and future principals, superintendents and other education leaders. As Virginia Tech president Tim Sands summed it up in an interview with the Northern Virginia Technology Council's Winter 2017 magazine, "Our partnership with Qualcomm and the Thinkabit labs at the Northern Virginia Center is an incredible opportunity to instill technology into problem solving for K through 12 students across Northern Virginia and even into Maryland and D.C."

Building on success of VT-Thinkabit Lab and other initiatives, Qualcomm is collaborating with more universities as well as school systems, libraries, local governments and private sector organizations to create their own "Inspired by Qualcomm Thinkabit Lab" spaces. Thinkabit Lab content is available online and free of charge in a toolkit that includes videos, activities for teachers, equipment lists, and posters. So far, eight Thinkabit sites have opened since December 2015 and more are on the way.