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MAKING THE CASE: THE IMPORTANCE OF A RIGOROUS SCIENCE EDUCATION

By Emily Loney

Innovation and ingenuity have long been hallmarks of the U.S.' economy. Our competitive strength is built on the legacy of great innovators—from Alexander Graham Bell and Lewis Latimer to the Wright brothers and Steve Jobs. The U.S. has prized its status as a leader in developing creative thinkers and entrepreneurs, but by many estimates, it is losing ground.

In 2012, foreign companies filed more than half of U.S. technology patent applications, continuing a trend that first began in 2009.[1] In addition, the U.S.' share of high-tech exports is decreasing. Today, China is the single largest exporter of high-tech products.[2]

A rigorous education is a key component of developing the next generation of entrepreneurs and scientists. In a recent survey, 97 percent of voters agreed that improving the quality of science education is important to our country's ability to compete globally.[3] The education demands of careers are rapidly advancing, and jobs across the economy are requiring greater levels of technical skill and education than ever before.

Unfortunately, recent data show that U.S. students are not prepared for these increasing demands. Our students do not have sufficient mastery of core science content to be prepared for college and careers, and the U.S. has fallen behind in science achievement on international assessments even as other countries accelerate. **To ensure that students are capable of taking on the challenges of tomorrow, investing in a rigorous and focused science education is critical.**

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CURRENT CONTEXT: WHY SCIENCE, WHY NOW?

The demand for individuals with strong science and technical expertise is growing. **Experts anticipate that by 2018, more than 2.8 million job openings will be available for workers in science, technology, engineering, and mathematics (STEM) fields;** 92 percent of these jobs will require at least some postsecondary education.[4] Opportunities for STEM workers exist even in the current time of economic recovery. While there are currently 3.6 unemployed workers for every unfilled job in the U.S., in STEM fields there is only *one* unemployed STEM worker for every two unfilled jobs.[5] These career paths also offer competitive salaries. According to the U.S. Department of Commerce, individuals working in STEM fields can earn as much as 26 percent more on average than those working in non-STEM fields.[6]

Unfortunately, supply is not meeting demand: the U.S. is not yet producing a sufficient number of workers for these STEM opportunities. This shortage has ramifications for both economic competitiveness and the strength of our national security. The U.S.' military, security, and research operations depend on a skilled workforce of scientists, engineers, and mathematicians.

Recent reports indicate that U.S. colleges and universities are not graduating sufficient numbers of individuals with expertise in these subjects to fully staff military intelligence agencies. Today, less than one-third of U.S. college students graduate with a major in science or engineering, compared to more than half of Chinese college students who graduate with a major in these fields.[7]

To exacerbate the problem, women and minorities are underrepresented both in STEM degree programs and careers. Women hold nearly 50 percent of the jobs in the U.S. economy, yet only 24 percent of women are employed in STEM-related careers. This pattern has held consistent over the last 10 years, even as the number of college-educated women in the workforce has increased.[8] The challenge is also acute for underrepresented minorities, who made up only 10 percent of the U.S. workforce in science and engineering in 2010.[9] The number of underrepresented minorities pursuing degrees in engineering and physical sciences has remained flat since 2000, and the number of math majors has fallen.[10]

Improving science education is necessary to prepare additional numbers of STEM workers, but a strong background in science also benefits students who enter other fields. **A rigorous science education helps all students develop key analytical and problem-solving skills that are applicable across all fields.** From the doctor's office to the kitchen stove, Americans make countless decisions every day that involve science, yet recent reports indicate that our country's scientific knowledge is sorely lacking. On the 2003 *National Assessment of Adult Literacy*, fewer than one in three college graduates could perform tasks such as interpreting a data table about blood pressure and physical activity.[11]

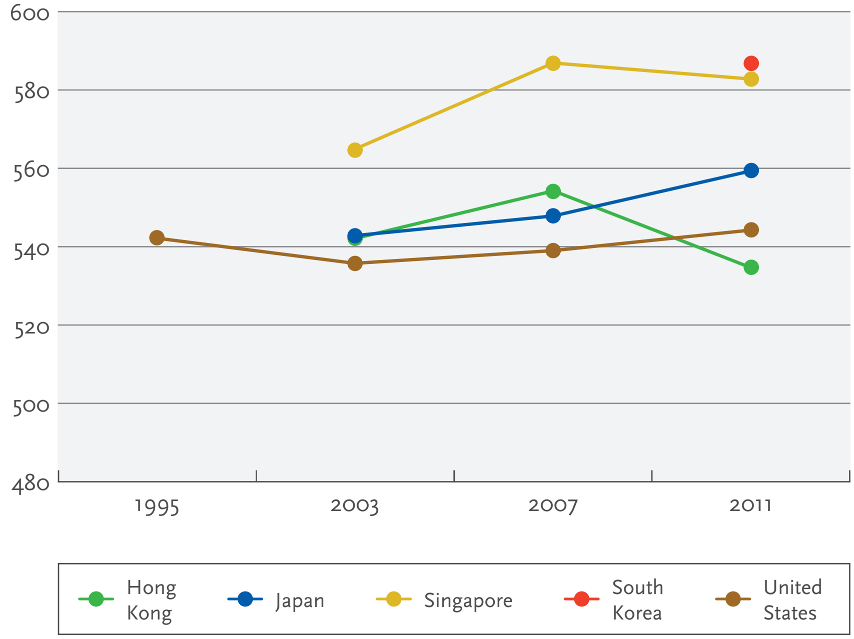
WHERE ARE WE NOW? THE STATE OF SCIENCE EDUCATION

Looking specifically at the state of science achievement, we see that U.S. students do not have sufficiently deep understanding of scientific concepts. According to 2011 results from the *National Assessment for Educational Progress* (NAEP)[i], **only one-third of U.S. eighth graders were proficient in eighth-grade science.** On the 2011 NAEP, just two percent of eighth-grade students scored at the highest level of proficiency, a percentage unchanged from the last administration of NAEP in 2009.

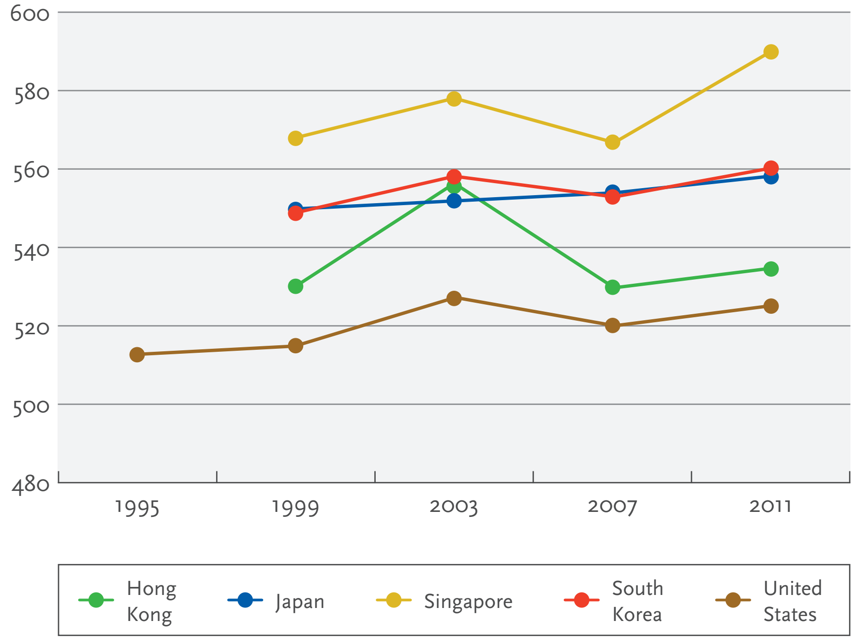
Only 7 percent of U.S. students are at top proficiency level on the PISA in science, compared to 27 percent in China and 23 percent in Singapore.[i]

International assessments which compare U.S. performance to that of other countries show that **our students' knowledge in science and math is plateauing at a time when other countries are moving ahead.** The *Program for International Student Assessment* (PISA) is an international assessment given every three years to 15-year-olds that evaluates students' capabilities in science literacy and problem solving. Results from 2012 tell us that U.S. science scores have not improved over the last decade. Even after adjusting for poverty, the U.S. continues to fall behind international peers. **The U.S. ranked 21st in science on the 2012 PISA, down from a ranking of 17th in 2009.**[12] Performance has also been flat on the *Trends in International Mathematics and Science Study* (TIMSS), which compares the science achievement of fourth- and eighth-grade students across 57 countries and education systems. There was **no measurable difference between the U.S. fourth-grade science scores in 2011 and scores in 2007 or 1995.** There was also no measurable difference between eighth-grade science achievement in 2007 (520) and in 2011 (525). (See charts at right.)

TIMSS Fourth-Grade Science Results – 1995-2011



TIMSS Eighth-Grade Science Results – 1995-2011



[i] This assessment is given to samples of fourth- and eighth-grade students around the country and tests students' knowledge in math, English language arts, and science [eighth-grade only].

Classroom instruction in science has in large part failed to keep pace with technological advancements and scientific discoveries. **The science standards currently used by states to guide classroom instruction are in many cases overly expansive and outdated.**[13] Many of these standards were developed based on the National Research Council's *National Science Education Standards* (1996) and the American Association for the Advancement of Science's *Benchmarks for Science Literacy* (1993). These standards were developed by considering each subject area of science independently. As scientists advocated for specific content to be included within their respective disciplines, the standards came to include more material than any K-12 school system could teach well.[14] Also, having not been updated in 15 years, the standards do not address the dramatic proliferation of technology and other advances in science that have occurred since the mid-1990s.

State science standards can also vary in how well inquiry and hands-on learning are integrated with the scientific content. Some standards emphasize the memorization of facts rather than involve students in the actual practices of science and engineering.[15] These hands-on practices are essential to putting scientific content in context, while also developing students' analytical and problem-solving skills. Students are also more likely to engage in the learning process—and perhaps even pursue STEM as a career—if they can see connections between the classroom and the real world through applied, hands-on learning.

At the high school level, student performance in science has plateaued even as states have increased the coursework requirements for a high school diploma. In the mid-1980s, most states required only two years of science for graduation.[16] Today, 19 states and the District of Columbia require three or more credits in science for graduation.[17] **Despite these increased requirements, only one in three high school students (36 percent) scored at the college-ready level in science on the 2013 ACT.**[18]

MOVING FORWARD: EFFORTS UNDERWAY TO IMPROVE SCIENCE EDUCATION

States across the country have recognized the need to improve student performance in science, and a number of efforts are underway to ensure that K-12 science education more effectively prepares students for careers and college. These activities address everything from increasing the rigor and focus of the science content taught in the classroom to partnering with higher education for more dynamic and hands-on professional development for teachers.

> *To date, 11 states, including **California, Delaware, Illinois, Kansas, Kentucky, Maryland, Nevada, Oregon, Rhode Island, Vermont**, and **Washington**, and the **District of Columbia** have adopted the NGSS. These states are each developing multi-year implementation strategies.*

Improving the Rigor and Focus of Classroom Instruction

One way to improve students' college and career readiness is to ensure the content they are learning in the classroom is focused and rigorous and builds in a logical sequence as students advance through grades. In response to this challenge, 26 states worked together from 2011-2013 to develop a new set of science standards. These standards, known as the **Next Generation Science Standards** (NGSS), are designed to impart both the scientific knowledge and experiential practices that students need to master in order to be ready for college and careers. These standards are internationally benchmarked and draw from the curricula and practices of top-performing countries on the PISA and TIMSS (such as Singapore, Finland, Korea, Canada, and Japan). The NGSS are structured in a clear developmental progression so that knowledge builds logically from year to year.

Many states are similarly increasing the rigor of K-12 instruction in mathematics and English language arts through the implementation of college and career ready standards. The **Common Core State Standards** (CCSS), for example, were created in a state-led process to establish a set of more focused, demanding expectations for students in mathematics and English language arts. The CCSS cover the continuum of student learning from kindergarten through twelfth grade and are structured so that content and student learning builds in a logical flow from grade to grade.

> Forty-four states, four territories, the District of Columbia, and the U.S. Department of Defense schools have adopted the CCSS. States are currently working on implementation, with a common goal of full implementation by the 2014-2015 school year.

Although these standards are in English language arts and math, **a key focus of the CCSS is increasing students' ability to read and analyze information across subject areas, especially in science.** As students graduate from high school and enter the workforce or the college classroom, they will need to be proficient at reading complex texts, instructional guides, and reports. The emphasis on careful reading and problem-solving skills in the math and English language arts standards will also benefit students in science coursework, where collaboration and deep analysis are important for success.

Strengthening Teacher Preparation and Support

Effective science teachers not only engage their students as they deliver content, but also have the power to inspire students to pursue science as a career. Given the ongoing shortage of science teachers, many states are adopting new recruitment and training programs to attract college students and mid-career professionals to teach science. States are also focused on enhancing the effectiveness of educators in the classroom through professional development programs.

TEACHER PREPARATION:

The **U-Teach** teacher preparation program at the University of Texas-Austin recruits undergraduate math and science majors into teaching. Students are able to graduate with both a degree in a STEM subject and a teaching certificate. Notably, this program involves faculty members from education, math, and science departments to train the future teachers in content and pedagogy.[19] **Indiana, Michigan, Ohio, New Jersey,** and **Georgia** are home to science teacher recruitment programs as part of the *Woodrow Wilson Teaching Fellowships for STEM Teaching*. Created in each state out of a coalition among governors, universities, state leaders, and unions, the fellowships recruit individuals with strong backgrounds in science, as well as technology, engineering, and math, into teaching in high-needs secondary schools. **Individuals receive a stipend and earn one-year master's degrees in exchange for a three-year teaching commitment.**

TEACHER SUPPORT:

Professional development programs keep teachers up to date with scientific developments and best practices in science instruction. As part of a collaborative effort between K-12 public schools and Rhode Island College, the Rhode Island STEM Center offers cutting-edge professional development, disseminates best STEM teaching practices, and fosters networks between teachers, higher education, and parents. The **Houston Independent School District**—as well as districts in **New Mexico** and **North Carolina**—are involved in a federal i3 grant to evaluate the National Science Resources Center's (NSRC) *Leadership Assistance for Science Education Reform* (LASER) model. The LASER program offers a systematic approach to science education reform with an emphasis on experiential, hands-on science learning. Both teachers and school leaders are receiving extensive professional development through the program.

Engaging Underrepresented Groups in Science

Recognizing the shortage of women and underrepresented minorities pursuing careers in science, a number of programs are using innovative approaches to engage these students throughout their K-12 experience. **Project Exploration** is a nonprofit science education organization based in Chicago dedicated to expanding access to science, particularly for minority youth and girls. Project Exploration offers free, hands-on science programs that incorporate mentorship and leadership development. Over one-third of the program's alumni pursue science as a major in college.[20] The **Expanding Your Horizons Network** is focused on providing mentoring and support to girls to pursue opportunities and career paths in STEM. The organization holds more than 80 conferences every year that involve girls in hands-on experiments and projects led by professional women in STEM fields. The network also connects girls with mentors and trains teachers on how to better support girls in STEM subjects.[21]

Identifying and Scaling Best Practices

As states implement initiatives to improve science education, many are carefully evaluating which programs generate the most significant innovation and results for schools and students. **North Carolina** has recently launched the **NC STEM Recognition** program to formally identify and recognize exemplary STEM schools. Schools will be evaluated on a formal rubric which includes components such as project-based learning, community and business engagement, and connections with postsecondary education. In **California**, a series brings together eight regional STEM networks and their leaders from the education, private, academic, and business sectors to launch STEM programs that address regional economic needs. These hubs also work to identify effective STEM practices that could be scaled up across the state.

State-Level Leadership for Science Education

State leadership can bring urgency and coherence to efforts to improve science education, in addition to linking these efforts to state economic needs. In **Iowa**, Governor Terry Branstad has established a STEM Advisory Council, which is co-chaired by the lieutenant governor and an Iowa-based CEO. This group led the development of the *Iowa STEM Strategic Plan Roadmap*, an effort to better coordinate STEM programs as well as develop college and career ready students. In 2012, **Oregon's** legislature established a permanent state council with the responsibility of advancing and evaluating STEM education in Oregon schools. The council originated out of a working group made up of business, education, and community leaders.

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