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Importance of STEM Education

Members of the subcommittee, thank you for the opportunity to address you today. I'm sure that everyone here believes that STEM education is critical for our nation's future for many reasons, for example:

To ensure our nation's youth are college and career ready. It is critical for ensuring that more of our young people will be equipped to pursue high paying STEM jobs, ones that currently are going unfilled far too often.[1] I do not refer only to needing enough advanced degree holders; many of our unfilled STEM slots in the job market require more students to pursue and succeed at STEM programs at the community college and four-year levels. This is key to our economic competitiveness in the world. For a few decades now, international comparisons have been helping us monitor whether U.S. STEM education is resulting in strong student achievement in mathematics and science that is needed for college and career readiness.[2] Most analysts conclude that there is a strong opportunity and need for more robust STEM achievement.

To develop STEM literacy for everyday life. The STEM fields are steadily bringing many big and small changes in everyday life. We need a constantly refreshed, strong STEM education that leads to every high school graduate being STEM literate, in ways consistent with 21st Century Skills. STEM literacy is becoming more and more indispensible for a person to thrive in today's world. It's also indispensible for our nation to have STEM literate citizens guiding how STEM developments should and should not unfold.

To ensure that all students have access to the best STEM preparation. Because our nation has diverse peoples, STEM education must be equally

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[1] Symonds, W., Schwartz, R. & Ferguson, R. (2011). *Pathways to Prosperity: Meeting the Challenge of Preparing Young Americans for the 21st Century*, Report issued by the Pathways to Prosperity Project, Boston, Mass: Harvard University, Harvard Graduate School of Education.

[2] Britton, E. & Schneider, S. (forthcoming). Large-scale Assessments in Science Education. In N. Lederman and S. Abell (Eds), *Handbook of Research on Science Education*, second edition. Taylor and Francis.

effective for students of all races and ethnicities, for both girls and boys, in both urban and rural areas. Currently, there are many achievement and opportunity gaps in success among our diverse students. A good portion of federal funding for STEM should continue to leverage attention to promoting equity and success for diverse students. Of course, equity always will be a matter of fairness in our democracy. However, my state of California has already become minority-majority and this shift in demographics will occur across the nation in short order. Therefore, effectively teaching *all* students is not only about fairness; it also is a national economic necessity to have enough students from every background choosing to enter STEM college and career paths and succeeding at them.

In short, a STEM education that is relevant and rigorous is a keystone for anyone and everyone to be college ready, career ready, or ready for succeeding in their everyday lives.

In my testimony, I make the case that strong, continuous but evolving leadership from the federal government is indispensible. And the needed federal efforts to catalyze, leverage and support changes in STEM education must adapt to changes in the challenges that we will face in STEM education, and do so in ways that are strategic, aligned and efficient.

Internationally Competitive STEM (not SteM)

It is important to take a moment to clarify what we mean by "STEM." As a convenience, I am using today's common acronym "STEM" to refer to science, technology, engineering and mathematics. However, there are some big advantages and big problems with the pervasive use of this phrase today.

The great news is that "STEM" includes all of these subjects. In the past, the education field focused primarily on science and mathematics. Now, increasingly we also are beginning to address the need for technology and engineering education in grades K-12.

A problem with the wide talk about "STEM" is that it may be desensitizing us to the fact that not enough is happening yet across all of these subjects:

- Mathematics is receiving appropriate, strong attention because it is one of the most accountable school subjects in our states' standards and assessments, and it can be either a gateway or a barrier to learning other STEM subjects.

- On the other hand, science is actually receiving less — not more — attention than it did a decade ago.[3] For years now, I've regularly heard colleagues in science education say something like 'science education has become a second-class citizen in the U.S. STEM agenda when compared to mathematics.' That this is the case is alarming on its own, but especially so because it is *not* similarly happening among our peer nations. I urge policy makers to strengthen attention to science without diminishing attention to mathematics. There isn't much point in getting students through the gateway of mathematics, without also providing high-level expectations for achievement in science and opportunities for attaining them.

- An exciting development is a recent start on more clearly adding technology and engineering to our U. S. education agenda, spurred by the leadership of federal policy efforts and calls from the private sector. Some peer nations already have had a strong spotlight on T&E, but these subjects are now getting on our school map. For example, the first update of national science standards in ov*er* a decade, scheduled to be released this week, will include strong calls for explicit inclusion of specific technology and engineering content within the nation's science instruction, in an integrated way.[4]

There is not enough qualified technology and engineering teachers, and it's difficult to make room in the school day for whole new T&E courses that all students would take. Consequently, policy makers are leveraging the nation's science teachers en masse in the next few years to add these subjects to their curriculum in an integrated fashion.[5] [6] Teachers and districts in most states have no preparation or experience for this. Therefore, federal investment is needed to support curriculum development, changes in teacher preparation, curriculum integration, professional development, and assessments.

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[3] Banilower, E., Smith, S., Weiss, I., Malzahn, K., Campbell, K. & Weiss, A. (2013). *Report of the 2012 National Survey of Science and Mathematics Education.* Chapel Hill, NC: Horizon Research.

[4] Board on Science Education, National Research Council. (2012). *Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*. Washington DC: National Academy Press.

[5] For example, in 2014, the National Assessment of Educational Progress (NAEP) will pilot an eighth-grade technology and engineering assessment. National Assessment Governing Board. (2011). *Technology and engineering literacy framework for the 2014 National Assessment of Educational Progress*. Washington, D.C.: author. The WestEd STEM Program facilitated development of this NAEP framework.

[6] Sparks, S. (March 27, 2013). New NAEP Demands Application of Knowledge: New NAEP to Gauge Engineering, Technology Literacy. *Education Week*. 32(26), p. 18.

Finally, an advantage of the term "STEM" is that it inherently suggests making connections in teaching among these subjects. That's important because these subjects are in fact connected in the work that goes on in STEM businesses and STEM research. Unfortunately, our typical K-12 STEM course structures and sequences and our staffing of them can be a barrier to teaching STEM in an integrated way, especially at the high school level. Federal leadership is needed to pry S, T, E and M education out of their silos, and further, to connect the teaching and learning of STEM to instruction in other school subjects.

The Importance of Continued Federal Leadership

Continued federal leadership for addressing barriers in STEM education is essential.[7] STEM education has been a continuing federal priority since the Soviet-era launch of the first satellite, Sputnik. If for no other reason than the constantly accelerating changes in science, technology, engineering and mathematics around us, federal efforts will likely always be needed to spur parallel innovations to keep STEM education contemporary. At this moment, specific needed federal efforts include:

(1) Continue to fund *rigorous research and development* in STEM that can:

- develop fundamental new understandings of how students learn STEM;
- create and promote rapid dissemination of leading edge STEM teaching and learning innovations, including technology innovations, that mirror developments in the fast-moving fields of STEM; and
- assess the effectiveness of educational products and teaching practices in STEM for the learning of diverse students.

(2) Foster efforts that create a *larger, better STEM teacher workforce* through:

- producing more STEM teachers, and promoting a diverse teacher corps reflecting that of the student population;
- providing induction for beginning STEM teachers in a way that launches their career-long learning about how to advance student learning in STEM, and

[7] Bybee, R. (forthcoming). *The Case for STEM Education: Challenges and Opportunities*. Arlington, VA: National Science Teachers Association. Note chapter 6: What is the Federal Government's Role?

- providing continuous, contemporary professional development of all STEM teachers so that they can provide our nation's youth with the most current understanding of STEM and develop the mind sets needed for innovation.

(3) Continue and expand *highlighting STEM as a priority in all education funding programs*, not just STEM funding programs, whenever appropriate.

The above efforts are especially important now because the recent sequestration already is beginning to erode rather than strengthen these efforts, which I will illustrate.[8]

Rigorous Development, and Research on Evidence of Learning by All

The field needs more, not less, federal support of both basic and applied research in STEM education. By basic research, I mean such things as more cognitive science research on how people think and learn. By applied research, I mean studies of the effectiveness of educational innovations, including whether they are effective for diverse learners. The Institute of Education Sciences at ED and the National Science Foundation are by far the largest sponsors of such research in STEM. In recent years, there has been a much-needed expansion of applied research and evaluation on the effectiveness of education innovations, including specifically in STEM subjects, and this should continue and be expanded.[9]

As the principal reviewer for science education in the What Works Clearinghouse, I have seen this resulting in the maturing of more innovations that have rigorous evidence to support their claims. But we have a long way to go before there will be enough evidence to transform educational practice so that all teachers are using evidence-based approaches.

The federal call for evidence of effectiveness can be credited with raising the expectation that all educators use evidence-based programs and practices throughout our education system. Projects that in the past amassed, reviewed and critiqued educational products were mostly descriptive efforts. At WestEd, in our work today for the corporate-sponsored *Change the Equation* review of STEM education products, developers had to provide strong evidence that their educational approaches produced results. Even some leading products were not

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[8] At the STEM Program at WestEd that I lead, 75 staff work on almost all of the above efforts, providing me with the grounded insights that I offer today; however, I acknowledge that our work often is supported through federal funds along with funds from private sector Foundations and corporations (e.g., Wiliam and Flora Hewlett Foundation, Google) and non-profits (e.g., Change the Equation, which represents first tier STEM companies).

[9] Findings from the National Center for Education Research (NCER) 2002-2011, particularly pp. 13-14. http://ies.ed.gov/ncer/pdf/Findings2011.pdf

included if they hadn't yet be able to generate such evidence. However, individual product developers and many of the nation's leading curriculum developers other than major corporations cannot afford the costs of the rigorous research needed to generate such evidence.

There are two challenges that concern me. First, sequestration is *immediately* reducing the amount of new research that will be funded. For example, both IES and NSF must reduce the number of new research studies they can launch in the next few months with FY13 funding, from among the backlog of proposals submitted last summer and fall. It is unfortunate that the across-the-board nature of the sequestration funding action ties the hands of policy makers to retain a priority on funding research and development in education, and STEM education in particular.

Second, while the rise of applied research and evaluation in STEM education has addressed some weakness in past research agendas, funding support for basic STEM education research may not be keeping pace with the investment needed to ensure the best possible STEM education in the future. If the demands for evidence are universally applied too early in the development process, this may stifle some kinds of high-risk, high-yield research needed in the early stages of thinking and development.

Preparation and Continuous Development of Enough STEM Teachers

We will need more STEM teachers, as evidenced by many organizations rallying to the PCAST report's call for 100K new STEM teachers in ten years.[10] The federal government should continue programs that recruit diverse students into STEM teaching and create innovation in STEM teacher preparation. New ideas will have to be explored for including some introduction to engineering fields and principles in the preparation of science teachers; currently only 14% of high school science teachers, 7% of middle school science teachers and 1% of elementary teachers had *any* college coursework in engineering (Horizon, 2013, footnote 3, see p. 12).

Some of our peer nations provide more robust teacher induction programs than the U.S. provides. For example, while U.S. induction programs typically last only one year, peer nations provide induction programs for beginning teachers for two years. Further, they more specifically recognize that beginning STEM teachers have

[10] President's Council of Advisors on Science and Technology (PCAST). 2010. *Prepare and inspire: Science, technology, engineering, and mathematics (STEM) education for America's future*. Office of Science and Technology Policy, Executive Office of the President, Washington, DC.

subject-specific needs and address these, in addition to the common needs faced by all beginning teachers.[11]

It is ironic and disturbing that at the same time the demands on STEM teachers to learn new things are escalating from initiatives such as Common Core and the upcoming Next Generation Science Standards, funds seem scare for the professional development that they need for effective implementation. And ongoing professional development always is needed in STEM, more so than in some other school subjects, to stay abreast of changes in STEM content knowledge spurred by the constant rapid changes in the STEM disciplines. For example, within the last three years: 59% of elementary teachers have had no professional development in science; only 47% of middle school mathematics teachers have had more than two days worth of professional development (Horizon, 2013, footnote 3, see pp. 33-4).

Highlighting STEM in funding programs

I want to acknowledge that there is significant room for improvement in aligning and focusing existing federal support for STEM education by different federal Departments and Agencies.[12] I have had experience over my career with many federal funding programs for STEM education, such as those supported by NSF, NASA, the U.S. Department of Education, which may overlap in name or general focus. I find that most of them, rather than being redundant, have differences in their specifics that are quite important distinctions in bringing about different needed elements of change in STEM education. However, what is needed is more strategic communication and alignment among federal programs to make these complementarities more explicit, and, also to reduce any true rather than perceived redundancy.

My comments thus far have been about urging continued or increased support of federal programs that specifically fund STEM education initiatives. There is an additional policy avenue for catalyzing stronger STEM education.

Include stronger attention to STEM within broader funding programs. For example, the recent re-competition of the ED department's Equity Assistance Centers requested that bidders include strategies that address the specifics of equity issues for STEM education. At WestEd, that new emphasis has resulted in exciting collaborations between my STEM Program and our Equity Assistance Center for

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[11] Britton, E., Paine, L., Pimm, D. & Raizen, S. (2003) *Comprehensive Teacher Induction: Systems for Early Career Learning*. San Francisco, CA and Dordrecht, Netherlands: WestEd and Kluwer Academic Press (now Springer).

[12] Government Accounting Office. (2012). *Opportunities to Reduce Duplication, Overlap and Fragmentation, Achieve Savings, and Enhance Revenue*. Washington, D.C.: author, GAO-12-342SP.

Region IX. Expanding this thinking, it would be exciting to see similarly stronger, more explicit calls for STEM emphases (not just for mathematics) in such programs as the Regional Education Laboratories and the Comprehensive Centers.

Recall that more than a decade ago, the federal government sponsored regional centers focused on STEM education, the Eisenhower Regional Consortia. I co-directed the consortium housed at WestEd. This program ensured that for every state across the country there was a place that could promote and broker collaboration on STEM issues among districts and regions within a state, and across departments of education in different states in the region. Today, there only is a thin patchwork of coordinating groups within some states, and they generally have less means to facilitate technical assistance for states and school districts to raise achievement in STEM education. Within many states, there is no such broker at all. And few entities span across states within their broader region.

In these tight fiscal times, I recognize that it most likely would be problematic to reinstate such dedicated STEM coordination entities at past funding levels. However, even funding some modest effort that would bring systematic assistance to states and school districts in the STEM area would be helpful. Additionally, there is an opportunity and a need for RELS, CCs and other federally funded Centers and technical assistance projects to do more to increase our nation's performance in STEM education. Perhaps national technical assistance centers on STEM education could be developed to support both the REL and CC contractor networks.

The Challenges of States, Districts and Private Education Companies Acquiring the Federal Role

States and districts do not have the capacity or wherewithal to fund or carry out much of what the federal government currently is leading and supporting. Particularly in these difficult fiscal times, they are overwhelmed with their core mandate of executing the provision of quality day-to-day instruction for their students.

Chances are that, as things stand now, any reallocated federal funds from the current high leverage, federal programs for STEM education improvement to states and districts would be used to address recent shortfalls in local funds for what they already have to do. Given this context, it is critical for the federal government to consider how it might promote capacity building at the district and state levels. [See footnote 5, Bybee.] In the long term, this would result in the ability to shift more of the needed research and evaluation and development activities to states or districts and perhaps decrease federal cost. In the immediate, however, it would require a funding increase to maintain momentum of federal efforts while also supporting states and districts to develop needed capacity in STEM leadership.

Many private companies that create educational products and services might have the funds to conduct such research, but they have little intrinsic incentive to pursue this agenda. I have asked friends who are leaders in private education firms, 'would you like me to study the effectiveness of your products and services?' Their response is: 'No thanks; the marketplace determines their effectiveness.'

Of course, products are commercially successful only if teachers are able to engage with and able to use a product. However, this important feature does *not* mean that firms are acquiring any evidence that students are successfully learning from the products, and, in particular, if our populations of students from very diverse backgrounds are being successful.

Also, the private sector generally is not going to aggressively create innovations that require users to move substantially past their comfort zone, because they aren't likely to have a sufficient market for success. It takes federal prompting to spur innovations that will lead rather than follow. In fact, funding programs for Small Business Innovation Research are prompting development of leading-edge innovations by the private sector; such efforts should continue. However, many of these grantees do not have staff with the expertise or experience with STEM education. In recent years I've had SBIR grantees reach out to us at WestEd, and *vice versa,* to collaborate on how to better incorporate evaluation of educational effectiveness of their innovations into development plans. The SBIR programs could be strengthened to require such collaboration.

Summary of Federal Strategies for Addressing Barriers in STEM Education

Based on the testimony above, what follows is a summary of federal strategies for addressing barriers in STEM education—

Balanced, integrated attention among STEM subjects.

1. Policy makers should continue their efforts to enhance mathematics education.

2. However, policies should foster more attention to science education, to redress its inadvertently diminished status in our educational system.

3. Federal leadership particularly is needed to catalyze introduction of technology and engineering education.

4. Leverage experiments in instructional models and courses that integrate STEM fields.

Sponsor more STEM education research and development, both basic and applied.

5. Increase funding for research on and development of promising practices in STEM education.

6. Ensure that applied research levels continue or grow and that basic research is strengthened.

7. Call for SBIR grantees to build in stronger collaboration with experts in STEM education and STEM education research.

Prepare, induct and continuously educate more STEM teachers.

8. Continue to catalyze production of more STEM teachers.

9. Foster experiments in science teacher preparation that include initial introduction to technology and engineering education.

10. Promote more robust teacher induction programs, including stronger attention to the subject-specific needs of beginning STEM teachers.

11. Increase professional development for implementation of major STEM initiatives and to stay current with developments in STEM disciplines.

Require and support a stronger STEM focus in broader education programs.

12. Create regional STEM education centers that can coordinate and lead STEM education efforts in each region of the country, similar to the Eisenhower Regional Consortia of the past.

13. Require stronger foci on STEM education (not just mathematics) in such programs as RELs and CCs.

14. Create national STEM education centers that can provide technical assistance to contractor networks for such programs as RELs and CCs.

I want to thank the committee for providing me this opportunity to share my expertise. I hope the committee will find the testimony helpful in deliberating how to strengthen STEM education.