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STEM EDUCATION: BOLSTERING FUTURE AMERICAN COMPETITIVENESS

The United States isn't number one anymore. We're not even number two. In fact, the U.S. doesn't even make the top 10 list in science or math literacy among 15-year-olds worldwide, according to the most recent Program for International Student Assessment scores. Rather, the U.S. is ranked 21st in science literacy among the survey's 30 participating countries that are a part of the Organization for Economic Cooperation and Development—the wealthiest and most technologically advanced nations in the world. And the U.S. fares even worse in math literacy, ranking 25th in the same group of countries.

Somewhere between fourth grade and high school, American students fall behind in math and science, according to Trends in International Mathematics and Science Study results—a study that provides data used by the U.S. Department of Education on math and science achievements of U.S. students compared to other countries. U.S. students hold their own against their international counterparts in fourth grade, but begin to fall behind in middle school. And by the time U.S. students finish high school, less than 15 percent of graduates have a strong enough math or science foundation to pursue science or technology degrees in college, according to the American Society for Engineering Education.

But why does it matter? Why are science, technology, engineering and math—commonly referred to as STEM education—so important?

In the mid-1950s, economists began to realize that economic growth cannot be solely explained as a function of increased capital investment. One economist, Robert Solow—later a Nobel Prize recipient for his seminal work on the subject—discovered that more than 50 percent of economic growth can be explained by technological innovation. This means every period of economic growth in the United States is directly related to the amount of technological innovation occurring during the same period. In layman's terms: As innovation goes, so goes the economy.

The United States is currently experiencing a period of slow innovation and a sluggish economy. While Asian countries continue to produce more scientists and engineers, the U.S. is facing job market demand for technically-trained employees that is far outpacing supply, according to the Council on Competitiveness—a nonprofit organization comprised of corporate CEOs, university presidents and labor leaders.

Fast Facts

- Each engineering job in the United States generates five to six additional jobs.
- Europe produces roughly three times as many engineering graduates as the U.S. each year. Asia produces almost five times as many.
- Female students make up only 17 percent of the current engineering enrollment at U.S. colleges and universities.
- Fewer than 2 percent of current U.S. high school graduates will earn an engineering degree.
- African-American and Hispanic students represent less than 14 percent of engineering enrollment nationwide.
- Fewer than 15 percent of high school graduates have enough math and science to pursue scientific/technical degrees in college.
- Five years after graduation, 80 percent of engineering graduates are working in other fields.

Source: Institute of Engineering Education *http://www.theinstitute.smu.edu/facts.html*

Even beyond economic concerns, STEM education is critical to providing the U.S. with new engineers to repair the nation's crumbling infrastructure, new scientists to solve increasing energy concerns and a better educated public that understands and supports national scientific goals. As a recent Stanford Institute for Economic Policy Research report explains, more innovation and faster economic growth will not occur "if the education system does not provide sufficient supply of scientists and engineers."

The National Science Foundation put it even more bluntly in a letter to the President's Council of Advisors on Science and Technology: "Civilization is on the brink of a new industrial order. The big winners in the increasingly fierce global scramble for supremacy will not be those who simply make commodities faster and cheaper than the competition. They will be those who develop talent, techniques and tools so advanced that there is no competition."

The Call for STEM Education Reform

In *Rising Above the Gathering Storm*, the National Academies sought to answer a question posed by Congress about future American competitiveness: "What are the top 10 actions, in priority order, that federal policymakers could take to enhance the science and technology enterprise so that the United States can successfully compete, prosper and be secure in the global community of the 21st century?" Rather than deliver a list of top 10 policy actions specific to Congress and the federal government, the report highlights four major areas critical to future competiveness at all levels of government:

- K-12 education
- research and development
- higher education
- policy incentives

Similarly, the Council on Competitiveness released its flagship report *Innovate America*, which called for reform in three essential elements of innovation:

- talent
- investment
- infrastructure

What both prestigious reports recognize is this: STEM education is a critical component to future American competitiveness. It is the foundation upon which all other innovation elements rely, and states play a major role in shaping the system.

Teachers Matter

According to the Education Commission of the States, one of the most visible actions states have taken in STEM education is increasing the number of math and science classes students need in order to graduate high school. In 1980, only Washington state required three math classes for graduation and no states required three science courses. But by 2012, 39 states will require three math units and by 2013, 36 states will require three science units to graduate.

But quantity of math and science courses does not always equal quality. The most recent data available show a significant number of unqualified teachers teaching high school science: 63 percent of physical science teachers, 45 percent of biology/life sciences teachers, 61 percent of chemistry teachers and 67 percent of physics teachers lacked degrees or certification in the subjects taught in the 1999-2000 school year, according to the National Center for Education Statistics.

What is alarming about these numbers is that the Center for the Study of Teaching and Policy at the University of Washington found that the level of teacher education and certification was the most powerful predictor of student outcomes. In fact, teachers who are fully certified and hold at least a bachelor's degree in their subject area produce students with the highest scores by far on standardized tests in math and reading, according to a 1999 University of Washington report.

Continued professional development and teacher training is critical to increase the quality of the current STEM teaching force. According to the National Academies, states should strengthen the skills of its current STEM teachers by supporting master's programs, summer training institutes and Advanced Placement training opportunities. Research shows that as teachers spend more time in professional development, higher percentages of their students meet science and math standards.

The Next Generation of Innovators

Experts believe much of the STEM education problem lies somewhere between middle school and high school when students lose interest and math and science understanding seems to decline. But a large problem also exists at the college level. According to ACT, a nonprofit college entrance exam administration and research service, the number of students who indicate they plan to study engineering in college continues to decrease since the early 1990s. Moreover, according to the group Tapping America's Potential, a coalition of 16 American business organizations including the U.S.

Chamber of Commerce and the Council on Competitiveness, the U.S. is falling behind on its goal to double the number of STEM majors to 400,000 by 2015.

With the cost of higher education on the rise in the U.S., more students are looking for ways to pay for their degrees. In other words, where money is available for higher education, eager students will flock. In this vein, many experts point to the need for more scholarships in STEM education as incentives for more students to major in STEM fields.

But a big problem for states has been the misalignment between K-12 core curriculum and the expectations of the 21st century work force. According to the U.S. Chamber of Commerce, industry is having an increasingly difficult time recruiting skilled workers able to succeed in the 21st century knowledge economy.

States Take Heed

Some states have gotten the message and are working to improve STEM education outcomes through very specific goals.

Arkansas, for example, has become a leader in rigorous academic requirements through its Smart Core college prep curriculum. Smart Core was designed to better align middle and high school education rigor with college entry expectations. Though it does not focus exclusively on STEM education, Smart Core incorporates rigorous math requirements, including the requirement that every student take algebra I, geometry and algebra II in order to graduate high school—a requirement that only two other states have.

States also have been busy vying for better teacher recruitment incentives—27 states offer some incentives to recruit high quality teachers. But two state university programs have emerged as leaders specifically for STEM education: the UTeach program at the University of Texas at Austin and the California Teach program operating at all 10 University of California campuses. Both programs offer generous scholarships to STEM majors who agree to teach for a specified number of years after they earn their degrees, which, according to the National Academies, is crucial to its goal of attracting 10,000 new science and math teachers to reach 10 million minds.

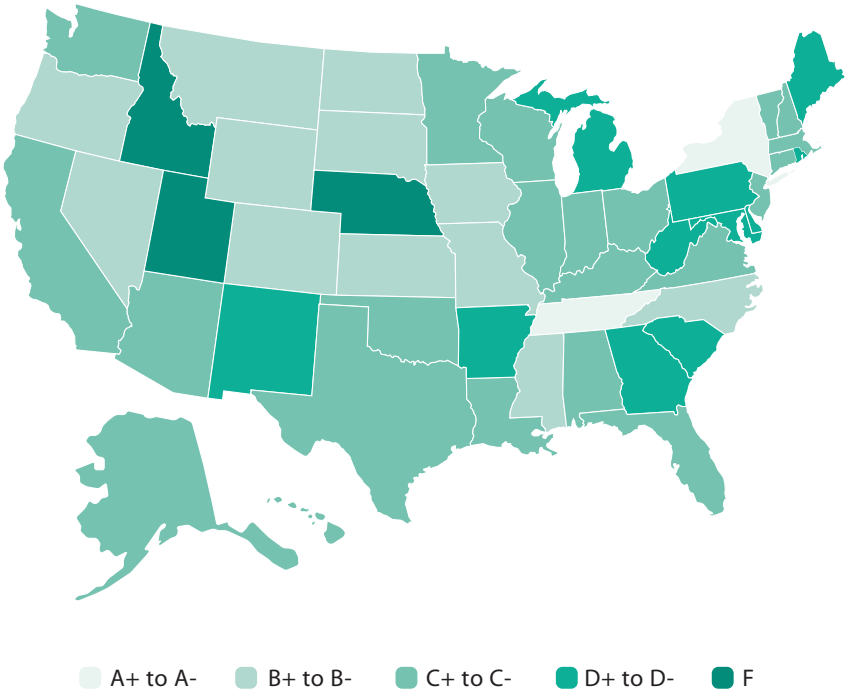
Several states also hold teacher preparation programs accountable for the performance of their graduates. In Alabama, for instance, universities are given report cards by the state detailing the quality of their teacher training programs. These report cards are based on measurable outcomes, such as teacher performance in the work force, and are designed to measure universities

Higher Education at a Glance

- The number of science and engineering bachelor's and master's degrees awarded in the U.S. continues to rise annually as the college-age population continues to increase.
- More than half of all U.S. doctorates in engineering, mathematics, computer sciences, physics and economics were awarded to foreign students in 2005.
- About 78 percent of science and engineering doctorates worldwide are earned outside the United States.
- Through the late 1990s and 2000s, the numbers of natural science and engineering doctoral degrees awarded have declined or remained stagnant in the U.S., the United Kingdom and Germany. Doctoral degrees awarded in these subjects in China, South Korea and Japan, however, continue to rise.

Source: National Science Foundation Science and Engineering Indicators 2008

State Efforts to Align K-12 Education with Early-Childhood Education, Postsecondary Education and the Work Force: Grading the States



Source: EPE Research Center Quality Counts 2008

according to the quality of the teachers they produce.

Eight states—Arizona, Arkansas, Connecticut, Kentucky, Minnesota, Missouri, Rhode Island and West Virginia—have taken steps toward more comprehensive STEM education reform by creating commissions that work specifically to set and achieve statewide STEM education goals. These commissions bring educators, executive branch officials, legislators, nonprofit organizations and public interest groups together to set STEM education goals and policies for the states.

Federal Action

In 2007, Congress passed the America Creating Opportunities to Meaningfully Promote Excellence in Technology, Education and Science Act, or the America COMPETES Act, based on the research of the National Academies and the Council on Competitiveness. The legislation focuses on three areas: research, STEM education and innovation infrastructure. Its education goals:

- Authorize state grants to promote better elementary, secondary and higher education (P-16) alignment;
- Establish teacher training and professional development programs at summer institutes at the National Laboratories and the National Science Foundation;
- Expand the Robert Noyce Teacher Scholarship Program at the National Science Foundation;
- Assist states in developing statewide specialty schools in math and science; and
- Increase the number of teachers trained to teach advanced placement courses.

If fully funded, this legislation would grant states the money they need to recruit highly qualified STEM teachers, create STEM specialty schools, realign curricula with work force expectations, recruit more college students into STEM fields, and ultimately recruit STEM-related business into their states. While the stated goals of this bill are taken directly from recommendations advocated by the National Academies, the Council on Competitiveness and others, no money has been appropriated, and without money to back the programs, they cannot succeed.

What's Next?

One state stands out as a pioneer in STEM education: Ohio. In early 2008, an unprecedented public-private partnership was created to work with public schools and higher education institutions in the state to grow Ohio's talent in STEM fields for the 21st century. The program will focus on areas critical to effective STEM education, including teacher training, specialty public school programs and college scholarships for STEM majors. This is the first-of-its-kind effort by a state to streamline its STEM education goals from elementary education to college degree to 21st century work force.

In a joint statement at the network's launch in January 2008, Gov. Ted Strickland, Senate President Bill Harris and Speaker Jon Husted said, "We can all agree that creating jobs and building our economy are essential and vital to our progress as a state. To do so we must prepare our students with the skills and tools needed to compete in the ever-changing global marketplace—an environment where talents in the STEM disciplines will drive the economy and dictate success. With Ohio's focus on STEM education, we are laying the groundwork for a highly competitive 21st century 'solutions' revolution."

The Ohio STEM Learning Network could serve as the future model of STEM education in the states.

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